State of Road and Transport Networks in Sikkim

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Abstract

Transportation infrastructure is one of the important factors for the growth and development of an economy. In the Himalayan region like Sikkim, a good quality road network can help in reducing isolation and economic vulnerability as it is the only mode of transport in the region. Using primary and secondary data, this paper analyzed the inter - district and inter – organizational performance of the road networks in Sikkim. By employing the principal component analysis technique, we found that the East Sikkim district outperformed the other districts in the state. Of the four indices employed, the "system condition and preservation," which includes six physical components of road quality, turned out to be the best. Though the road density was not found to be very high, the average physical condition of the roads available in the state turned out to be quite impressive. However, the inter-district variation, in terms of vehicle density, was found to be quite high, concentrated mainly in the capital city.

Keywords : **development, road density, vehicle density, Sikkim, transport**

JEL Codes : R1, R40, R420

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Transportation infrastructure is considered as one of the important factors for the growth and development of an economy. It encompasses four different modes such as – rail, air, road, and water transport. Within the broader transportation infrastructure, road transportation is very important in the hill areas as other modes of transport are either absent or limited. The road transport consists of three basic elements – road, vehicle, and human. A well-developed transport infrastructure saves time and cost of the network users and consequently enhances economic performance (Skorobogatova & Kuzmina-Merlino, 2017). A study conducted by The World Bank indicated that a 10% increase in transport infrastructure led to a 1% increase in economic growth in the long run (The World Bank, 2012). As the road network occupies a major share of the transport infrastructure, it plays an important role in the economic development activities by enhancing logistic systems and connectivity, especially the unconnected and inaccessible regions of our country. A study by Panda and Mishra (2018) found that the growth in state highways subsequently led to an increase in national highways, and the growth in national highways further led to an increase in the gross capital formation of the region. Another study conducted in Ethiopia by Sanfilippo and Sundaram (2018) showed that trade liberalization might boost firm productivity in developing countries only when there is better road accessibility. It further elaborated that the farms located in the regions where there was better road connectivity happened to increase their productivity with a reduction in input

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tariffs that came along with the trade liberalization. Global market competition has made the existence of efficient road transport and logistics systems as an absolute imperative in the delivery chain (Ministry of Road Transport and Highways, Government of India, 2010). As compared to other modes of transportation, the movement of passenger and freight over the years has increasingly shifted towards road transport. For instance, in 2011–12, the roads and railways together contributed about 86% of the total passenger traffic in India, and the corresponding figure for freight movement by road network stood at 64.5% during the same period (Ministry of Road Transport and Highways, Government of India, 2013). Most of the developing countries are still facing an inadequate supply of basic services like – health, education, market, and employment. Speedy delivery of these services primarily depends on the transport infrastructure, especially the road network. In the hilly and mountainous regions, a good quality road network helps in reducing the isolation and economic vulnerability of the population (Shrestha, 2013).

Sikkim, the erstwhile independent Buddhist kingdom – located in the eastern Himalayas – merged with the Indian Union on May 16, 1975, and became the 22nd and the second smallest state in the country. This landlocked hilly state covers an area of 7096 sq. km., with a population of 6.11 lakhs (as per the 2011 population census). The state is divided into four districts : East, west, north, and south. Around 50% of the state's boundary is shared with international borders with China toward the north and northeast, Bhutan to the southeast, Nepal to the west, and a small portion of the Darjeeling – Kalimpong region of the West Bengal state of India to the south. The Bhutia, Lepcha, and Nepali are the major communities living in the state. The tourism sector, which provides employment to around 7% of the state's population directly or indirectly and contributed revenue of 8% to GSDP in 2016 – 17, mainly depends on the road transport (Department of Tourism and Civil Aviation, Government of Sikkim, 2018). There is no rail, water, and air[1] connectivity in Sikkim till toady. Connecting rural and urban areas with an adequate and modern state-of-the-art road network will boost Sikkim's tourism sector and the organic mission, for which the state is known to the world.

Objectives and Methodology

The study centers on the inter-district road network analysis in Sikkim. While doing this, the quantity and the quality of roads have been assessed. Nevertheless, the specific objectives of the study are :

- To assess the growth and trend of the road network in Sikkim,
- To compare and contrast different dimensions of the road network maintained/constructed by different agencies/organizations in Sikkim, and
- To measure inter-district and inter–organizational performance/quality of the road network in Sikkim.

Both primary and secondary data were employed in this study. The primary data were collected using a well-structured schedule for the field survey and was conducted in the month of November – December 2018. The sample consisted of 40 Black Top (BT) roads (5 roads each from the R&B and PMGSY) in four districts of the state [40 roads = (5 PMGSY + 5 R&B in every district) × 4 districts]. The secondary data were majorly drawn from the Department of Road and Bridges (R&B) and the Pradhan Mantri Gramodaya Sadak Yojana (PMGSY). Data were also gathered from other agencies like the Border Roads Organization (BRO) and the National Highways & Infrastructure Development Corporation Limited (NHIDCL). Simple descriptive statistics were

[1] Airport (Pakyong Greenfield Airport near Gangtok) opened at the end of 2018. However, right after its inauguration, operation of flight services got suspended due to technical issue (VFR). Of course, there is chopper service from Gangtok to Bagdogra.

employed to analyze the growth and trend of the road network in Sikkim. However, to measure quality and quantity performance, the principal component analysis (PCA) technique was employed. The index values constructed by using PCA were used to make the inter - district and inter – organizational comparison. Finally, to understand inter–dimensional and inter – component (variables within the dimension) relations, a simple correlation technique was also employed.

Analysis and Results

Road Network in Sikkim

Till 2012, the total road length available in Sikkim was 5616 km excluding Jawahar Rojgar Yojna (JRY) roads (ENVIS Centre on Himalayan Ecology, G.B. Pant Institute of Himalyan Environment & Development, 2015). In 2015, it rose to 7450 km (Ministry of Statistics and Programme Implementation, Government of India, 2017) that includes surfaced and non-surfaced roads (Table 1).

In terms of the compound annual growth rate (CAGR), the road network growth rate in Sikkim has been quite impressive, registered at 26% over the period from 2008 – 2015. There has been a significant jump in the growth

Table 1. ***Road Length under Different Agencies in Sikkim (in km)***

Types	Year	2008	2009	2010	2011	2012	2013	2014	2015	CAGR
NH*	Surfaced	62	62	62	62	149	149	149	309	-
	Non-Surfaced	-	-	-	-	-	-	-	-	-
	Total	**62**	**62**	**62**	**62**	**149**	**149**	**149**	**309**	**25.58**
SH	Surfaced	179	179	179	179	179	179	179	701	-
	Non-Surfaced	-	-	-	-	-	-	-	-	-
	Total	**179**	**179**	**179**	**179**	**179**	**179**	**179**	**701**	**12.05**
PWD**	Surfaced	1145	1292	1388	1388	1228	1228	1308	697	-
	Non-Surfaced	453	478	478	508	722	764	642	718	-
	Total	**1598**	**1770**	**1866**	**1896**	**1950**	**1992**	**1950**	**1415**	**–0.17**
RR	Surfaced	-	-	-	-	2401	3343	3129	3890	-
	Non-Surfaced	-	-	-	-	-	-	874	890	-
	Total	**-**	**-**	**-**	**-**	**2401**	**3343**	**4003**	**4780**	**25.18**
UR	Surfaced	29	41	67	160	160	131	133	134	-
	Non-Surfaced	-	-	-	2	2	2	14	14	-
	Total	**29**	**41**	**67**	**162**	**162**	**133**	**147**	**148**	**26.66**
PR	Surfaced	3	3	3	3	745	745	95	95	-
	Non-Surfaced	2	2	2	2	30	29	2	2	-
	Total	**5**	**5**	**5**	**5**	**775**	**774**	**97**	**97**	**94.20**
Total Road in Sikkim		**1873**	**2057**	**2179**	**2304**	**5616**	**6570**	**6525**	**7450**	**26.34**

Source : Ministry of Statistics and Programme Implementation, Government of India (2017).

Note. As of March 31 of every year ; NH - National Highways are maintained by the Border Roads Organization (BRO), SH - state highways, PWD - Other public work department, RR- rural road, UR- urban road, and PR- project road.

*Till 2014, NH length was 149 km single lane, and in 2015, a total of 30 km double lane was added.

**PWD and R&B are the same, so they may be interchangeably used throughout this paper.

Table 2. ***District - Wise Area, Population, and Road Density (as per 2011 Census)***

District	East	North	South	West	Sikkim
Area (in sq. km.)	954	4226	750	1166	7096
	(13.44)	(59.55)	(10.57)	(16.43)	(100)
Population (in Lakh)	2.84	0.44	1.47	1.36	6.11
	(46.45)	(7.16)	(24.05)	(22.35)	(100)
Road Length (in '000 km)*	1.16	0.30	1.34	1.34	4.14
Road Density (Land)[#]	1.22	0.07	1.78	1.15	0.58
Road Density (Population)[@]	4.11	6.82	9.10	9.81	6.78

Note. Figures given in the parentheses are % of the state's total ;* the roads maintained by PWD and PMGSY; [#]road length in km/sq. km of geographical area ; [@] road length/1000 population.

trend after 2011. This indicates that the road network development in the state was ramped up in the recent past, especially after 2011. Of the different types of roads, the highways (NH and SH) in the state are exclusively surfaced, and the total length of the NHs in the state increased from 309 km in 2015 to 463 km in 2016 (Ministry of Statistics and Programme Implementation, 2017). According to a local daily (Sikkim Express, 24 March 2018), the total length of NH in Sikkim (as of March 2018) stood at 492 km. Out of this 492 km of NH, 351 km was declared as New National Highways after 2014, mainly to improve road connectivity in the state. In 2015, out of the total road length available in Sikkim, 64.16% of the roads turned out to be rural roads. A very limited share of double–lane roads were found in Sikkim, probably due to the state's geographical condition.

Table 2 depicts that only 7.16% of the state's population lives in the North district with 60% of the total geographical area. On the other hand, 46.45% of the state's population is found to be concentrated in the East district, the state's 13.44% of land area. With regard to the road length, the South and West districts have more or less the same length of roads with 1336.32 km and 1338.85 km, estimated at 1.78 km and 1.15 km of road per sq. km of land area, respectively. In the case of North district, 0.07 km of road per sq. km of the land area was found, compared to 0.58 km of road per sq. km. of the state as a whole. In the East district, it was 1.22 km of road per sq. km of land area. The same is true for the road density (in terms of population) in East district, having 4.11 km of road per 1,000 population compared to 6.78 km of road per 1,000 population in the state as a whole.

With reference to the vehicle density of motor vehicles, as on March 31, 2012, a total of 43,334 registered motor vehicles were found on 5,616 km of roads in Sikkim. Of these, 14,306 were registered transport vehicles,

Table 3. ***Vehicle Density (No. of Registered Vehicles per sq. km of Road) in Sikkim***

Year	Regt. Vehicle (in No.)	Road Length (in km)	Vehicle/km of Road
2008	26025	1873	14
2009	28551	2057	14
2010	33626	2179	15
2011	38783	2304	17
2012	40814	5616	7
2013	42952	6570	7
2014	45202	6525	7
2015	47569	7450	6
CAGR	**9.09**	**26.34**	**--**

Note. Vehicle density implies registered vehicles per km of road.

and 29,028 were registered non-transport vehicles (Central Statistics Office, Ministry of Statistics and Programme Implementation, 2014). Sikkim being a frontier state, bordering China, a large number of military heavy vehicles and artillery-laden trucks are found to be plying on the roads of Sikkim. However, the estimation of its exact number is beyond the reach of this present study. From Table 3, we can see the vehicle density (number of registered vehicles per sq. km of road) in Sikkim. In 2008, a total of 26,025 registered vehicles (excluding military vehicles) were found in Sikkim, and the figure rose to 47,569 in 2015, estimated at a 9.09% growth rate (CAGR) during the period. In terms of road length, a total of 1,873 km of roads were found in Sikkim in 2008, and the figure rose to 7,450 km in 2015, estimated at 26.34% of growth rate (CAGR) during the period. This indicates that the growth rate of the road network was much higher than that of the vehicle growth rate. In terms of the density of vehicles (excluding army vehicles), in 2008, around 14 registered vehicles were found on per km of road in Sikkim, but it got reduced to around six vehicles per km of road in 2015. This further indicates that the pace of road construction work in the state has been very rapid in the recent past.

Table 4 depicts district-wise road length, number of vehicles, and vehicle density in 2018 in Sikkim. Of the districts, 70% of the state's total vehicles in 2018 were found in East Sikkim district. Barely 5% of the total vehicles of the state were found in North Sikkim district, 10% in West Sikkim, and 15% in South Sikkim district. In terms of road length (excluding NHs), 31% of the total roads were found in East Sikkim district, followed by 29% each in South and West Sikkim districts. Despite the North Sikkim district being the largest district in terms of the land area (60% of the state's total land area), hardly 11% of the total road length was found in 2018. In terms of vehicle density, East Sikkim district registered the highest, with 29 registered vehicles per km of road, which is much higher than that of the state average of 13 registered vehicles per km of road. However, the vehicle density in the other three districts was very small, registered at seven vehicles, six vehicles, and four vehicles per km of the road network for the South, North, and West districts, respectively.

Table 4. ***District-Wise Registered Vehicles, Road Length, and Vehicle Density in 2018***

Number	East	West	North	South	Total
Private 4 Wheeler	19545	2941	1078	5079	28643
Private 2 Wheeler	4638	330	242	626	5836
Govt. 4 Wheeler	2522	185	107	231	3045
Govt. 2 Wheeler	161	12	15	31	219
Local Taxi	6575	555	232	537	7899
Contract Carriage	3223	938	529	1027	5717
Tourist Luxury Taxi	865	175	84	188	1312
Bus	391	28	10	64	493
Tractor & Trailers	122	27	39	33	221
Ambulance	143	5	11	12	171
Goods Carriage	3423	742	655	1069	5889
Total (in No.)*	**41608**	**5938**	**3002**	**8897**	**59445**
	(70)	(10)	(05)	(15)	(100)
Road Length (in km)**	1455	1339	510	1336	4640
	(31)	(29)	(11)	(29)	(100)
Vehicle Density***	**29**	**4**	**6**	**7**	**13**

Note. Figures in the parentheses are percents of the corresponding total.

*Total registered vehicles as of March 31, 2018, **Summation of R&B Department, PMGSY and BRO roads only, ***Number of registered vehicles per km of road length.

When we further calculate from Table 4, around 70% of the vehicles in 2018 were found in East Sikkim district alone. Of the total private four-wheelers, 68.24% of the four - wheelers were found in the East Sikkim district and 3.76% in the North Sikkim district. Again, out of the total government four-wheelers, 82.82% and 3.51% of government four-wheelers were found in East Sikkim and North Sikkim districts, respectively. The same is true for the four-wheelers plying as local taxis. In 2018, a total of 83.24% of the registered four-wheeler local taxi vehicles were found in East Sikkim district alone. This indicates a significant inter-district variation in the state in terms of vehicle density and government institutions.

Roads under Different Organizations/Agencies

As mentioned above, roads in Sikkim are constructed and maintained by different organizations – the R&B department, the PMGSY, the BRO, and the National Highways & Infrastructure Development Corporation Limited (NHIDCL). Major national highways in the state are primarily constructed and maintained by the three organizations – the BRO, the NHIDCL, and the state's Roads & Bridges Department. Of the NHs passing through the state, NH-10 from Rangpo (town of Sikkim bordering West Bengal) to Zero points, Gangtok (41 km stretch) is considered as the lifeline of Sikkim. Of course, there have been some overlapping reports of the road network among the agencies.

Table 5 depicts district–wise roads under different agencies. Of the total road network (4640.18 km in 2017), around 50% of the total road length came under the R&B Department. It is followed by PMGSY with 39%, which looks after the rural roads. Around 11% of the total road networks of the state were maintained by the BRO, which looks after the NHs and SHs. In the North and East Sikkim districts, around 42% and 20%, respectively of the state's road network came under the purview of BRO. In East Sikkim district, the district's total roads were maintained more or less equally with 40% by the PMGSY and R&B/PWD. In the West district, around 58% and 42% of the total roads came under the R&B Department and PMGSY, respectively ; while in the North district, the share was 20% and 38% between the R&B Department and PMGSY, respectively.

Table 6 reveals that around 45% of the total length of NHs was being maintained by the R&B Department of the state, followed by the BRO with 38%. As mentioned above, NHIDCL has started working in Sikkim very

Table 5. ***District-Wise No. of Roads and Length (in km) Under Different Agencies in 2017****

Districts	R&B		PMGSY		BRO		Total	
	Number	Length	Number	Length	Number	Length	Number	Length
East	113	588.98	110	575.71	17	289.95	240	1454.64
	(47.08)	(40.49)	(45.83)	(39.58)	(7.08)	(19.93)	(100)	(100)
West	122	779.35	104	559.50			226	1338.85
	(53.98)	(58.21)	(46.02)	(41.79)	-	-	(100)	(100)
South	140	838.44	104	497.88	-	-	244	1336.32
	(57.38)	(62.74)	(42.62)	(37.26)			(100)	(100)
North	52	101.75	44	196.28	8	212.34	104	510.37
	(50.00)	(19.94)	(42.31)	(38.46)	(7.69)	(41.61)	(100)	(100)
Total	**427**	**2308.52**	**362**	**1829.37**	**25**	**502.29**	**814**	**4640.18**
	(52.46)	**(49.75)**	**(44.47)**	**(39.42)**	**(3.07)**	**(10.82)**	**(100)**	**(100)**

Source : Authors' estimation from R&B, RMDD, Govt. of Sikkim, and BRO, Gangtok.

Note. Figures in the parentheses are the percent of the total.

*This does not cover the roads under NHIDCL, Project Roads, Municipal Roads, and Army Roads.

Table 6. ***Share of NHs and SHs in Sikkim under Major Agencies (Length in km) in 2017***

Organization	NH	SH
BRO	151.93	350.36
	(38.99)	(34.57)
R&B/PWD	176.78	663.09
	(45.36)	(65.43)
NHIDCL	61.00	--
	(15.65)	
Total	**389.71**	**1013.45**
	(100)	**(100)**

Source : Authors' estimation from the NHIDCL, BRO, and R&B Department, Govt. of Sikkim.

Note. Figures in the parentheses are the percent of the total.

recently and has completed 61 km of NH work in 2017, which was estimated at 16% of the total length of NH in the state.

Table 7 depicts the details of the urban roads maintained by different agencies in Sikkim. The total length of the urban roads in the state, which includes the roads under military and municipal corporations, were found to be fluctuating over the years from 2008 – 2015. As the state borders with three international boundaries and understanding the need for the presence of military and central security forces in the state, many roads found to be directly managed by the Military Engineering Services (MES) was quite small, estimated as 14 km in 2015. The NH-310 connecting Gangtok to Nathu-La pass in the East district, estimated at around being a 56 km road, is being maintained by BRO under the project *Swastik,* but is mainly used by the military services, barring few tourist vehicles. Though the road directly maintained by the MES was very small, a large number of roads were found to be maintained by the BRO and mainly used for military purposes.

With respect to the total road length under the municipality council in Sikkim, a quantum jump was witnessed after 2011 (Table 7). Till 2008, hardly 12 km of roads were found under the municipality council, which rose to 38

Table 7. ***Urban Roads in Sikkim (Length in km)***

Year	Type	Military Engineering Services	Municipality Roads	Total
2008	Surfaced	17	12	29
	Non-Surface	0	0	0
	Total	**17**	**12**	**29**
2009	Surfaced	29	12	41
	Non-Surface	0	0	0
	Total	**29**	**12**	**41**
2010	Surfaced	29	38	67
	Non-Surface	0	0	0
	Total	**29**	**38**	**67**
2011	Surfaced	29	131	160
	Non-Surface	0	2	2
	Total	**29**	**133**	**162**
2012	Surfaced	29	131	160
	Non-Surface	0	2	2

	Total	**29**	**133**	**162**
2013	Surfaced	0	131	131
	Non-Surface	0	2	2
	Total	**0**	**133**	**133**
2014	Surfaced	0	133	133
	Non-Surface	14	0	14
	Total	**14**	**133**	**147**
2015	Surfaced	0	134	134
	Non-Surface	14	0	14
	Total	**14**	**134**	**148**

Source : Ministry of Statistics and Programme Implementation (2017).

Note : As on March 31 of every year.

km in 2010. However, in 2011, a total of 133 km of roads came under the municipality and further rose to 148 km in 2015. This was mainly because many roads in the city were brought under the municipal council, and the Gangtok Municipality Area itself was expanded from 3.5 sq. km to 19.01 sq. km in 2010.

Roads under R&B Department and PMGSY

As depicted in Table 5, the R&B and PMGSY shared around 50% and 39% of the state's total road network, respectively. The two organizations – R&B and PMGSY have been considered as the major players in maintaining the road network in Sikkim. As also mentioned above, the terms R&B and PWD may be used interchangeably throughout this study. The PMGSY programme was taken up by the Rural Management & Development Department (RMDD), Government of Sikkim, and these two may also be used interchangeably in this study.

Table 8 depicts district - wise roads under the R&B department as of January 2018. Of the total roads maintained by the PWD/R&B in the state, around 47% were major district roads (MDR), followed by 29% of state highways (SHs). In the third and fourth positions, around 17% of ODR and 8% of NH, respectively were maintained by the R&B Department in Sikkim. This indicates that PWD/R&B still covers major roads' share in

Table 8. ***District-Wise Roads under R&B Department (as in Jan 2018, Length in km)***

		NH	**SH**	**MDR**		**ODR**	**All Roads**		
Districts	**BT**	**BT**	**BT**	**WBM**	**Earthen**	**BT**	**WBM**	**Earthen**	**Total**
North	0.00	0.00	25.21	5.00	37.56	20.55	1.32	12.77	102.41
East	38.00	203.73	140.80	24.48	79.68	41.94	4.00	55.82	588.45
South	124.00	197.50	248.12	0.00	99.99	23.21	0.00	145.49	838.31
West	14.78	261.86	172.04	3.51	248.87	22.28	0.00	56.01	779.35
Total	**176.78**	**663.09**	**586.17**	**32.99**	**466.1**	**107.98**	**5.32**	**270.09**	**2308.52**
G. Total	**176.78**	**663.09**		**1085.26**			**383.39**		**2308.52**
	(7.66)	(28.72)		(47.01)			(16.61)		(100)

Source : Department of Road and Bridges, Govt. of Sikkim.

Note. Figures given in the parentheses are the percent of the total.

BT = Black Top, WBM = Water Bound Macadam, NH = National Highways, SH = State Highways, MDR = Major District Roads, and ODR = Other District Roads.

Sikkim. Of the different types of roads under the ODR, the share of WBM roads has been very minimal, found in North district and South district only. No WBM roads are found in the South Sikkim district. Similarly, in West Sikkim and South districts, no WBM roads are found under the ODR category. Within the different categories of roads, especially under the MDR and ODR, the length of earthen roads outnumbered other types like BT and WBM. Understandably, the NHs and SHs under the R&B Department were mainly black - topped (BT) roads, though all were not double-lane. In totality, as on January 1, 2018, the total length of BT roads under the R&B Department stood at 1534.02 km, WBM roads at 38.31 km, and earthen roads at 736.19 km. Within the districts, South Sikkim district covered around 36% of the total roads under the R&B Department and 70% of the total NHs (under this organization) were found to be passing through this district. No highway (NH and SH) was found under the North Sikkim district understandably as this district is the biggest and mostly covered with snow at the bottom in terms of the road network.

Table 9. ***District-wise Roads under PMGSY (as in Jan 2018, Length in km)***

District	BT	WBM	Earthen	NC(S-1)	Total
East	453.65	--	2.50	119.56	575.71
North	105.16	2.00	--	89.12	196.28
South	373.20	--	--	124.68	497.88
West	453.54	--	--	105.96	559.50
Total	1385.55	2.00	2.50	439.32	1829.37
	(75.72)	(0.10)	(1.37)	(24.01)	(100)

Source : PMGSY

Note : NC (S-I) are those roads which are sanctioned recently and are under progress.

Figures given in the parentheses are the percent of the total.

The roads under the RMDD/PMGSY were exclusively rural roads (Table 9). Of the total roads under PMGSY, around 76% were black-topped roads. The WBM and earthen roads under the RMDD in Sikkim were minimal, estimated as 0.10% and 1.37%, respectively. The largest share of BT roads under PMGSY was found in East and West districts with around 33% each. In terms of the new roads (NC-S1) sanctioned under this organization, all the four districts were more or less equally distributed. In totality, at present, around 24% of new roads (under construction) have already been taken up by this organization. Nevertheless, as shown in Table 5, the contribution of PMGSY to the road network in Sikkim has been very significant, estimated to be around 39% of the total road network in Sikkim.

Cost and Expenditure on Road Network

A brief discussion is made here on the cost of construction, maintenance cost, and sanctioned costs of the roads. Budget and expenditure patterns roughly indicate the performance of any scheme or organization. It was also witnessed that many of the Centrally funded programmes were not completed within the stipulated time, and funds were often returned to the Centre. Therefore, to understand the performance of the road network in Sikkim, budget and expenditure trend over the years has been depicted in Table 10, albeit it is not the only means. District-wise costs and expenditures on road networks under PMGSY road analysis are also presented in Table 11.

From Table 10, we can estimate that the budget expenditure growth trend stood at 50% over 4 years in Sikkim. However, the budget outlay growth rate was estimated at 37% from 2010 – 2013 and the growth rate of the

Table 10. ***Road Length, Budget, and Expenditure in Sikkim***

Year	Road Length (in km)	Budget Outlay (in Lakhs)	Expenditure (in Lakhs)
2010	4420	7708.35	7708.35
2011	4630	7433.51	5418.68
2012	5616	10635.28	19080.31
2013	6570	19456.50	19456.50
CAGR	**14.82**	**36.83**	**49.73**

Source : ENVIS Centre on Himalayan Ecology, G.B. Pant Institute of Himalyan Environment & Development (2015).

Note. Outlay and expenditure are for roads and bridges in Sikkim ; Expenditure is out of the total Outlay.

road length in the state increased by 15% in the last 4 years. After 2011, the expenditure made on roads increased significantly, estimated at 252% from 2011 – 2012, compared to a 43% rise in the budget outlay during the same period.

The number of roads and their maintenance work done under the Department of R&B, Government of Sikkim

Table 11. ***District-Wise PMGSY Sanctioned Cost (₹ in crore)***

Year	East	West	South	North	Sikkim
2000	0.17	0.00	0.00	1.66	1.83
2001	4.66	4.66	3.80	1.66	14.78
2002	4.29	4.66	3.80	1.66	14.40
2003	4.66	4.66	3.80	1.66	14.78
2004	4.66	5.48	7.62	2.83	20.59
2005	12.79	19.70	17.46	1.71	51.65
2006	8.87	31.63	28.90	3.49	72.89
2007	18.07	34.38	33.35	5.88	91.68
2008	28.24	57.70	48.20	5.88	140.02
2009	56.07	74.99	86.43	4.71	222.20
2010	55.03	63.56	106.60	4.34	229.54
2011	99.27	65.91	115.70	3.39	284.26
2012	125.91	76.56	125.81	12.27	340.55
2013	158.97	71.98	131.48	19.16	381.58
2014	151.34	62.04	108.83	26.90	349.11
2015	189.27	164.40	116.29	51.50	521.46
2016	179.13	164.70	192.24	52.89	588.96
2017	215.05	193.88	146.54	41.62	597.09
2018	194.43	181.37	132.88	34.73	543.42
Total	**1510.89**	**1282.26**	**1409.71**	**277.92**	**4480.77**
CAGR	**37.60**	**25.78**	**27.16**	**23.71**	**31.88**

Source : Authors' estimation from PMGSY.

has been very volatile over the years. It is primarily due to the responsibility of maintenance works of the roads that were often shifted from the R&B to other organizations. For instance, from 2000 – 01, most of the rural roads, which were under the PWD, if not all, have been handed over to PMGSY for maintenance. The PMGSY's work is mostly confined to the rural roads. On the other hand, no work has been handed over by PMGSY to other organizations for maintenance.

From Table 11, we can see that the growth rate of sanctioned cost for road networks under the PMGSY programme since 2000 has been spectacular, increasing at 32% till 2018. Looking at the district-wise sanctioned cost under PMGSY ; understandably, East district recorded the highest growth rate from 2000 – 2018, estimated as a 38% growth rate. In the case of other districts, the growth trend of sanctioned cost progressed more or less from 24% to 27%.

Quality/Performance of Roads in Sikkim

The main purpose of measuring the quality of the road network is to improve transportation services that include goods and passenger traffic. Using different components, Chakrabartty and Gupta (2015) compared the public transport performance of the Calcutta State Transport Corporation (CSTC) with other services of the major metro cities in India, and the CSTC was found to be weaker in terms of technical efficiency. This does not mean that the road network in Kolkata is weak. Due to the administration or the service providers' focus more on customers' expectations makes road performance measures more challenging. At the same time, the service providers have also increasingly focussed on the road quality. For measuring road quality, internationally, several models and methods like Pavement Performance Index (PPI), Visual Condition Index (VCI), Priority Ranking Model (PRM), International Roughness Index (IRI) or simple Roughness Index (RI), Cracking Index (CI), etc. were found to be employed. However, all these methods have their drawbacks and shortcomings, and their applicability depends on the nature and conditions of the location, environment, topography, and need of the agency. The type of performance measuring techniques and the implementation mechanisms vary significantly from one jurisdiction to another. Nevertheless, there are some common practices and standard performance measures followed across the globe and organizations.

According to Tawalare and Raju (2016), methods like PPI, VCI, and PRM ignored the distress parameters. Therefore, they developed a modified Pavement Performance Index by incorporating pavement distress parameters. In 2006, a project report prepared by the Transportation Association of Canada (TAC) found a considerable commonality of road performance measures adopted internationally and covered the following four dimensions : a) system condition and preservation, b) safety, c) accessibility, and d) cost effectiveness. Considering the importance of the dimensions adopted by TAC, a slightly modified version of the four dimensions has been employed in this present study. The four dimensions are given as : a) mobility and accessibility, b) safety and reliability, c) system condition and preservation, and d) cost effectiveness and maintenance.

As given in Table 12, each dimension is composed of five components/indicators, barring the third dimension that consists of six components [21 components = (5 components × 3 dimension) + (6 components × 1 dimension)]. As per the Likert scale, all the components/indicators were assigned their value ranging from one to five, indicating that higher the value, better the road performance. Weights of the components have been assigned through the PCA technique and are also considered as the index value. While constructing PCA to obtain the weight of the components, the Eigen values of the components have to be generated. The highest Eigen value, but greater than one, was considered as pivot Eigen value and was multiplied by each component to generate weight. The total weight generated through the PCA technique was considered as dimensional value and the composite index/weight value was arrived at by adding all the four–dimensional values together. The districts/organizations/dimensions have been ranked based on the weights and composite values.

Table 12. ***Weight of the Components, Dimensions, and Their Ranks***

Dimensions	Components	Weight	Total	Rank
Mobility and Accessibility	Average daily traffic volume	2.94	14.30	3
	No. of villages/block connected/5 km	2.63		
	No. of urban centres covered/5km	2.97		
	Average daily heavy vehicle	3.18		
	Average daily public transport	2.58		
Safety and Reliability	Annual vehicle accident	2.80	15.32	2
	Average annual vehicle break downs	3.31		
	Average annual road blocked	3.06		
	Manned by traffic police/security	2.95		
	Annual maintenance	3.20		
System Condition and	Potholes, rut-depth condition	3.00	16.62	1
Preservation	Drainage and edge breaking condition	2.97		
	Footpath and waiting sheds condition	3.08		
	Bridge/culvert condition	2.61		
	Asphalt/bitumen condition	2.99		
	Average breadth	1.97		
Cost–Effectiveness	Convergence with other scheme	2.17	13.41	4
and Maintenance	Involving locals/panchayat in fund allocation	2.37		
	Annual community voluntary service	2.52		
	Construction/repairing interrupted in between	3.25		
	Construction/repairing by sub and sub-sub-contractors	3.10		

Source : Authors' Estimation from the Field Survey.

Based on the component values (21 components) collected from the field using PCA, weights were generated and four dimensions were ranked accordingly. Of the index values of the four dimensions given in Table 12, the "system condition and preservation" that indicates the physical and distress condition of the roads turned out to be the best dimension (index value = 16.62) in Sikkim. Of course, this dimension consists of six components, while the other three dimensions are made up of five components each. Even if we minus the weight value of the additional/sixth component (average breadth/width of value 1.97) to make it an equal number of components with other dimensions, still this dimension (system condition and preservation) is found to be at the top with 15 index value (14.65 =16.62 – 1.97), same with the dimension of "safety and reliability." This dimension (system condition and preservation) reflects the physical condition of the roads in Sikkim through the indicators like potholes, rut-depth, drainage, edge breaking, culvert/bridge, Asphalt/bitumen conditions, and width. Based on the weights, the dimensions of "safety and reliability" and "mobility and accessibility" turned out to be the second and the third–best ranks, respectively ; whereas the component of "cost–effectiveness and maintenance" ranked at the bottom (4^{th} rank).

When we compare and rank the districts in terms of road quality and based on weights, understandably, the East Sikkim district turned out to be the best performing district in Sikkim with a weighted score of 20.31. The same is also reflected in Table 13. The districts of West and South have been ranked as the second (16.84 weight score) and third (15.01 weight score), respectively. As expected, the North Sikkim district (the most thinly populated district in Sikkim) came at the bottom, the fourth position, in the state in terms of road performance. The weight score/index of the North district turned out to be half (7.50) of the weight score attained by the district (South district) ranked at the third position. Of the districts, the North district performed the least in terms of mobility and accessibility dimension, while the other three districts performed more or less the same (around 4 – 5

Table 13. ***District-Wise Weight/Index and Rank***

Districts	Mobility and Accessibility	Safety and Reliability	System Condition and Preservation	Cost Effectiveness and Maintenance	Total	Rank
East	4.33	6.67	6.18	3.13	20.31	1
West	4.65	4.88	4.19	3.12	16.84	2
South	3.98	3.11	4.69	3.23	15.01	3
North	1.35	0.67	1.56	3.92	7.50	4
Total	**14.30**	**15.33**	**16.61**	**13.41**	**59.65**	

Source : Authors' estimation from the field survey.

index value) in this dimension. In terms of the safety and reliability dimension, the four districts like East, West, South, and North were found to be performing from the best to the least order with an index value of 6.67, 4.88, 3.11, and 0.67, respectively. With reference to the system condition and preservation dimension, the districts showed their performance in the following descending order as East, South, West, and North district from best to the least. However, North district performed the best in cost – effectiveness and maintenance dimension with index value 4, while the remaining three districts scored equally with index value of 3 each. This indicates that the North district performed the least in all first three dimensions, but the district exhibited the best performance in terms of the last dimension, cost – effectiveness and maintenance.

When we look at the organization-wise performance, Table 14 clearly shows that PMGSY performed slightly better than the R&B Department, albeit the gap is not very significant. There were some basic fundamental differences between these two organizations. The R&B (erstwhile PWD) department has been maintaining/constructing the road network in Sikkim out of the state government budget for many decades. While the PMGSY practically started functioning in full swing after 2000 out of the fund coming from the Central government, and most of the roads maintained by this organization were found to have been constructed in the last 5 – 7 years. Though there was a delay of around 5 – 10 years in initiating the construction of the roads from the date of sanctioning/approving the project, the interruption of the work due to the shortage of funds was hardly faced. This may be the reason why this organization seemed to have performed slightly better than the R&B Department. In the West district, the performance of the two organizations was found to be more or less the same ; whereas, the gap between the two was more apparent mainly in the districts of East and North.

Table 14. ***Organisation-Wise Weights in Different Districts***

District	PMGSY	R&B
East	7.50	5.50
West	7.70	7.30
South	8.20	6.80
North	9.30	7.30
Total	**32.70**	**26.90**

Source : Authors' estimation from the field survey.

When we exercise correlation analysis, we find a negative correlation between the length and overall performance of the roads, estimated with a correlation coefficient value of –0.92. This indicates that the longer the road, lesser is the performance. Shorter roads seemed to have been given more attention by the organization in maintaining them ; whereas, the cost–effectiveness dimension is found to be positively correlated with the overall performance of the roads in Sikkim. On the other hand, the system condition and preservation dimension, indicating physical status and distress level of the roads and having six components (refer Table 12), is found to be

strongly correlated with the frequency of repairing roads, estimated with a correlation coefficient value of 0.56. At the same time, the correlation between system condition and the percentage of heavy vehicle traffic is also found to be positive with the coefficient value of 0.093. This implies that the roads with heavy vehicular traffic were given more attention. In a nutshell, road performance depends on the traffic volume. This may be the reason why the North district's road network performance seemed to be slightly poorer than that of the other districts in the state. One must also remember that the number of heavy vehicles of security forces (Army) plying in the East Sikkim district is relatively large, and more attention is given to the NH connecting to Nathu-La pass, bordering China.

Summary and Concluding Remarks

From the statistics, the efforts of the government for the growth and development of the road network in Sikkim in recent years has been quite impressive. Despite the state's rugged hilly terrain and difficult topographical conditions, the agencies involved in maintaining/constructing the road network – R&B Department, BRO, PMGSY, and NHIDCL have been working relentlessly for the development of the road network in Sikkim. Of the total road network, around 64% in the state until 2015 was found to be rural roads. This indicates that the state's rural road network was given special attention, which shows that the Centrally funded infrastructure development projects run quite smoothly in the state, without any interruptions. For instance, the percentage of village access to the all–weather roads in Sikkim has also been very impressive, estimated at 81.15%. Based on the field experience, it is visible that the state government has been trying its best to reduce inter-district disparity in terms of the road network. Not only have the construction of the new roads, but also the expansion/up–gradation works of the existing roads been initiated at their fullest level.

The secondary data revealed that 76% and 67% were BT roads under PMGSY and R&B Department, respectively. In terms of overall road traffic, in 2008, a total of 14 registered vehicles were found on every kilometre of road in Sikkim, which reduced to six registered vehicles per kilometre of road in 2015. Understandably, the situation was quite different in the East Sikkim district, especially in Gangtok and its surrounding areas. Traffic congestion on the NH-10, especially from Ranipool to Gangtok has become a major problem. Finding an alternative road to ease this problem has already been discussed at the ministerial level. Due to this, two by-pass roads from Ranipool to Gangtok have been approved and their construction work is going on in full swing. This will reduce the traffic problem. Nevertheless, 70% of the state's vehicles were found in the East district (in and around Gangtok).

While analyzing inter - district and inter–organizational variation in terms of road network quality or performance, the variation rate was very negligible. Using primary data and PCA technique, we found that the East district performed better in all parameters/dimensions, but the North Sikkim district was found to be lagging much behind the other districts. Of the four dimensions, the dimension "system condition and preservation," which includes six road physical components is found to be the best dimension in this study. This, in turn, indicates that the physical condition of the existing roads in Sikkim seems to be good, and the distress level of the roads was very less. The correlation analysis has also reaffirmed that the frequency of repairing and road conditions is highly correlated.

Recommendations

In terms of construction of new roads and expanding/improving existing roads, the government has been working tirelessly in this regard with appropriate/sufficient manpower. Of course, the process has been expedited across the districts only in the last 5–10 years. The present study expects that the ongoing/aforesaid road construction/maintenance works will complete in the stipulated time with the desired quality. Though not

exhaustive, the present study suggests five achievable/manageable recommendations basically to ease the ever-increasing traffic problem in the urban centres in Sikkim.

(1) As vehicle density in East Sikkim district has reached a certain threshold level, especially in Gangtok and its surrounding areas, small public buses with a seating capacity of around 20–25 passengers (e.g. traveller minibus) may be encouraged.

(2) Since the percentage of government four - wheelers in Sikkim was found to be quite high (little more than 5% of the total registered vehicles), the public servants (government officers) may be encouraged to use public transport and sacrifice government vehicles (of course, it is not possible for all officers) by providing some incentives to those who use public transport.

(3) The major urban centres in Sikkim have been increasingly facing a big problem of parking space and difficulty in horizontal road expansion works (due to space constraints in the hilly terrains), using two - wheelers may be encouraged.

(4) Encroachment of the footpaths and tempering railing/iron fencings of the pedestrian by the private individuals in the urban centres of Sikkim must be controlled.

(5) The concentration of government offices, institutions, and business establishments may be slowly shifted from the capital city to other districts.

Limitations of the Study and Scope for Further Research

Since the present study is looked at from the perspective of social sciences, the detailed technical and engineering aspects of the subject have been ignored. Being a frontier state, though a significant number of military vehicles were found to be plying in Sikkim, their information could not be included in this study. Therefore, a study of this kind with a larger sample and involving all stakeholders may bring a better understanding of the subject. As also the issue of skewed urbanization – concentrated mainly in the capital cities – is visible in the hilly landlocked states, this kind of study may be helpful for the policymakers and planners for their further policy implications.

Authors' Contribution

Dr. Komol Singha and Dr. Rajesh Raj S. N. conceived the idea and developed qualitative and quantitative design to undertake the empirical study. The field survey was conducted by Dr. Singha. The numerical computations and preparation of the manuscript were done by both authors.

Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter, or materials discussed in this manuscript.

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