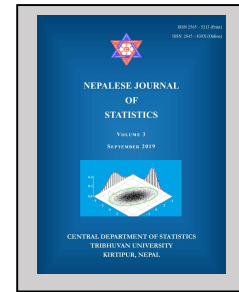# Linkages between Time to Reach Education Centers, Health Facility Centers, Poverty Status and Geography: A Multivariate Approach

Pravat Uprety

ABSTRACT

Background: The first, third and fourth goals of SDG are concerned with ending poverty in all its forms everywhere, ensure healthy lives and promote well-being for all at all ages and ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, respectively. Nepal is committed to ensuring all children with access to free, compulsory, and good-quality basic and secondary education in Nepal.

Objectives: This study aims to compare the average time to reach education centers and health facility centers by poverty status and ecological region.

Materials and Methods: This study is based on NLSS 2011 data. In this study two major factors of access to facility namely education and health are considered. Four variables on access to education and three variables on access to health are used. Mean vectors, correlation matrices, and covariance matrices have been computed. The Multivariate Analysis of Variance is used to compare the mean vectors and to check the homogeneity of the variance-covariance matrix using Box's M test. Four tests namely Wilk's Lambda, Lawley- Hoteling trace, Pillai trace and Roy's largest root have been used to compare the mean vectors.

Results: This study has shown that the average time to reach each nearest education center of poor households is higher than non-poor households in each ecological region. The average time to reach the primary school is lowest and highest to reach secondary school in each poverty status and ecological region. The average time to reach the nearest health post is lowest among different health facility centers in each poverty status and ecological region. The p-values of each Box's M and Pillai trace tests are less than 0.0001.

Conclusion: The mean vectors of time to reach the nearest education center are significantly different between poor and non-poor households in each ecological region. The average time to reach the health facility centers is also significantly different in poor and non-poor households within each ecological region.

Keywords : Box's M test, correlation matrix, health facility centers, Hoteling T^2, MANOVA, poverty, time to reach education centers, Wilk's lambda.

_____

Address correspondence to the author: Central Department of Statistics, Tribhuvan University, Kirtipur, Kathmandu, Nepal.
Email:pravatup@gmail.com
_____

INTRODUCTION

Nepal is a small landlocked and least developed country in the world. Geographically, the country is divided into three North-South ecological zones: the Northern Range – Mountain, the Mid-Range – Hill and the Southern Range – Terai (flat land). According to UNICEF (n.d.), over the last 20 years, Nepal has made significant progress in education. The net enrolment rate in primary schools has risen to 97 per cent. However, the country still has many challenges to tackle. Issues that persist in education include poor quality and inequity in access, geographical remoteness, gender, socioeconomic and ethnic differences. Key barriers to enrolment and attendance include poverty, social exclusion, disability, migration, child labor, social norms and gender bias. In Nepal, currently, 770,000 children aged 5-12 years are still out of school, only a half of students in grades 3, 5 and 8 meet the academic achievement criteria for Nepali and Mathematics, and attendance in Early Childhood Education (ECE) is still low at 51 percent. The maternal mortality ratio is 239, the proportion of births attended by skilled health personnel is 58.0, under five mortality rate is 39 and Neonatal mortality rate is 21 (NDHS, 2016). To improve these indicators, there should be good access to facility, trained and qualified health workers and doctors and there should be sufficient medicine and infrastructure facilities.

Among the 17 goals of SDG, the first, third and fourth goals are related to ending poverty in all its forms everywhere, ensure healthy lives and promote well-being for all at all ages and ensure inclusive and equitable quality education and promote lifelong learning opportunities for all respectively (NSDG, 2017). Within the second goal of SDG, there are other targets of health related indicators to be done in 2030, such as reducing maternity ratio ending preventable deaths of newborns and children under 5 years of age, ending the epidemics of AIDS, TB, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases,) reducing by one third premature mortality from Non-communicable Diseases (NCDs) through prevention and treatment and promote mental health and wellbeing, and strengthening the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol (NSDG, 2017). Likewise, the targets of fourth goal of SDG are all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes, all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education, equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university, a larger percent the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship, and elimination

of gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, among others. The other goals of SDG are directly and indirectly related to each other. If people are educated then they are concerned not only with their health but also with family members and neighbors they can think of the development of society and nation. Nepal is committed to ensuring that all children have access to free, compulsory, and good-quality basic and secondary education. Measures have subsequently been taken to increase access to education, particularly for the poor and other disadvantaged groups.

The world is healthier and more educated than ever. In 1980, only 5 in 10 primary school-age children in low-income countries were enrolled in school. By 2015 this number had increased to 8 in 10. In 1980 only 84 of 100 children reached their fifth birthday, compared with 94 of 100 in 2018. A child born in the developing world in 1980 could expect to live for 52 years. In 2018 this number was 65 years. Worldwide, more than 260 million children and youth are not in school. Meanwhile, nearly 60 percent of primary school children in developing countries fail to achieve minimum proficiency in learning. Human capital consists of the knowledge, skills, and health that people accumulate over their lives, enabling them to realize their potential as productive members of society. It has large payoffs for individuals, societies, and countries. For individuals, an additional year of school generates higher earnings on average. These returns are large in low- and middle-income countries, especially for women. However, what children learn matters more than how long they stay in school. (WDR, 2019). Health is an important component of human capital. People are more productive when they are healthier (WDR, 2019).

Education is one key factor to get any job in private as well as public organizations. Still many children are deprived from education due to poverty, long distance to reach the school. Nepal has achieved the goal of primary enrollment but the dropped out ratio is very high. Many children do not complete the primary level, they drop the school due to various reasons such as not aware of their parents about the education, to work at home and farm, to support their parent, being the far education facility centers, poverty etc. Due to the poor access in education, School enrolment becomes very low and absenteeism becomes very high (often among teachers as well as children). Infrastructure is the prerequisite for the development of any economy. Infrastructure plays a crucial role in promoting economic growth and thereby contributes to the reduction of economic disparity, poverty and deprivations in a country. Greater access of the poor to education and health services, water and sanitation, road network and electricity is needed to bring equitable development and social empowerment. It is an important pre-condition for sustainable economic and social development (Srinivasu & Rao, 2013).

There is direct linkage between human capital, economic development and economic growth. Improvements in the health, education and skill of labor can increase considerably the productivity and earning of labor and may be preconditions for the introduction of more sophisticated, advanced technology applied to production (Thrilwall, 2011). As a country develops economically,

the health of its population improves. This improvement in health is direct evidence that people are leading better lives. In other words, health is something that people value for itself. But health also has a productive side: Healthier people can learn better and longer; they can also think more clearly. Healthier students can learn better. Thus, better health in a country will raise its level of income. Intellectual ability is far more important than physical ability in determining a person's wage and for this reason; investment that improves a person's intellect-in other words, education has become the most important form of investment in human capital (Weil, 2009) Health and education are closely related in economic development. On one hand, greater health capital may improve the return to investments in education, in part because health is an important factor in school attendance and in the formal learning process of child. A longer life raises the return to investments in education; better health at any point during working life may in effect lower the rate of depreciation of education capital. On the other hand, greater education capital may improve the return to investment in health, because many health programs rely on basic skills often learned at school (Todaro & Smith, 2016).

In Nepal, one barrier to access the different facilities related to health and education is geography composition. Through research and looking at different facts of Nepal, World Bank has focused to invest in human capital services. The priority interventions to invest in people and scale up human capital are to eliminate barriers for the poor in accessing human capital services such as increase public financing to ensure the availability of a standardization and basic healthcare service packages, another reform area is to increase the availability of services in poor and underserved geographic area and within this reform area the first point is to increase resources allocated at the local level to ensure sufficient and well equipped facilities for provision of basic health and education . Likewise, within the second priority 'Improve the quality of education, health nutrition, labor, and social protection services from early childhood to adulthood' there are some points such as increase the quality and coverage of early child hood education (ECD), build capacity of local government to monitor the quality of early ECD programs, etc. and invest in the systems necessary to deliver quality health service (WB, 2019). In Nepal, various households are deprived from the good education and health facility due to being far education center and health center from their households. Due to lack of road, not reaching the health post on time, lack of awareness and good education large number of mothers give childbirth at home and it makes the maternal mortality, neonatal mortality, under five year child mortality high. Standards of healthcare are low because clinics are hard to reach and health workers cannot travel easily.

To increase the economic growth and economic development, human capital is major component and investment in human capital is essential. Two major components of human capital are education and health. Due to the geographical difficulty and variation, many people of Nepal are deprived from good education and health. Distance to reach is one major component of depriving the people from good education and health and finally it increases dropout ratio, irregularity to go education center, the maternal mortality, infant mortality, child mortality, death from different diseases, etc. Consequently, in developing countries like Nepal, reducing the time

to reach nearest facility centers is essential by geography and poverty level. This study deals with time to reach nearest different education centers and health facility centers and their variations according to geography and poverty level.

MATERIALS AND METHODS

This study is based on the secondary data. In this study, the data of Nepal Living Standards Survey (NLSS) 2011 conducted by Central Bureau of Statistics, Nepal Government was used. This survey was conducted in 2011 and in this survey data from 5988 households were collected from 499 Primary Sampling Units (PSUs) from the cross-sectional sample.

Data and variables

In this study two major factors of access to facility namely education and health are taken. Four variables on access to education and three variables on access to health are used. The four variables on access to education are distance to reach Childhood Development Center (CDC), distance to reach to primary school, distance to reach the secondary school and distance to reach the higher school. Likewise, three variables on health are distance to reach the health post /sub health post, public hospital and clinic/private hospital. Data on poverty status and ecological region are used. Due to the recent changes in rural and urban areas, it is not considered in this study. In order to measure the distance to reach the facility center the question "how long does it take to get from your household to the closest facility center (one way total time taken)" has been asked so that the distance to reach the nearest facility centers are measured in minutes whatever the transportation type the households used.

Statistical model and analysis

This study has used descriptive as well as inferential analysis. All analysis are based on considering household weights and analysis has been compared by poverty status and ecological region. Mean vectors, correlation matrices as well as covariance matrices have been computed in each category of poverty status and ecological regions. The mean vectors are compared by poverty status in each ecological region and also their differences were statistically tested. The Multivariate Analysis of Variance (MANOVA) is used to compare the mean vectors and to check the homogeneity of the variance-covariance matrix, Box's M test is used. Four tests such as Wilk's Lambda, Lawley- Hoteling trace, Pillai trace and Roy's largest root have been used to compare the mean vectors.

The MANOVA model

MANOVA is a generalization of ANOVA to a situation in which there are several dependent variables. MANOVA emphasizes the mean differences and statistical significance of difference among groups. According to Johnson and Wichern (2009), one way MANOVA Model for comparing g population mean vectors is specified as:

$$X_{lj} = \mu + \tau_l + e_{lj} \quad \text{j=1,2,}\ldots\ldots\ldots \text{ n}_l \quad \text{and} \quad l = 1,2,3 \ldots\ldots\ldots \text{ g} \tag{1}$$

where e_{lj} are independent $N_p(0, \Sigma)$ variables. Here, the parameter vector $\boldsymbol{\mu}$ is an overall mean (level) and $\mathbf{r}_l$ represents the lth treatment effect with $\sum_{l=1}^{g} n_j \tau_l = 0$. In the above model, each component of the observation vector X_{lj} satisfies the univariate model. A vector of observations may be decomposed as:

$$X_{lj} = \qquad \overline{X} \qquad + \qquad (\overline{X}_l - \overline{X}) \qquad + \qquad (X_{lj} + \overline{X}_l) \qquad (2)$$

(Observations)   (Overall sample mean) +   (estimated treatment effect) + (residual)

Simplifying, squaring and summing the above model (2) becomes:

$$\sum_{i=1}^{g}\sum_{j=1}^{n_l}(X_{lj} - \overline{X})(X_{lj} - \overline{X})^t = \sum_{i=1}^{g}n_l(\overline{X}_l - \overline{X})(\overline{X}_l - \overline{X})^t + \sum_{i=1}^{g}\sum_{j=1}^{n_l}(X_{lj} - \overline{X}_l)(X_{lj} - \overline{X}_l)^t$$

Total (corrected) sum of squares and cross products

Treatment (Between) sum of squares and cross products

Residual (Within) sum of squares and cross products

Table 1. MANOVA table for comparing population mean vectors.

Source of variation	Matrix of sum of squares and cross products (SSP)	Degrees of freedom (d.f)
Treatment	$B = \sum_{i=1}^{g}n_l(\overline{X}_l - \overline{X})(\overline{X}_l - \overline{X})^t$	g-1
Residual (Error)	$W = \sum_{i=1}^{g}\sum_{j=1}^{n_l}(X_{lj} - \overline{X}_l)(X_{lj} - \overline{X}_l)^t$	$\sum_{l=1}^{g} n_l - g$
Total (corrected for the mean)	$B + W = \sum_{i=1}^{g}\sum_{j=1}^{n_l}(X_{lj} - \overline{X})(X_{lj} - \overline{X})^t$	$\sum_{l=1}^{g} n_l - 1$

Source: Applied multivariate statistical analysis (Johnson & Wichern, 2009)

Here, B and W are distributed as Wishart distribution (Anderson, 2004). MANOVA table is used to compute Wilk's Lambda, Lawley Hotelling trace, Pillai trace and Roy's largest root. In MANOVA null hypothesis is stated as:

Null Hypothesis (H$_0$) : $\tau_1 = \tau_2 = \ldots\ldots\ldots\ldots \tau_g = 0$ OR

Null Hypothesis (H$_0$) : $\mu_1 = \mu_2 = \cdots = \mu_g$ to test the equality of three or more mean vectors, Wilk's Lambda statistic (also known as the U statistic) is used and it is defined as:

$$\lambda = \frac{|W|}{|B+W|} = \frac{\left|\sum_{i=1}^{g}\sum_{j=1}^{n_l}(X_{lj}-\overline{X}_l)(X_{lj}-\overline{X}_l)^t\right|}{\left|\sum_{i=1}^{g}\sum_{j=1}^{n_l}(X_{lj}-\overline{X})(X_{lj}-\overline{X})^t\right|}$$

which is equivalent to the likelihood test (Johnson & Wichern, 2009). Likewise, other multivariate test statistics are also used to compare the several mean vectors and they are Lawley- Hoteling trace = tr[BW^{-1}], Pillai trace = tr[B(B+W)$^{-1}$] and Roy's largest root = maximum eigenvalue of W(B+W)$^{-1}$. All four of these tests give the almost same result for extremely large sample case. All these tests rely upon the analogous assumption that the within-group covariance matrices for all groups are equal, $\Sigma_1 = \Sigma_2 = \cdots = \Sigma_g$. To test the equality of covariance matrices, Box's M test is used. According to Hair et. al. (2009), Wilk's Lambda is referred as the multivariate F and is commonly used for testing overall significance between groups in multivariate situation and Pillai's criterion is considered more robust and should be used if sample size decreases, unequal cell sizes appear and homogeneity of covariance is violated.

RESULTS

Results are described and presented in the subsequent sub-sections below.

Comparison of time to reach the education facility by poverty status and ecological region

In education facility there are four variables. The first variable is the distance to reach the nearest early childhood center (X_1), second variable is distance to reach the primary school(X_2), third is distance to reach secondary school (X_3) and fourth variable is distance to reach the higher secondary school (X_4). Each distance is measured in minute and which is the time taken by the households to reach the education center by any kind of transportation the household frequently used. The mean vector gives the average value of each distance.

Comparison of time to reach the education center by poverty status and ecological region

Analysis of mean vector

Analysis of mean vectors are given below.

Table 2 consists of mean vectors of time to reach different education centers of poor and non-poor households in three ecological regions and in Nepal. In mountain, the average time to reach the nearest early childhood center of poor and non-poor households are 25.32 and 17.37 minutes, respectively. Likewise, the average time to reach nearest primary school are 15.81minutes and 14.10 minutes, 55.40 minutes and 47.75 minutes in secondary school, and 132.51 minutes and 95.21 minutes in higher secondary school for poor and non-poor households, respectively.

Table 2. The mean vectors for non-poor and poor households to reach the nearest education center.

	Mountain	Hill	Terai	Nepal
Poor	$\bar{X}_{MP} = \begin{pmatrix} 25.32 \\ 15.81 \\ 55.40 \\ 132.51 \end{pmatrix}$	$\bar{X}_{HP} = \begin{pmatrix} 28.85 \\ 20.83 \\ 66.23 \\ 152.74 \end{pmatrix}$	$\bar{X}_{TP} = \begin{pmatrix} 15.79 \\ 12.08 \\ 29.05 \\ 52.20 \end{pmatrix}$	$\bar{X}_{P} = \begin{pmatrix} 22.78 \\ 16.45 \\ 48.93 \\ 107.03 \end{pmatrix}$
Non-poor	$\bar{X}_{MN} = \begin{pmatrix} 17.37 \\ 14.10 \\ 47.75 \\ 95.21 \end{pmatrix}$	$\bar{X}_{HN} = \begin{pmatrix} 23.87 \\ 14.13 \\ 40.36 \\ 71.71 \end{pmatrix}$	$\bar{X}_{TN} = \begin{pmatrix} 14.41 \\ 11.22 \\ 21.60 \\ 34.35 \end{pmatrix}$	$\bar{X}_{N} = \begin{pmatrix} 18.98 \\ 12.78 \\ 32.11 \\ 55.63 \end{pmatrix}$
Overall	$\bar{X}_{M} = \begin{pmatrix} 20.03 \\ 14.67 \\ 50.30 \\ 107.70 \end{pmatrix}$	$\bar{X}_{H} = \begin{pmatrix} 24.82 \\ 15.40 \\ 45.28 \\ 86.74 \end{pmatrix}$	$\bar{X}_{T} = \begin{pmatrix} 14.67 \\ 11.38 \\ 23.01 \\ 37.88 \end{pmatrix}$	$\bar{X} = \begin{pmatrix} 19.74 \\ 13.51 \\ 35.46 \\ 65.89 \end{pmatrix}$

In both poor and non-poor households, the average time to reach ECD center is higher than the average time to reach the primary education. Each average time to reach the nearest education facility center of poor households is higher than non-poor households in the mountain region. The average to time to reach the higher secondary school is more than one hour in non-poor households and more than two hours in poor households.

In hill region, the average time to reach the primary school is lowest and to reach higher secondary school is highest in both poverty status. The distance to reach each education center is higher in poor households than the non-poor households. The average time to reach higher secondary school in non-poor households is about one hour higher than the average time to reach the secondary school while the average time to reach the secondary and higher secondary school is two hours higher than the average time to reach the secondary school in poor households within hill region. The average time to reach primary school is lowest in poor as well as non-poor households and the time taken to reach each education center of poor is higher than poor households and each time is less than one hour in terai region.

To compare the average time between poor and non-poor households irrespective of ecological region, it is found that the average time to reach primary school is lowest in poor as well as non-poor households and the time taken to reach each education center of poor is higher than non-poor households. It can also be seen that the average time to reach the primary school of poor households is slightly higher than the non-poor households but the average time to reach

higher secondary school in poor households is approximately two times higher than the non-poor households. Table 2 also indicates that despite more difficult geography in mountain, the average time to reach the early childhood center and primary school are lowest in terai and highest in hill. This is obvious because in mountain region, households are clustered in certain area and early childhood center and primary school are located there. However, the average time to reach the nearest secondary school and higher secondary school are highest in mountain and lowest in terai regions.

Testing of equality of covariance matrices of time to reach the education centers between poor and non-poor households in ecological regions and in Nepal

To test the significance difference in covariance matrices of non-poor and poor households (i.e. H_o: $\sum_n = \sum_p$) in ecological regions and in Nepal, the Box's M test, F-value and p-value are obtained as follows. The Box's M value and p-value (<0.05) in each ecological region and in Nepal indicate that the covariance matrices of poor and non-poor households are significantly different in each ecological region and overall Nepal.

Tests for equality of covariance matrices between ecological regions

Table 3. Box's M test for covariance matrix of time to reach the education center by poverty status in ecological region.

Region	Box's M	F Value	P value
Mountain	106.58	10.50	<0.0001
Hill	851.806	84.85	<0.0001
Terai	1413.8	140.91	<0.0001
Nepal	1664.8	166.21	<0.0001

Table 4. Box's M test for covariance matrix of time to reach the education center by overall ecological regions.

Region	Box's M	F Value	P value
Nepal	7986.50	398.274	<0.0001

The Box's M test indicates violation of equality of covariance matrices (p-value <0.05) in ecological regions. Variance, covariance and correlation of all pairs are shown in Appendix 1 and 2.

Tests for equality of mean vectors to reach the education centers between poor and non-poor in ecological regions and in Nepal

Table 5. Tests of equality of mean vectors of time to reach the education centers.

Region		Pillai's Trace	Wilk's Lamda	Hotelling's Trace	Roy's Largest Root
Mountain	Test statistic	0.032	0.968	0.033	0.033
	F-value	2.771	2.771	2.771	2.771
	P-value	0.027	0.027	0.027	0.027
Hill	test statistic	0.032	0.968	0.033	0.033
	F-value	16.955	16.955	16.955	16.955
	P-value	<0.0001	<0.0001	<0.0001	<0.0001
Terai	test statistic	0.025	0.975	0.025	0.025
	F-value	15.644	15.644	15.644	15.644
	P-value	<0.0001	<0.0001	<0.0001	<0.0001
Nepal	test statistic	0.021	0.979	0.021	0.021
	F-value	26.188	26.188	26.188	0.000
	P-value	<0.0001	<0.0001	<0.0001	<0.0001

Table 5 depicts that the F-value and p-value of all tests are almost similar. Since equality assumptions of covariance matrices of poor and non- poor households is violated in each ecological region and overall, Pillai's trace test is more preferable. The p-value (<0.05) of Pillai's trace test shows that there is significant difference in mean vectors of average time to reach educational centers between poor and non-poor households in each ecological region and overall Nepal.

Tests for equality of mean vectors to reach the education centers between ecological regions

Table 6. Tests of equality of mean vectors of time to reach the education centers between ecological regions.

Statistic	Pillai's Trace	Wilk's Lamda	Hotelling's Trace	Roy's Larget Root
Test statistic	0.066	0.934	0.070	0.068
F-value	41.78	42.42	43.05	83.43
P-value	<0.0001	<0.0001	<0.0001	<0.0001

Since equality of covariance matrices is violated, the less sensitive test Pillai's trace is used. It indicates that there is significant difference (p-value <0.05) in average time to reach the different educational centers across the ecological region.

Comparison of time to reach the health facility centers by poverty status and ecological region

Analysis of mean vectors

In health facility, there are three variables namely time to reach the nearest early health post (X_1), time to reach the nearest public hospital (X_2), and time to reach the nearest clinic/private hospital (X_3).

Table 7. Mean vectors of time to reach health facility centers.

Poverty Status	Mountain	Hill	Terai	Nepal
Poor	$\overline{X}_{MP} = \begin{pmatrix} 59.23 \\ 609.60 \\ 1066.42 \end{pmatrix}$	$\overline{X}_{HP} = \begin{pmatrix} 75.90 \\ 368.41 \\ 277.79 \end{pmatrix}$	$\overline{X}_{TP} = \begin{pmatrix} 34.31 \\ 76.17 \\ 57.68 \end{pmatrix}$	$\overline{X}_{P} = \begin{pmatrix} 57.01 \\ 308.08 \\ 312.87 \end{pmatrix}$
Non-poor	$\overline{X}_{MN} = \begin{pmatrix} 48.34 \\ 371.92 \\ 540.09 \end{pmatrix}$	$\overline{X}_{HN} = \begin{pmatrix} 56.51 \\ 216.11 \\ 178.09 \end{pmatrix}$	$\overline{X}_{YN} = \begin{pmatrix} 27.57 \\ 60.84 \\ 38.50 \end{pmatrix}$	$\overline{X}_{N} = \begin{pmatrix} 42.34 \\ 190.45 \\ 166.85 \end{pmatrix}$
Overall	$\overline{X}_{M} = \begin{pmatrix} 52.29 \\ 506.82 \\ 807.84 \end{pmatrix}$	$\overline{X}_{H} = \begin{pmatrix} 60.78 \\ 306.80 \\ 245.05 \end{pmatrix}$	$\overline{X}_{T} = \begin{pmatrix} 28.82 \\ 74.38 \\ 48.57 \end{pmatrix}$	$\overline{X} = \begin{pmatrix} 45.50 \\ 176.17 \\ 162.43 \end{pmatrix}$

Table 7 of mean vectors indicates that the average time to reach the nearest health centers. In mountain region, the average time to reach the nearest health post is lowest in both groups and which are 59.23 minutes and 48.34 minutes in poor and non-poor households, respectively. The average times to reach nearest public hospital are 609.60 minutes (more than 10 hours) and 371.92 minutes (more than 6 hours) in poor and non-poor households, respectively. In hill region, the average time to reach nearest health post, public hospital and clinic or private hospital in poor households are 75.99 minutes, 368.41 minutes and 277.79 minutes, respectively and these time in non-poor households are 56.51 minutes, 216.11 minutes and 178.09, respectively. Both vectors indicate that the average time to reach public hospital is highest in poor and non-poor households.

In terai region the above mean vectors depicts that the average time to reach nearest health post is lowest and nearest public hospital (more than one hour) is highest in both poor and non-poor households. The each average time of poor households is higher than non-poor households. Overall, the average time to reach the nearest health post is lowest in both non poor and poor households irrespective of ecological region. The average time to reach the nearest hospital (public/private) is greater than three hours in both groups. The average time to reach nearest each health facility center in poor households is higher than the non-poor households. Likewise, in

ecological region, irrespective of poverty status, the average time to reach the nearest health post is lowest. This time is lowest in terai (28.82 minutes) and highest in hill (68.78 minutes). The average time to reach nearest clinic or private hospital is highest in mountain and the average time to reach the public hospital is highest in hill and terai. This is because of in terai and hill there are various clinics in different market centers but the public hospital is located only in district headquarter.

Tests for equality of covariance matrices between poor and non-poor

To test the significance difference in covariance matrices of non-poor and poor households (i.e. $H_o: \sum_n = \sum_P$) to reach the nearest health facility centers in ecological region and overall Nepal, the Box's M test, F-value and p-value are obtained as follows:

Table 8. Box's M test to compare the covariance matrix of time to reach health facility centers.

Region	Box's M	F Value	P value
Mountain	55.68	9.17	<0.0001
Hill	224.52	37.30	<0.0001
Terai	93.56	15.55	<0.0001
Nepal	892.635	148.593	<0.0001

The Box's M value and p value (<0.0001) indicate that the covariance matrices between poor and non-poor households are not equal in three ecological regions as well as in Nepal. (Variance, covariance and correlation of all pairs are provided in Appendix 3 and 4)

Tests for equality of covariance matrices between ecological regions

Table 9. Box's M test to compare the covariance matrix of time to reach health facility centers by ecological regions.

Region	Box's M	F Value	P value
Nepal	14756.52	1226.991	<0.0001

The Box's M test and p-value (<0.0001) indicate that there is a significant difference in covariance matrices of time to reach the nearest health facility centers across the ecological regions irrespective of poverty status.

Tests for equality of mean vectors of average time to reach health facility centers between poor and non-poor in ecological regions and overall Nepal

Table 10. Tests of equality of mean vectors of time to reach the health facility centers.

Region		Pillai's Trace	Wilk's Lamda	Hotelling's Trace	Roy's Largest Root
Mountain	test statistic	0.060	0.940	0.059	0.059
	F-value	5.830	5.830	5.830	5.830
	P-value	<0.0001	<0.0001	<0.0001	<0.0001
Hill	test statistic	0.012	0.988	0.012	0.012
	F-value	7.569	7.569	7.569	7.569
	P-value	<0.0001	<0.0001	<0.0001	<0.0001
Terai	test statistic	0.011	0.988	0.011	0.011
	F-value	8.237	8.237	8.237	8.237
	P-value	<0.0001	<0.0001	<0.0001	<0.0001
Nepal	test statistic	0.017	0.983	0.017	0.017
	F-value	23.14	23.14	23.14	23.14
	P-value	<0.0001	<0.0001	<0.0001	<0.0001

The p-value (<0.05) of all tests show that there is significant difference in mean vectors of average time to reach health facility centers between poor and non-poor households in each ecological region and overall Nepal.

Tests for equality of mean vectors to reach the health facility centers between ecological regions

Table 11. Tests of equality of mean vectors of time to reach the health facility centers in ecological region.

Statistic	Pillai's Trace	Wilk's Lamda	Hotelling's Trace	Roy's Largest Root
Test statistic	0.205	0.804	0.234	0.176
F-value	167.4	169.7	171.9	259.1
P-value	<0.0001	<0.0001	<0.0001	<0.0001

All four tests indicate (p-value < 0.05) that there is significant difference in mean vectors of time to reach the nearest health facility centers across the ecological regions.

DISCUSSION

Access to facility is one major component of human capital, economic development and economic growth. According the Sen (2009) if education makes a person more efficient in commodity production, then this is clearly an enhancement of human capital. This can add to the value of production in the economy and also to the income of the person who has been educated. According to him even with the same level of income, a person may benefit from education, in reading, communicating, arguing, in being able to choose in a more informed way. Likewise he has added that if a person can become more productive in making commodities through better education, better health and so on, it is not unnatural to expect that she can also directly achieve more- and have the freedom to achieve more- in leading her life. In Nepal, various households are deprived from the good education and health facility due to being far education center and health center from their households. Due to lack of road, people are unable to reach health post on time, due to lack of awareness and good education, large number of mothers give childbirth at home which makes maternal mortality, neonatal mortality and under five year child mortality high. Standards of health care are low because clinics are hard to reach and health workers cannot travel easily. Time to reach the nearest health facility centers and education centers is another reason for that.

Various factors of SDG, economic development and growth are associated with education and health. Receiving good education and health are directly associated with infrastructure, equipment, technology, resources, and travel distance. In the context of Nepal and other developing countries, time to reach the education centers and health facility centers are major factors. In order to reduce this, constructing new schools, colleges, health posts and hospitals are not only the important factors but to improve quality, constructing roads to reach facility centers are another important factors. Thus, access to facility means not only making the facility centers but also making easy road to reach there. Discussing about the findings of this study, the average time to reach each education center of poor households is less than non-poor households in each region. Each tests show that there are significant differences in mean vectors between poor and non-poor households in each region. In each region and poverty group, the average time to reach the nearest primary school is lowest and to reach higher secondary school is highest. The average time to reach ECD centers is higher than the average time to reach nearest primary school.

Discussing about the average time to reach the nearest health facility centers, in mountain, the average time to reach the nearest health post is one hour less than in poor than in non-poor households. The average time to reach the nearest public hospital is around 6 hours in non-poor and 10 hours in poor households and which are very high. The average time to reach each health center facilities of poor households is higher than non-poor households and there is significant difference in mean vectors between two groups in mountain. In hill and terai regions, the average time to reach the health post is lowest but the average time to reach the public health post is highest in both groups. It shows that there are various clinic and private hospitals in hill and terai

but not in mountain. There is significant difference in mean vectors of average time to reach the health facility centers between poverty groups in each ecological region.

Regarding economic growth and economic development, human capital is a major component and investment in human capital is essential. Two major components of human capital are education and health. These two factors are also linked with various indicators of SDG. To meet the goals of SDGs on time and to the economic growth: government, INGO, donor agency and private sector should invest in education and health. Still in mountain, hill and various areas of terai region, large number of households require long time to reach the nearest education center and health facility centers due to lack of road, transportation, etc. Building new education centers, health facility centers alone cannot ensure reduction in time to reach there. Construction of roads and infrastructure reduces the time to reach these centers. Consequently, interventions and investment in health, education, nutrition, water, sanitation, income and infrastructure complement each other and play vital role in improvement of SDG and reducing poverty in Nepal.

CONCLUSION

Access to facilities, especially health and education center play vital role in human capital and economic growth. In Nepal, time to reach the nearest education center and health facility is very high. Four variables on education centers and three on health centers are considered. The average time to reach the nearest education centers and health centers varies according to ecological regions and poverty status. Box's M test is used to compare the covariance matrices and four tests are used to compare the mean vectors. Most of the tests are rejected and shows significant differences in mean vectors and covariance matrices.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

ACKNOWLEDGMENTS

REFERENCES

Anderson, T. W. (2004). *An Introduction to Multivariate Statistical Analysis* (3rd ed.). Singapore: Wiley & Series.

Central Bureau of Statistics (2011). *Nepal Living Standard Survey2010/2011. Statistical report, Volume I.* Kathmandu: CBS.

Hardle, W., & Simar, L. (2007). Applied *Multivariate Statistical Analysis* (2nd ed.). New Delhi: Springer.

Johnson, R. A. & Wichern, D. W. (2009). *Applied Multivariate Statistical Analysis* (5th ed.). New Delhi: PHI Learning.

National Planning Commission (2017). *Nepal's Sustainable Development Goals, Baseline Report.* Retrieved from https://www.npc.gov.np/images/category/SDGs_Baseline_Report_final_29_June-1(1).pdf

Sen, A. (2009) Human Capital and Human Capability. *Handbook of Human Development* (pp. 35-37), University Press.

Srinivasu, B. & Rao, P. S. (2013). Infrastructure Development and Economic Growth: Prospects and Perspective. *Journal of Business Management & Social Sciences Research. 2*(1)*,* 81-91. *Retrieved from* https://pdfs.semanticscholar.org/8fcd/6cb961185007b6f929473a716fe588c0ff86.pdf

Tabachnick, B. G., & Fidell L. S. (2018). *Using Multivariate Statistics* (6th ed.). Noida: Pearson.

Thirlwall, A. P. (2011). *Economics of Development* (9th ed.). New Delhi: Palgrave Macmillan.

Todaro, M. P., & Smith S. C. (2016). *Economic Development* (10th ed.), Noida: Pearson. Retrieved from https://www.unicef.org/nepal/education

Weil, D. N. (2009). *Economic Growth* (2nd Ed.). New Delhi: Pearson Education.

World Bank Group (2019). The *Changing Nature of Work, World Development Report.* Retrieved from https://www.worldbank.org/en/publication/wdr2019

APPENDIX

Appendix 1. Correlation between time to reach education centers in poverty status and ecological region.

Ecological Region	Poverty Status	r_{12}	r_{13}	r_{14}	r_{23}	r_{24}	r_{34}
Mountain	P	0.188* (0.027)	0.454** (<0.001)	-0.017 (.844)	0.123 (0.150)	-0.153 (0.073)	0. .309** (<0.001)
	NP	0.586** (<0.001)	0.305** (<0.001)	0.113** (<0.001)	0. 293** (<0.001)	0.070 (0.249)	0.313** (<0.001)
	Overall	0.427** (<0.001)	.359** (<0.001)	0.059 (0.230)	0.248 (<0.001)	-0.022 (0.651)	0.299** (<0.001)
Hill	P	0.557** (<0.001)	0.197** (<0.001)	-0.072 (0.124)	0.171** (<0.001)	0.008 (0.861)	0 .629** (<0.001)
	NP	0.097** (<0.001)	0.051* (0.026)	0.033 (0.149)	0.160** (<0.001)	0.086** (<0.001)	0.294** (<0.001)
	Overall	0.123** (<0.001)	0.063** (<0.001)	0.020 (0.313)	0.168** (<0.001)	0.080** (<0.001)	0.359** (<0.001)
Terai	P	0.163** (0.001)	0.044 (0.350)	0.041 (0.387)	0.303** (<0.001)	0.151** (<0.001)	0.239** (<0.001)
	NP	0.033 (0.138)	0.018 (0.424)	0.026 0.253)	0.089** (<0.001)	0.038* (0.070)	0.241** (<0.001)
	Overall	0.039 (0.052)	0.025 (0.225)	0.030 (0.143)	0.099** (<0.001)	0.045* (0.020)	0.247** (<0.001)
Nepal	P	0.284** (<0.001)	0.140** (<0.001)	0.012 (0.688)	0.250** (<0.001)	0.068* (0.019)	0.571** (<0.001)
	NP	0.069** (<0.001)	0.049** 0.002	0.037** 0.017	0.123** (<0.001)	0.068** (<0.001)	0.296** (<0.001)
** is significant at 0.01 and * is significant at 0.05.; P = Poor; NP = Non-poor							

Appendix 2. Covariance between time to reach education centers in poverty status and ecological region.

Ecological Region	Poverty Status	$\hat{\sigma}_{11}$	$\hat{\sigma}_{12}$	$\hat{\sigma}_{13}$	$\hat{\sigma}_{14}$	$\hat{\sigma}_{22}$	$\hat{\sigma}_{23}$	$\hat{\sigma}_{24}$	$\hat{\sigma}_{33}$	$\hat{\sigma}_{34}$	$\hat{\sigma}_{44}$
Mountain	P	673.5	63.8	445.1	-100.8	171.8	60.7	-463.2	1427.6	2700.0	53591.0
	NP	364.6	158.0	257.1	288.4	199.7	182.7	131.3	1949.4	1843.3	17820.7
	Overall	480.6	129.3	332.63	223.9	190.5	144.6	-53.1	1784.1	2187.2	30007.5
Hill	P	1042.0	362.8	425.4	-601.2	436.4	235.4	43.5	4349.2	11415.5	75723.7
	NP	5409.6	254.6	353.2	377.6	1136.6	486.5	520.2	8182.8	4745.6	31836.0
	Overall	4579.4	279.6	386.2	252.5	1010.0	465.3	513.6	7554.1	6337.6	41195.6
Terai	P	5218.6	142.4	80.0	299.8	152.0	94.6	241.3	642.2	781.6	16661.4
	NP	5065.1	99.1	25.1	96.7	1573.9	67.5	136.3	367.0	412.3	7991.6
	Overall	5091.6	107.2	36.7	137.8	1304.7	73.5	158.3	427.4	502.1	9673.0
Nepal	P	2817.9	252.5	386.8	136.8	299.3	225.4	262.8	2714.8	6651.2	49881.1
	NP	4933.5	182.5	232.9	309.8	1286.5	289.1	348.4	4303.6	2772.7	20401.5
P = Poor; NP = Non-poor											

Appendix 3. Correlation between time to reach health facility centers in poverty status and ecological region.

Ecological Region	Poverty Status	r_{12}	r_{13}	r_{23}
Mountain	P	0.171** (0.049)	-0.051 (0.562)	0.313** (<0.001)
	NP	.173** (0.008)	-0.056 (0.395)	0.438** (<0.001)
	Overall	0.180** (0.001)	-0.026 (0.619)	.391** (<0.001)
Hill	P	0.328** (<0.001)	0.228** (<0.001)	0.638** (<0.001)
	NP	0.349** (<0.001)	0.228** (<0.001)	0.826** (<0.001)
	Overall	0.346** (<0.001)	0.230** (<0.001)	0.784** (<0.001)
Terai	P	0.259** (<0.001)	0.212** (<0.001)	0.945** (<0.001)
	NP	0.071** (0.003)	0.074** (0.002)	0.865** (<0.001)
	Overall	0.111** (<0.001)	0.107** (<0.001)	0.884** (<0.001)
Nepal	P	0.335** (<0.001)	0.168** (<0.001)	0.538** (<0.001)
	NP	0.348** (<0.001)	0.205** (<0.001)	0.746** (<0.001)

** is significant at 0.01 and * is significant at 0.05.

P = Poor; NP = Non-poor

Appendix 4. Covariance between time to reach health facility centers in poverty status and ecological region.

Ecological Region	Poverty Status	$\hat{\sigma}_{11}$	$\hat{\sigma}_{12}$	$\hat{\sigma}_{13}$	$\hat{\sigma}_{22}$	$\hat{\sigma}_{23}$	$\hat{\sigma}_{33}$
Mountain	P	1491.9	5820.2	-2590.7	752713.6	354965.3	1712348.3
	NP	1741.1	3748.1	-2355.0	248249.7	207568.9	903755.5
	Overall	1673.8	4990.5	-1229.8	428113.7	284023.8	1232437.9
Hill	P	4593.4	13898.7	8711.5	363697.5	208404.0	293083.1
	NP	9504.0	19741.6	12501.3	266502.2	212619.9	248461.8
	Overall	8491.7	18878.5	11921.7	288479.3	214083.4	258393.0
Terai	P	890.5	927.7	776.4	12151.4	11607.4	12427.2
	NP	1047.8	254.5	250.7	10117.7	8230.0	8930.5
	Overall	1024.1	399.4	372.40	10535.2	8911.86	9645.81
Nepal	P	3081.1	10623.8	6486.9	289891.3	189386.1	428066.8
	NP	5217.9	11035.7	7215.46	155370.3	128280.6	190043.7
	P = Poor; NP = Non-poor						