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Impact Of Road Connectivity On Daily Livelihood Sustainability Of Commuters In Sandeshkhali-I CD Block, North 24 Parganas, West Bengal, India.

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Abstract:
Background: *The study area has different infrastructural deficiencies with compare to other regions. The natural constraints for communication, Poverty, Infrastructural deficiency, Rurality, and Transportation barriers are the main problems in this region. This study has tried to determine the different road connectivity and their impacts on daily sustainable livelihoods among the commuters of Sandeshkhali-I CD block in North 24 Parganas district of West Bengal, India.*
Materials and Methods: *The study has used the Primary and Secondary data to fulfill the objectives. To execute the objectives, road networks are differentiated to measure the road connectivity indices (Alpha, Beta and Gamma Index) from different Gram Panchayats (GPs) to find out the road network condition in this rural deltaic region of the Indian Sundarban. Using the Random sampling to collect the primary data through questionnaire from commuters at different busiest places in the study area. Based on different selected livelihood components, the daily livelihood sustainability index has been evaluated. To find out the relationship the road connectivity Indices (R.C.I.) and daily livelihood sustainability index (D.L.S.I.) are correlated with the help of Karl Person 'r' value.*
Results: *The highest values of Alpha, Beta and Gamma Indices are 0.34, 1.89 and 0.65 with respect to Metalled and Unmetalled roads. The daily livelihood sustainability index value has been found 54.33 and 17.54 as the highest and lowest respectively. The positive and negative values are present in the correlation between R.C.I. and D.L.S.I.*
Conclusion: *From the outcome, most of the GPs are under the low and very low livelihood sustainability category whereas, the rest of the GPs have medium to high livelihood sustainability status as per selected class. The study concluded that the development needs to be accounted for because of intra-regional imbalance among the road connectivity as well as daily livelihood sustainability that has already existed in this area.*
Keywords: *Road Connectivity Index, Daily Livelihoods Sustainability Index, Metalled Road, Unmetalled Road, Gram Panchayat, Commuters.*

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I. Introduction

The road is a major link to transport the people and freight from one place to another place above the earth's surface. Transportation has a strong influence on the spatial structure at the local, regional and global levels (Rodrigue, 2013). According to the latest road data, the total length of roads in the world is 64,718,646 Km. (Wikipedia, 2024). To road infrastructure, India is now in second position with a total of 67 lakh Km. road length along with 204 Km. per 100 Sq. Km. road density (USCIA, 2024). As a state of India, West Bengal has 92,023 Km. total road length of 103.69 Km. per 100 Sq. Km. (MoF, GoI, 2007). In North 24 Parganas has total road is about 8547 Km. density and the study area has a total road length is about 579.8 Km. (Datta and Sahu, 2021).

The road has played a role in daily commuters towards and return journeys from origin to destination. The daily commuters face many problems in their daily livelihoods due to its geographical location and absence of transport infrastructure. Most of the people are engaged with primary economic sector. The livelihood strategies depend on land capital such as farming and also several dimensions from human capital to financial and social capital (Sati, 2014). Being a part of the Indian Sundarban, Sandeshkhali-I CD block, people are communicating with roads and ferry service transport infrastructure. Out of 08 GPs, 03 GPs are bounded by the river as a deltaic area. As a deltaic region, people are communicate with ferry service and roadways infrastructure in terms of communication as well as economy. Every habitation delta connected with ferry services, is one of the most important transport communication for local people.

The study area has also faced a major problem in communicating with the main streams of society as well as the economy due to its geographical location and lack of infrastructure. The people and commuters or both, who depend on roadways communication as an occupation, have faced different problems in their daily sustainable socio-economic livelihoods. In this area, the natural constraints for communication systems, infrastructure development and infrastructural deficiency, poverty alleviation, rurality, and Transportation problems are the main problems in this region due to its geographical location and some socio-economic factors. In most of the developing countries, the agricultural practices are largely associated with socioeconomic development and livelihood strategies (Sati, 2014).

As per the Sustainable Development Goals (SDGs), infrastructure development, ensuring healthy lives and promoting well-being for all, at all ages, sustainable economic growth, and building resilient infrastructure are very much required in this biotic and naturally constrained region, which has already been taken by the state and central government in different ways. The local government (i.e. Panchayat) has played an important role in shaping the Sustainable Development Goals in this region. The government has been effectively committed to implementing the said SDGs to change towards development.

The study has selected this deltaic rural CD block due to some reasons related to road infrastructure and lack of communication. The Sandeshkhali-I CD block has inter-regional disparities in transport infrastructure. Some GPs are well connected to the nearest urban centre but some have natural constraints to build up the roads. The commuters of 03 GPs have daily faced the ferry as the bulk point of the communication. Only 03 GPs (Bayermari-I & II, Sarberia Agarhati), where state highway is present and 01 GP (Nazat-I) has a district highway and rest of the GPs have no such type of road infrastructure.

II. Study Area:

The study area of selected as Sandeshkhali-I CD block of North 24 Parganas, as well as the Sundarban biotic region (between 22°22 ' N and 22°31 ' N latitude and 88°43 ' 30 " E and 88°55 ' 30 " E longitude) are bounded by Hasnabad and Hingalganj CD blocks in the east, Canning-II and Minakhan in the west, the Minakhan and Hasnabad CD blocks in the north and the Sandeshkhali-II CD block is situated in the south. The study area, Sandeshkhali-I CD block covering an area of 182.30 Sq. Km. with 164465 population and 37344 households (Census of India, 2011). The population density is 900 persons/sq. km. and the sex ratio 960 per 1000 males. This study area has 30.90% Schedule Caste Population and 25.95% Schedule Tribe Population. The literacy rate is 71.08% and Rural Poverty Households is 59.70%. In respect to transport infrastructure, only 04 terminating or originating bus routes are there, 10 ferry service are operating and the nearest railway station situated from 27 Km. away.

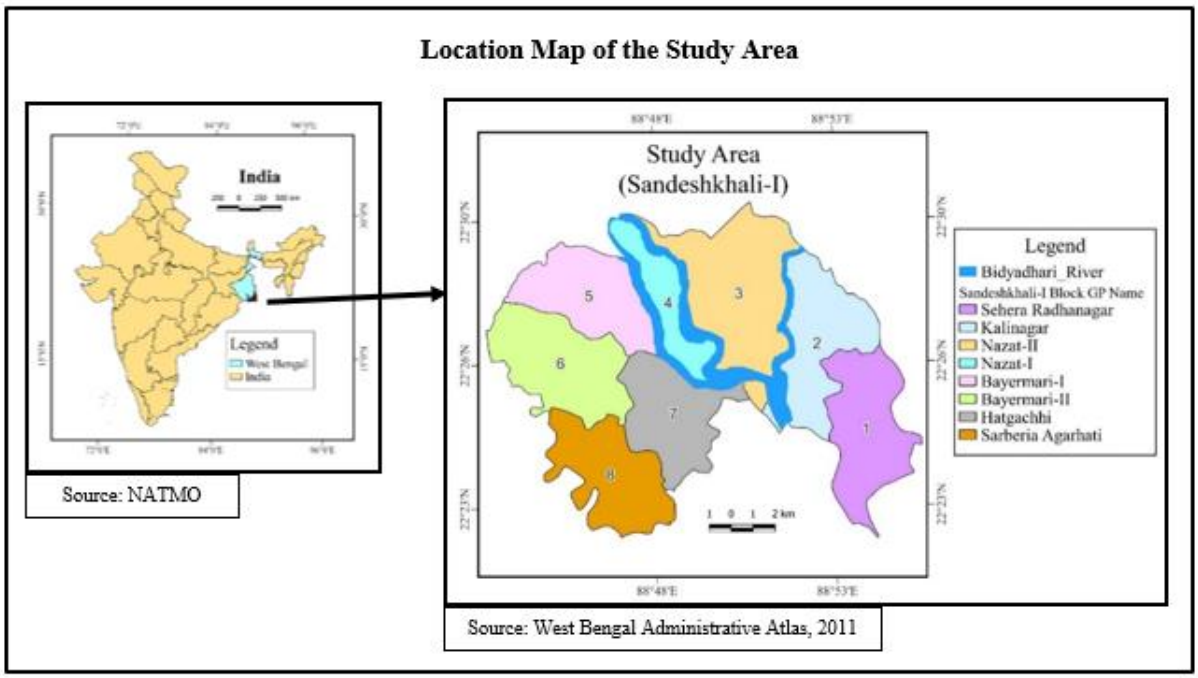

Figure 1: Location Map of the Study Area.

The study area is totally rural deltaic region of Indian Sundarban having low transport infrastructural facilities. Most of the villages are dependent on ferry service as a major mode of communication. The following

table shows the actual number and percentage of the different aspects related to demography, occupation structure and other rural amenities available in the study area as per the census of India, 2011.

Table No. 1: The Different Aspects of the Study Area:

Aspects		Number		Aspects		Percentage
Demography	**Total Inhabited Villages**	30		***Religion***	**Hinduism**	69.19%
	Area in Sq. Km.	182.30			**Islam**	30.42%
	Number of Mouza	30			**Christianity**	0.00%
	Census Town	0			**Others**	0.39%
	Total Population	164465		***Literacy***	**Total Literacy**	71.08%
	Total Number of Households	37344			**Male Literacy**	78.09%
	Population Density/Sq. Km.	900			**Female Literacy**	63.80%
	Sex Ratio	960		***Work Participation***	**Total Workers**	37.09%
	Rural Population	164465			**Nom-Workers**	62.91%
	Urban Population	0			**Cultivators**	13.94%
	Male Population	83925			**Agricultural Labourer**	45.65%
	Female Population	80540			**Households Industry Workers**	3.92%
	Schedule Caste Population	50812			**Other Workers**	36.49%
	Schedule Tribe Population	42674		***Poverty***	**Rural Poverty Households**	59.70%
Education	**Primary School**	87		***Transport***		**Number**
	High School	06			**Ferry Service**	10
	Higher Sec. School	06			**Originating/ Terminating Bus Route**	04
	Degree College	01			**Nearest Railway Station**	27 Km.
Health	**Hospital**	01				
	Primary Health Centre	02				
	Family Welfare Sub Centre	35		Source: Census of India, 2011		

Objectives: The main objectives of the study are as follows:
1. To determine the gram panchayat wise metalled and unmetalled road connectivity in the study area.
2. To measure the daily livelihood sustainability of the commuters.
3. To evaluate the impact of road connectivity on the daily livelihood sustainability of the commuters.

III. Materials And Methods

To execute the objectives of the study, different methods and techniques have been used. The Primary and Secondary Data have been collected from different sources. Primary data has been collected through the questionnaire survey from various places in the study area. The questionnaire survey was done through random sampling from daily commuters in different busiest places of the study area among the target group at a 95% confidence level. The questionnaire survey was done in every GP of the study block from 398 commuters (216 males and 182 females) (Table No. 2). The following places were selected to collect the primary data from the commuters. The secondary data was also collected from the Census of India (2011) for demographic data, metalled and unmetalled road maps are prepared based on Open Street Map (OSM). The following tables shows the sample size collected from different GPs in the study area.

Table No. 2: The Sample Size of the Study:

Gram Panchayat(s)	Place	Male Respondents	Female Respondents	Total
Bayermari-I	Matbari Market	12	14	26
	Khariat	14	09	23
Bayermari-II	Bayermari Market Area	22	17	39
Hatgacha	Kanmari Market	25	18	43
	Rajbari Market	18	12	30
Kalinagar	Kalinagar Market	12	15	27
	Ghoshpur Hospital More	13	16	29
Nazat-I	Baunia Market	11	18	29
Nazat-II	Nazat Market	15	10	25
	Metiakhali Bazar	22	12	34
	Old Nazat Hospital	08	08	16
Sarberia Agarhati	Sarberia Market	24	14	38
Shera Radhanagar	Bholakhali Ferry Ghat	08	11	19
	Chotto Sehara Market	12	08	20
Total		**216**	**182**	**398**

The R.C.I. has been determined based on metalled and unmetalled roads with the following formulae. The individual connectivity index has shown the road connectivity condition of the different GPs of the study block. The graphical representation of the indices have been prepared for metalled and unmetalled roads.

1. Cyclomatic Number (μ): $\mu = e - (v + p)$
   Where, e = Edge, v = Vertex, p = Graph
2. Alpha Index (α): $\alpha = \mu / (2v - 5)$
   Where, μ = Cyclomatic Number, v = Vertex
3. Beta Index (β): $\beta = e / v$
   Where, e = Edge, v = Vertex
4. Gamma Index (γ): $\gamma = e / 3 (v – 2)$
   Where, e = Edge, v = Vertex

The D.L.S.I. of commuters has been determined based on the difference in the mean value between per capita income and expenditure per day (INR) in different (08) GPs of the study area. The livelihood sustainability index has been prepared using the following formula (Sati, 2014). The D.L.S.I. of commuters shows, how commuters are sustain their daily life.

Daily Livelihood Sustainability Index (D.L.S.I.) = X (x1 + x2 + x3) – Y (y1 + y2) =XY

Where, X stands for household income that includes-

x1 = Income from Primary Sector
x2 = Income from Secondary Sector,
x3 = Income from Tertiary Sector
Further, Y stands for household expenditure,
y1 = Expenditure for Basic Needs (Food, Shelter and Clothes)
y2 = Expenditure for Other Needs (Education, Health and Transport)
X –Y is equal to XY, i.e. saving.

The D.L.S.I. has been categorized as per the following classes which indicates the spatial distribution of the actual livelihoods condition in different GPs. With the help of D.L.S.I. category of commuters, spatial distribution map has been prepared based on different GPs level.

Category	D.L.S.I.
Very High	>50
High	40-50
Moderate	30-40
Low	20-30
Very Low	<20

The R.C.I. of metalled and unmetalled roads have been aggregate to each other to get the total values of alpha index, beta index and gamma index. Based on the total value of R.C.I., it is selected as an independent variable and D.L.S.I. of commuters is selected as a dependent variable to determine the relationship between the R.C.I. and D.L.S.I. The correlation has been incorporated through Karl Pearson's 'r' value between R.C.I. and D.L.S.I and shows with the relationship curve. The positive correlation means they are proportional to each other and negative shows the inversely proportional.

IV. Result

The connectivity indices calculated based on edge and vertex of the metalled road and unmetalled road networks with the help of formulae of different indices. In the study area, State Highway (SH-3), district road and village road selected as metalled road. From the Figure No.4, the spatial distribution of metalled road and unmetalled roads are represented in different GPs. Based on this network, the edges and vertices have been found out. The metalled road network has more edges and vertices rather than unmetalled road network. The value of alpha index varies 0.00 to 0.29 in metalled and unmetalled road networks. Whereas, beta index value found 0.93 to 1.27 in metalled road network and 0.00 to 0.66 in unmetalled road network. In case of gamma index, the value observed between 0.32 to 0.44 in metalled road and 0.00 to 0.25 in unmetalled road networks.

Table No. 3: The Connectivity Indices of Metalled Road:

METALLED ROAD							
Block	**Name of the GPs**	**Edge**	**Vertex**	**Cyclomatic Number**	**Alpha Index**	**Beta Index**	**Gamma Index**
Sandeshkhali-I	Bayermari-I	57	47	11	0.12	1.21	0.42
	Bayermari-II	60	54	07	0.07	1.11	0.38
	Hatgacha	74	69	06	0.05	1.07	0.37
	Kalinagar	92	88	05	0.03	1.05	0.36
	Nazat-I	52	56	-03	0.03	0.93	0.32
	Nazat-II	75	79	-03	0.02	0.95	0.32
	Sarberia Agarhati	79	62	18	0.15	1.27	0.44
	Sehara Radhanagar	76	71	06	0.04	1.07	0.37
Source: Computed by Author							

The Connectivity of Metalled Road: The GP wise metalled road connectivity has been carried out and maximum Edges (92) and Vertex (88) are found in Kalinagar GP and the minimum number of edges (52) and vertex (54) are found in Nazat-I GP and Bayermari-II GP respectively. Based on the metalled road the alpha index value is the highest in Sarberia Agarhati GP (0.15) and the lowest alpha index is found in Nazat-II GP (0.02). In case of the beta index, the maximum and minimum values have been found in Sarberia Agarhati GP (1.27) and Nazat-I GP (0.93) respectively. Concerning the gamma index, the maximum value is observed in Sarberia Agarhati GP (0.44) and the minimum value is found in Nazat-I and Nazat-II GPs (0.32) (Table No. 3).

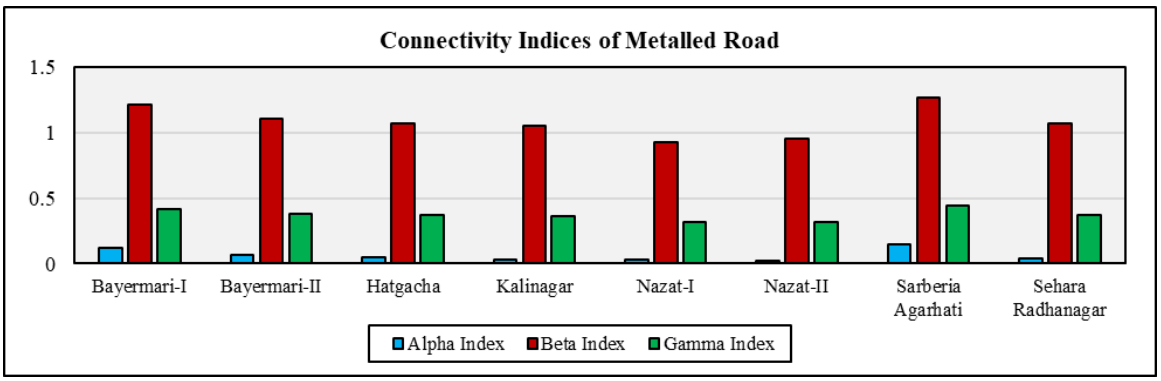

Figure 2: Gram Panchayats Wise Connectivity Indices for the Metalled Road.

Table No. 4: The Connectivity Indices of Unmetalled Road:

UNMETALLED ROAD							
Block	**Name of the GPs**	**Edge**	**Vertex**	**Cyclomatic Number**	**Alpha Index**	**Beta Index**	**Gamma Index**
Sandeshkhali-I	Bayermari-I	00	00	00	0.00	0.00	0.00
	Bayermari-II	21	32	-10	0.17	0.66	0.23
	Hatgacha	04	08	-03	0.27	0.50	0.22
	Kalinagar	03	06	-02	0.29	0.50	0.25
	Nazat-I	01	02	00	0.00	0.50	0.00
	Nazat-II	01	02	00	0.00	0.50	0.00
	Sarberia Agarhati	32	52	-19	0.19	0.62	0.21
	Sehara Radhanagar	03	06	-02	0.29	0.50	0.25
Source: Computed by Author							

The Connectivity of Unmetalled Road: The unmetalled road connectivity is also measured through the different gram panchayats and the highest number of edges (32) and vertex (52) is found in Sarberia Agarhati GP and Bayermari-I GP has the lowest number of edges (00) and vertex (00), where any kind of unmetalled road are not present. The alpha index value found as highest number in Kalinagar and Sehara Radhanagar GPs (0.29). In case of the beta index, the highest value is observed in Bayermari-II GP (0.66). Whereas the gamma index is found as the highest number in Kalinagar and Sehara Radhanagar GPs (0.25). The lowest number of the alpha, beta and gamma index are found in Bayermari-I GP due to the absence of unmetalled roads (Table No. 4).

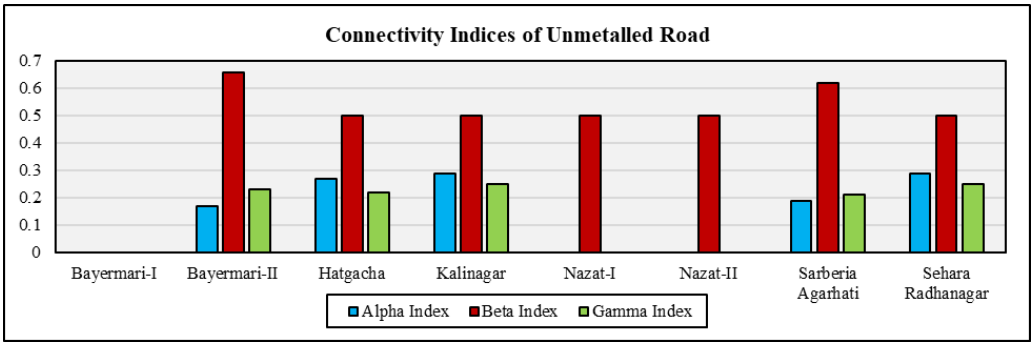

Figure 3: Gram Panchayats Wise Connectivity Indices for the Unmetalled Road.

The Road Connectivity: To find out the road connectivity, the value of alpha, beta and gamma index of metalled and unmetalled roads have been aggregate. In case road connectivity index (metalled and unmetalled) the maximum value of alpha index, beta index and gamma index are found in Sarberia Agarhati 0.34, 1.89 and 0.65 respectively. Whereas the minimum value of alpha index observed in Nazat-II (0.02), beta index found in Bayermari-I (1.21) and gamma index found in Nazat-I & II (0.32) (Table No. -6).

The Daily Livelihood Sustainability Index (D.L.S.I.): Generally commuters use transport facilities in their everyday life for different socio-economic activities. Most people use originating/ transitional bus routes and different ferry services for their daily journey from origin to destination. Some commuters use their vehicles to reach the destination point. The D.L.S.I. has been carried out based on the mean value of daily per capita income and expenditure (INR) of commuters in the different gram panchayat levels. The highest value of D.L.S.I. is found in the Bayermari-II GP (54.33) and the lowest value of D.L.S.I. is found in Sehara Radhanagar GP (17.54) (Table No. 5). So, the commuters are saved their earning as a very low in amount.

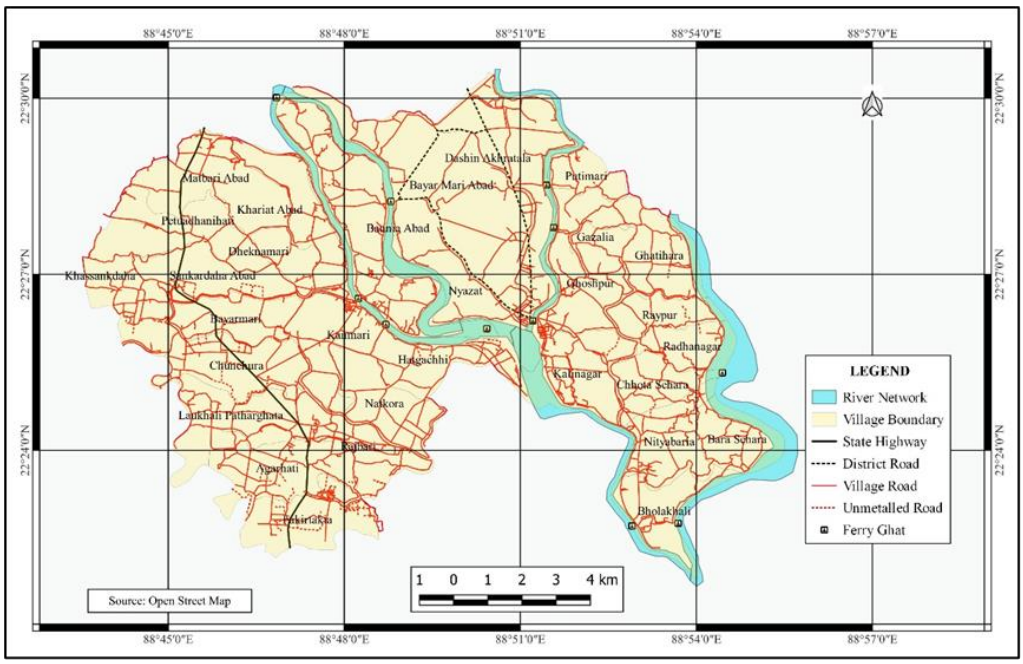

Figure 4: Road and River Network of Sandeshkhali-I CD Block.

Table No. 5: The Daily Livelihood Sustainability Index (D.L.S.I.):

Name of the GPs	Mean							D.L.S.I. (X-Y)	Rank	Category
	X1	X2	X3	X	Y1	Y2	Y			
Bayermari-I	152.56	51.02	41.74	**245.32**	124.17	83.34	**207.51**	**37.81**	**3**	**Moderate**
Bayermari-II	134.93	89.45	45.56	**269.94**	144.23	71.38	**215.61**	**54.33**	**1**	**Very High**
Hatgacha	125.89	52.79	39.17	**217.85**	122.98	66.82	**189.8**	**28.05**	**4**	**Low**
Kalinagar	112.39	56.26	48.6	**217.25**	132.33	64.36	**196.69**	**20.56**	**7**	**Low**
Nazat-I	117.59	46.65	37.46	**201.7**	102.47	78.05	**180.52**	**21.18**	**6**	**Low**
Nazat-II	121.89	85.28	52.77	**259.94**	125.99	84.97	**210.96**	**48.98**	**2**	**High**
Sarberia Agarhati	126.18	61.77	48.37	**236.32**	126.59	82.32	**208.91**	**27.41**	**5**	**Low**
Sehara Radhanagar	127.05	44.49	37.47	**209.01**	122.39	69.08	**191.47**	**17.54**	**8**	**Very Low**
Source: Primary Data, 2023										

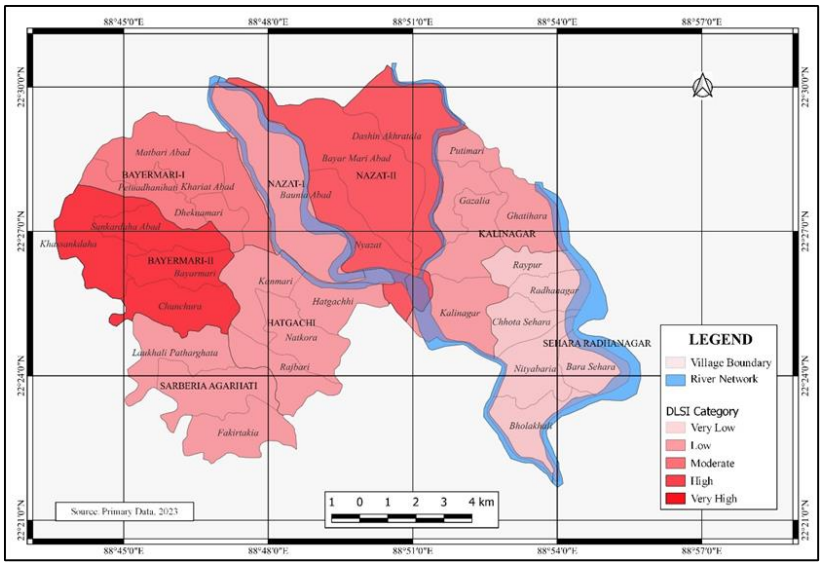

Figure 5: Gram Panchayat wise D.L.S.I. Category of the commuters.

Correlation between R.C.I. and D.L.S.I.: The impact of road connectivity on daily livelihoods has been measured with the value of alpha, beta and gamma index along with the D.L.S.I. The negative relation has been lies between the alpha index and D.L.S.I. in the study area (R-value: -0.390232094). On the other hand, the beta index and D.L.S.I. correlate with a positive value (R-value: 0.030460929). In addition, the Gamma Index and D.L.S.I have a negative relationship (-0.234110955).

Table No. 6: Correlation between R.C.I. and D.L.S.I.:

Name of the CD Blocks	Name of the GPs	R.C.I.			D.L.S.I.	Pearson's 'r' value		
		Alpha Index (A.I.)	Beta Index (B.I.)	Gamma Index (G.I.)		A.I. & D.L.S.I.	B.I. & D.L.S.I.	G.I. & D.L.S.I.
Sandeshkhali-I	Bayermari-I	0.12	1.21	0.42	**37.81**	-0.390232094	0.030460929	-0.234110955
	Bayermari-II	0.24	1.77	0.61	**54.33**			
	Hatgacha	0.32	1.57	0.59	**28.05**			
	Kalinagar	0.32	1.55	0.61	**20.56**			
	Nazat-I	0.03	1.43	0.32	**21.18**			
	Nazat-II	0.02	1.45	0.32	**48.98**			

	Sarberia Agarhati	0.34	1.89	0.65	**27.41**			
	Sehara Radhanagar	0.33	1.57	0.62	**17.54**			
Source: Computed by Author								

V. Discussion

Rural Poverty Households found in Sandeshkhali-I is about 59.70%. In this area, most of the people work in the primary economic sectors. From Table No. 5, it has been found that the commuters are facing daily economic problems in their livelihoods as well as transportation problems due to the very low savings. In this area, commuters have a low income due to the lack of employment. Most of the commuters are workers in primary, secondary and tertiary economic sectors (e.g. agricultural labourers, brick industrial workers, shopkeepers, household workers etc.).

So, based on the D.L.S.I. value, category-I is found at Bayermari-II GP only and D.L.S.I. category-II is found at Nazat-II. Bayermari-I GP falls under the category-III of D.L.S.I. Hatgacha, Kalinagr, Nazat-I and Sarberia Agarhati GPs are under the category-IV. D.L.S.I. category-V is only found in Sehara Radhanagar GP in this CD block. Due to the presence of a state highway and connections to the nearest metro city, the commuters of Bayermari-II GP have to utilize the transport infrastructure in well manner in their daily livelihoods and fall into the very high D.L.S.I. category. The commuters of Nazat-II GP, have benefited from the district highway to communicate in their daily life, the resultant D.L.S.I. is found as a high category. In case of Bayermari-I GP, the state highway plays a role among the commuters, hence the area falls under the moderate D.L.S.I. category. In case of Sarberia Agarhati GP, a state highway is present but commuters have low income, the resultant it has a low D.L.S.I. category. The commuters of Hatgacha GP have no such type of major road infrastructure to communicate to the nearest urban centre and fall into the low category of D.L.S.I. The Kalinagar and Nazat-I GPs are bounded by the Bidyadhari and Dansa Rivers, the commuters have so many problems communicating their daily journey, and hence the low D.L.S.I. category is found. The Sehara Radhanagar GP is also surrounded by rivers, due to this reason, the commuters have taken more time to communicate which also impacts their daily livelihoods, the resultant it has a very low D.L.S.I. category.

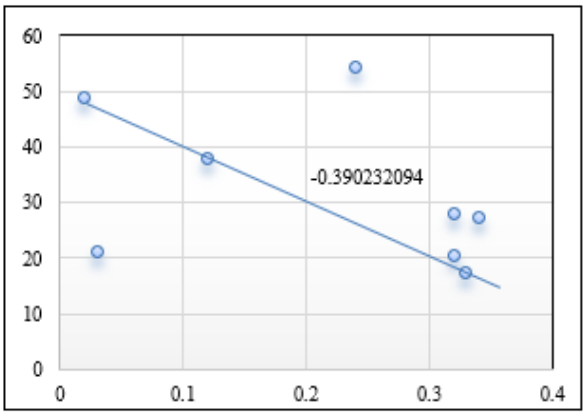

Figure 6: Correlation between Alpha Index and D.L.S.I.

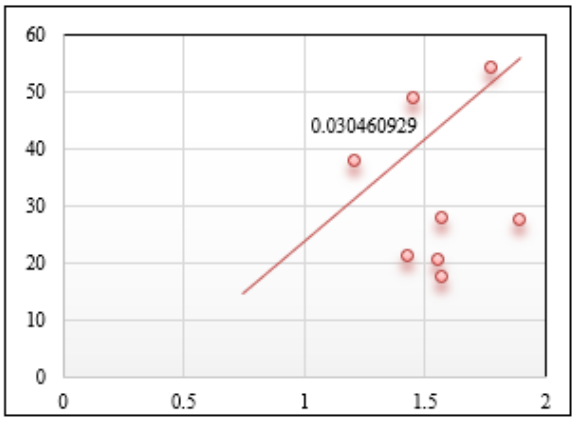

Figure 7: Correlation between Beta Index and D.L.S.I.

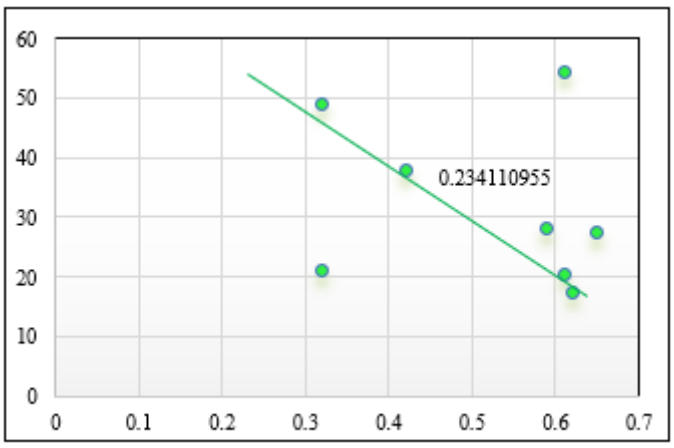

Figure 8: Correlation between Gamma Index and D.L.S.I.

VI. Conclusion

This study is concluded with the view of road connectivity and its relation to the daily sustainability livelihood status of the commuters in the GP level of Sandeshkhali-I CD blocks of North 24 Parganas in West Bengal, India. More or less road infrastructure has low to moderately developed in the GP level of the study area. From the study, it would be concluded that poverty reduction, employment and transport infrastructure development have to be taken into account otherwise, commuters and local people would face different kinds of socio-economic problems in their daily livelihoods. Less communicated GPs, especially Sehara Radhanagr, Kalinagar, and Nazat-I have to give special attention to the development of the different livelihoods and sustainable factors of the commuters as well as residents. It can be said that if the road network is better in the future in this area, the daily livelihood sustainability status of the commuters and local people would be increased. So road networks have a great role on commuters in respect to the daily livelihood status in this natural constraints rural deltaic region of the Indian Sundarban.

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