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PERCEPTION STUDY ON THE EFFECT OF SIVOK – RANGPO RAILWAY PROJECT ON THE LANDSLIDE OF DARJEELING HIMALAYA

Project Work on Disaster Management for the Partial Fulfillment of 6th Semester Honours Degree in Geography

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1. Introduction

A landslide is a geological phenomenon that occurs when a mass of rock, soil, or debris moves down a slope or hill (Anbalagan et al. 2007). Landslides can be triggered by a variety of factors, including heavy rainfall, earthquakes, volcanic activity, human activities such as excavation, and changes in slope due to natural processes such as erosion (**Figure 1**). According to the United Sates Geological Society, USGS (2023), landslides can vary in size and speed, ranging from slow, gradual movements of soil to rapid, catastrophic events that can cause significant damage and loss of life. They can also occur in different forms, such as rock falls, debris flows, and mudslides. Landslides can pose a significant hazard to people, property, and infrastructure, and it is important to understand the risks and take appropriate measures to mitigate them.

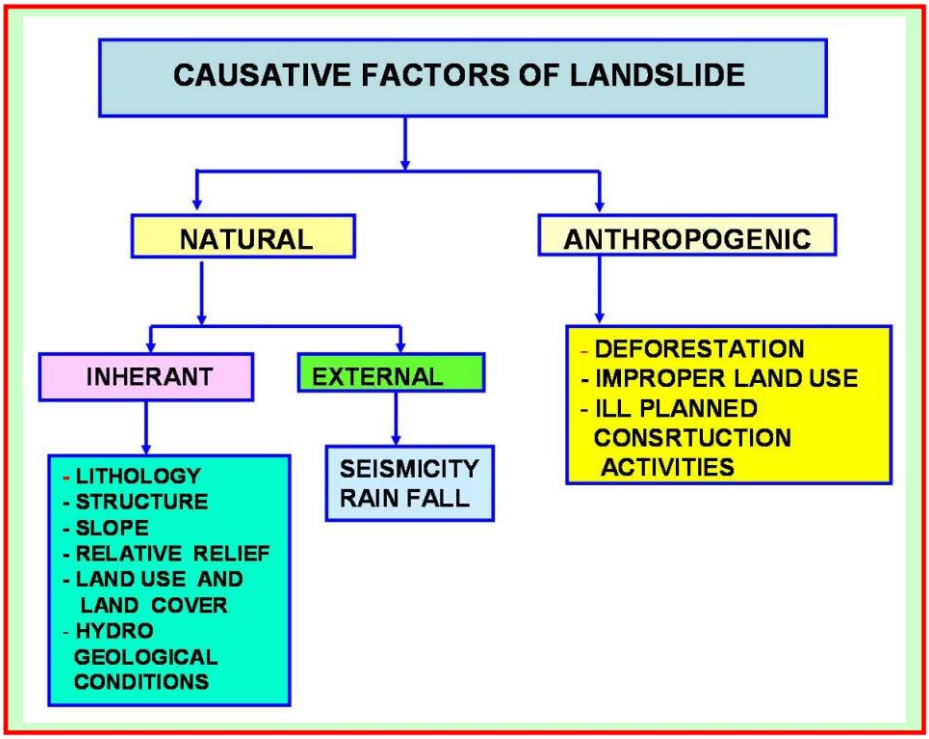


Figure 1: Major causative factors of landslide (Source: after Anbalagan et al. 2007)

Anthropogenic factors, such as land-use changes, deforestation, and urbanization, can have a significant impact on landslides. Human activities that modify the landscape or alter the natural balance of soil and vegetation can increase the likelihood of landslides. For example, deforestation can lead to soil erosion and destabilization of slopes, making them more susceptible to landslides. When trees are removed, the soil is no longer held in place by their roots, which can increase the risk of soil movement and slope failure. Similarly, urbanization and development can alter the natural drainage patterns of a landscape, increasing the amount

of water that flows into a particular area and contributing to landslide risk (Anbalagan et al. 2007).

Transportation systems, such as roads and railways, can have both direct and indirect impacts on landslides. Directly, transportation systems can impact the stability of slopes and increase the risk of landslides. When roads or railways are built on or near steep slopes, excavation and slope cutting can alter the natural balance of the slope and make it more prone to failure. Construction activities can also disturb the soil and vegetation, leading to soil erosion and instability. Indirectly, transportation systems can contribute to landslides by altering the hydrological and geological conditions of the surrounding landscape. For example, when roads are built in mountainous areas, they often require the construction of drainage systems that can alter the natural water flow patterns of the area. This can lead to increased water saturation in the soil, which can contribute to slope instability and landslides. Tunnelling is a most advanced civil engineering structure to cross the obstacles on terrain (e.g., hills, snow cover, water bodies) by an underground passage in the way of transport networks. Tunnelling can also contribute to landslides by altering the natural balance of the slope. Tunnelling activities can disturb the soil and rock layers, leading to changes in the stress distribution and potentially triggering landslides. When tunnels are constructed through hillsides or mountains, excavation can create an unstable slope above the tunnel, which can fail and cause a landslide. In addition, the increased weight and pressure of the tunnel can also contribute to slope instability, particularly in areas with weak or unstable geological conditions. Study finds that the global level proximity analysis shows ~40% of landslides happen within the 500 m of any major roads only, while at the regional scale it becomes ~65% irrespective of the degree of seismicity (Roy, 2022). Effect on tunnelling on massive landslide has been also experienced through the recent phenomena happened near Joshimath in Uttarakhand due to the ongoing construction work by NTPC hydro-project.

With this concern, in the present work we have focused on the perception of local people and stakeholders on the possible impact of the Sivok-Rangpo Railway Project on tiggering landslide of this region, which is a proposed railway line in India that would connect the town of Sivok in the state of West Bengal to the town of Rangpo in the state of Sikkim (**Figure 2; Plate 1**). The railway line is intended to improve connectivity and promote economic growth in the region by providing a reliable and efficient transportation option for both passengers and goods. The proposed railway line would cover a distance of approximately 44 kilometers and would include 22 major bridges and 14 tunnels. The line would traverse through steep and

rugged terrain, including several areas that are prone to landslides and other natural hazards. One of the major challenges of the project is ensuring the stability and safety of the railway line in the face of these natural hazards. To address these concerns, the project includes several engineering measures, such as slope stabilization and the construction of protective structures, to minimize the risk of landslides and other natural disasters. In addition, the project includes a comprehensive monitoring and early warning system to detect any potential risks and take appropriate action.

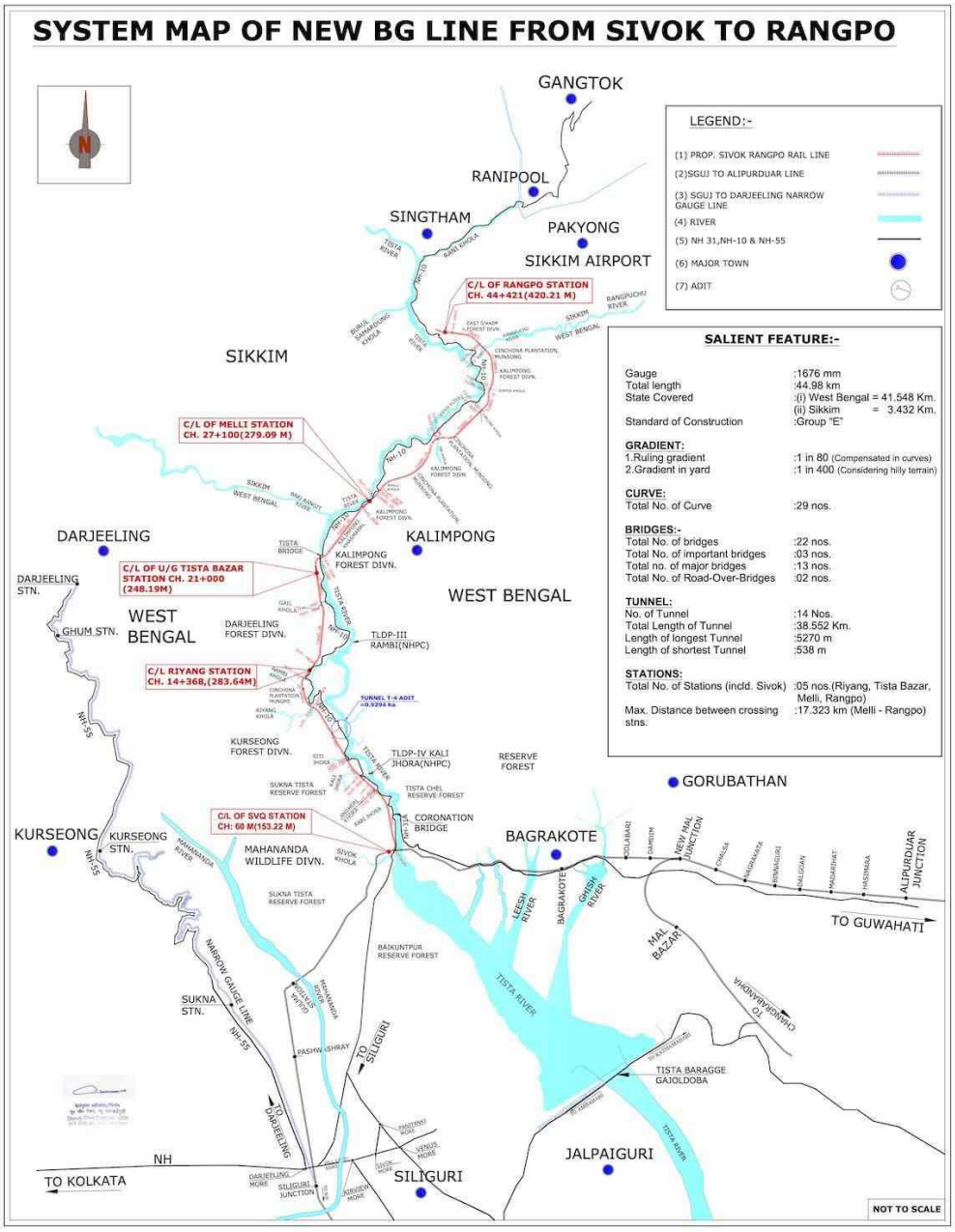


Figure 2: The plan map of Sivok – Rangpo Railway Project prepared by the construction authority (Source: https://scroll.in/article/1030774/a-railway-project-to-the-china-border-in-sikkim-is-violating-land-rights-of-indigenous-communities accessed on 20th May, 2023)

2. Objective of the Study

The primary objective of the present study is to know the perception of the local people and stakeholders on this railway project as a cause of landslide triggering factor and possible impact on environment and local livelihood.

3. Study Area and Importance to Select

To investigate on the above-mentioned objective, present study has been focused on the local peoples from the villages located in and around the railway line and nearest major tourist spots to know their perception on the role of this project negatively as well as positively (Figure 3). The project is expected to have a significant impact on the region, including improving connectivity between Sikkim and the rest of India, promoting tourism and economic development, and creating employment opportunities for local residents. However, the project has also faced some opposition from local communities and environmental groups who are concerned about the potential impact on the environment and local livelihoods. As of May 2023, the project is still under construction, and it is expected to be completed by 2024.

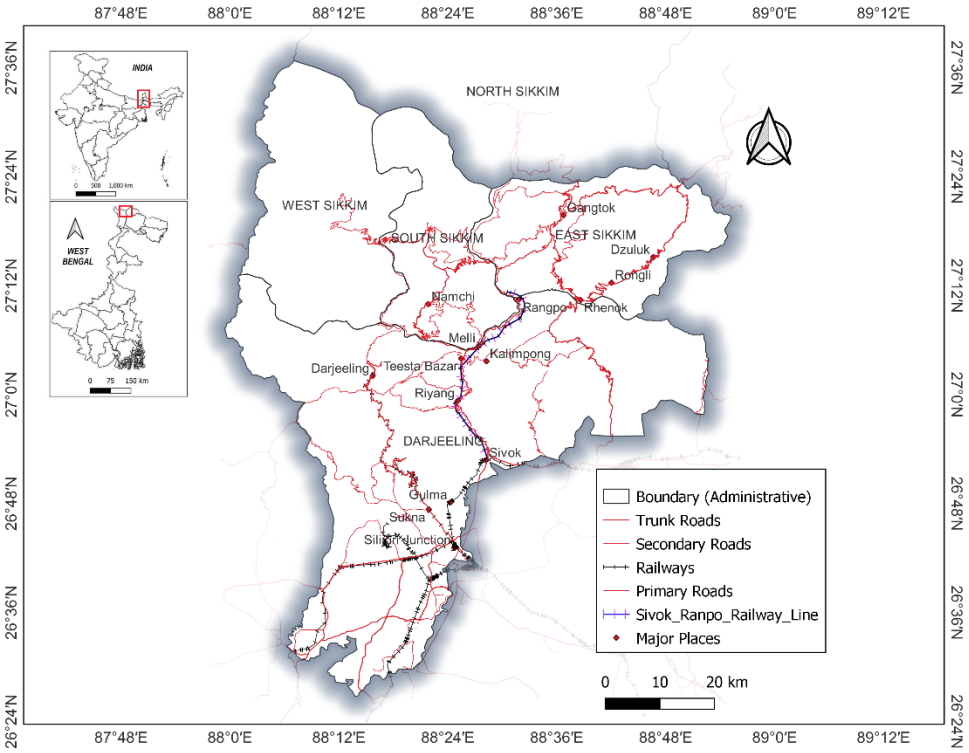


Figure 3: Location Map of the Study Area

Plate 1: Upper photograph showing the starting point of the railway project at Sevok, West Bengal with Tunnel No. 1 (26°52'52.43"N; 88°28'14.87"E); lower phograph showing the end station of the railway project at Rongpo, Sikkim (27°11'17.00"N; 88°30'34.13"E)

As per the engineering plan (Figure 2), the length of this project would be 44.980 km and width of the gauge being 1676 mm, out of which 41.548 km (~92%) is in West Bengal and 3.432 km (~8%) is in Sikkim. The route of this project constructed with 22 bridges and 14 tunnels, including five railway station e.g., Sivok, Riyang, Tista Bazar, Melli, and Rangpo. About 86% of the total length of this project in going through 14 tunnels, which is good to avoid the problem of road blockage by frequent landslides during rainy season, however, that could be a significant cause for the tiggering landslide of this region. The elevation of this railway route ranges from 153 m at Sivok railway station to 420 m at Rangpo railway station.

The primary geomorphological map shows the railway project starts at the foothill region of the moderate to highly dissected hilly region of Darjeeling Himalaya (**Figure 4**). The geological map also shows the railway line runs over the different geological formation like, starts from the sedimentary deposits of Siwalik range and goes through Damuda Formation,

Gorubathan or Daling Formation, Reyang Formation. Most of the part comes under the Gorubathan or Daling formation only (**Figure 5**). The details of this formation have been shown in **table 1**.

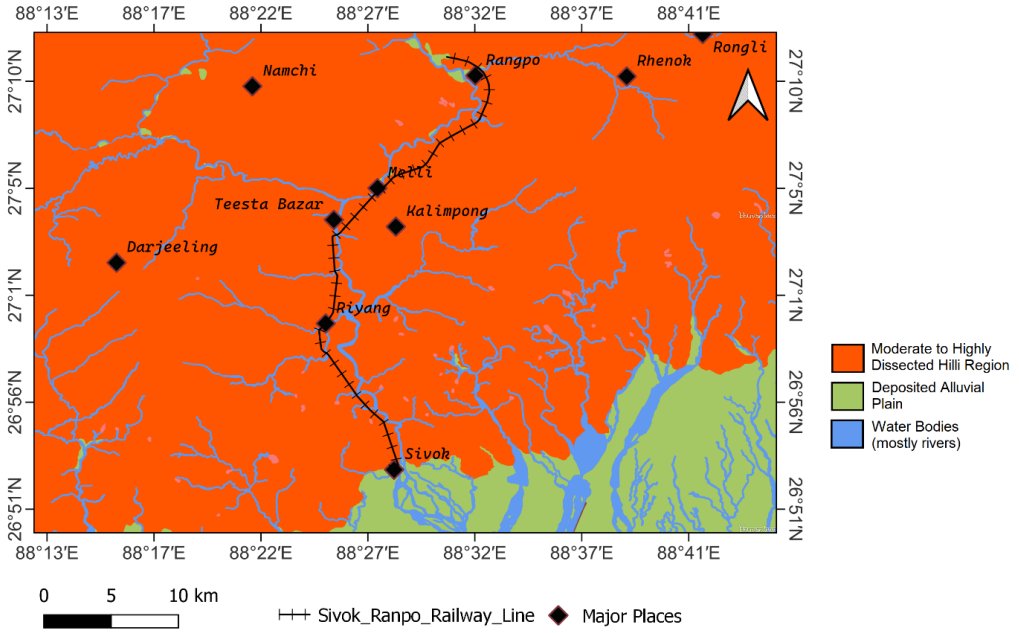


Figure 4: Basic Geomorphology of the Study Region (Source: Bhuvan-ISRO, https://bhuvan-app1.nrsc.gov.in/thematic/thematic/index.php)

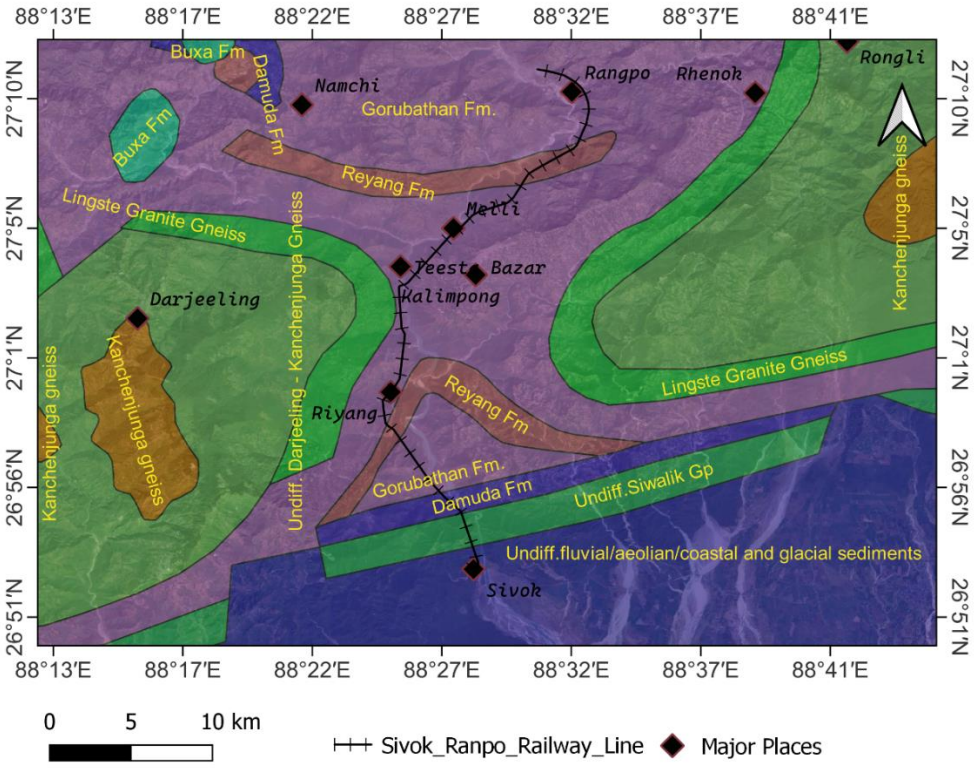


Figure 5: Geological formation of the study area (Source: bhukosh.gsi.gov.in, Geological Society of India)

Table 1: Geological succession of Darjeeling Himalaya (Source: Das, 1947)

Age	Series	Lithological Characteristics
Recent to Sub-recent	Alluvium	Younger flood plain deposits of rivers consisting of sands, pebbles, gravels, boulders etc.
Pleistocene to Lower Pleistocene (Lower Tertiary)	Siwalik	Micaceous sandstone with siltstone, clay, lignite lenticles, etc.
Thrust (Main Boundary Fault)		
Permian	Damuda (Lower Gondwana)	Quartzitic sandstone with slaty bands, seams of graphitic coal, lampophyre silt and minor bands of limestone.
Thrust (Fault Of Nappe Qutlier)		
Pre-Cambrian	Daling Series	Slate, chlorite-sericite schist, chlorite- quartz schist.
	Darjeeling Gneiss	Golden silvery mica-schist, carboniferous mica-schist, coarse grained gneiss.

The land use land cover map shows the area along the railway line is covered by dense forest and crossing number of streams at different location (**Figure 6**). However, the inventory map of the regional landslide shows around the railway line numbers of landslide have been occurred previously. In particular, within the buffer of 500 m and 1000 m, the number of landslides is 42 and 96, respectively (**Figure 7**). Therefore, the study region already a severe landslide prone region of Darjeeling Himalaya. In addition, the region also receives lots of rainfall during the rainy season, which is also major tiggering cause of landslide here (**Table 2**).

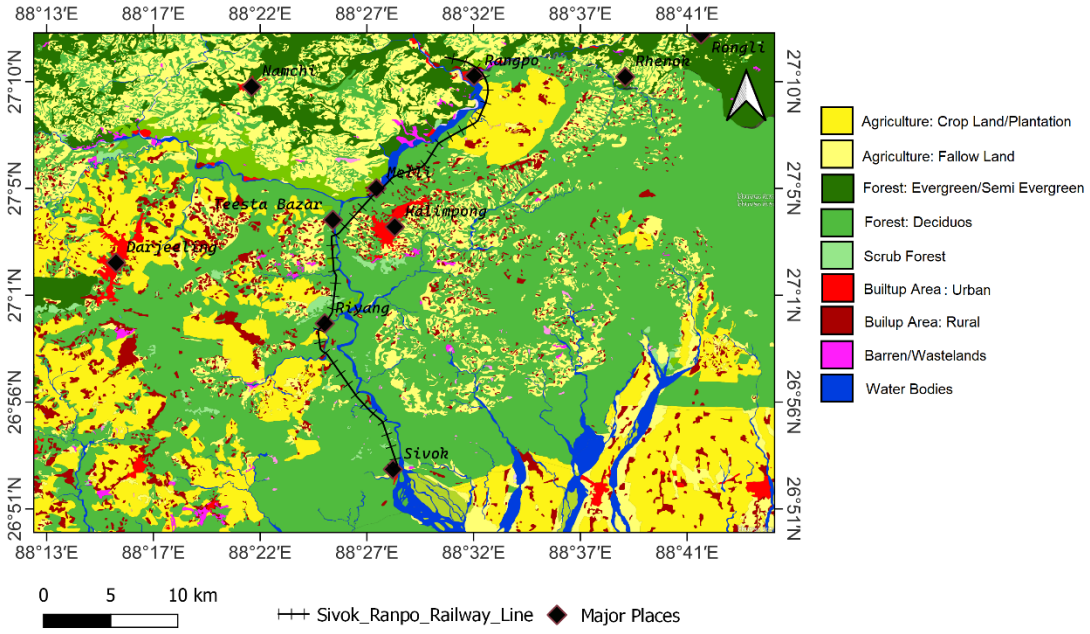


Figure 6: Major land use land cover characteristic of the study area (Source: Bhuvan-ISRO, https://bhuvan-app1.nrsc.gov.in/thematic/thematic/index.php)

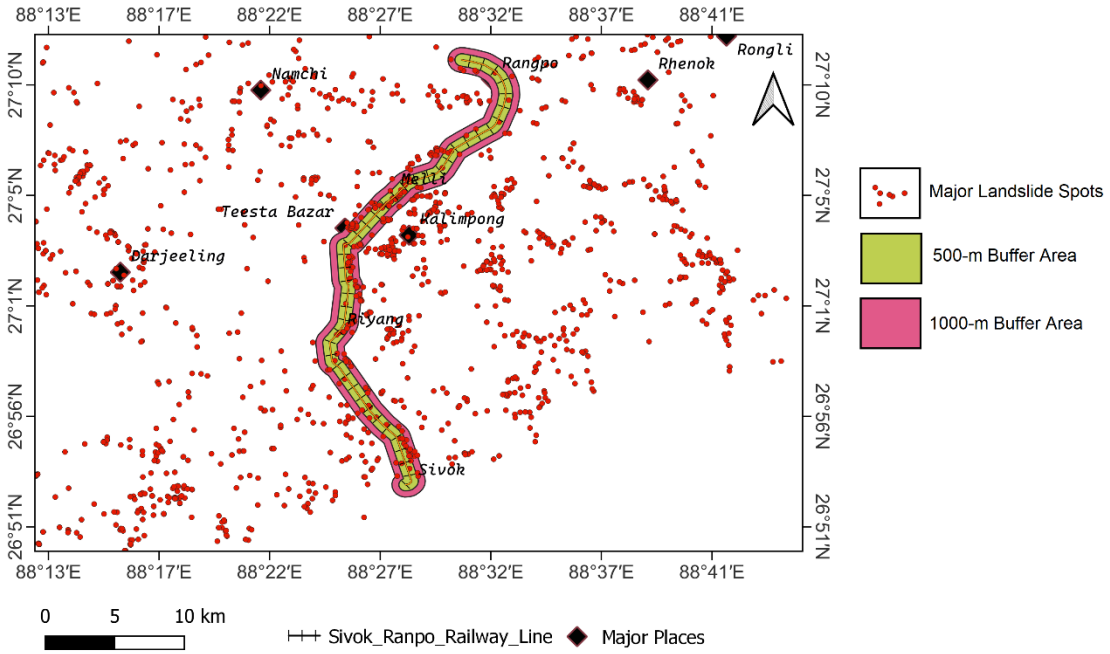


Figure 7: Location of past landslides of the study area with buffer area of railway line at 500m and 1000m (Source: bhukosh.gsi.gov.in, Geological Society of India)

Table 2: Average rainfall and temperature characteristics of the Darjeeling Himalaya

	Darjeeling		Kalimpong		Kurseong	
Months	Rainfall In Mm	Temperature In °C	Rainfall In Mm	Temperature In °C	Rainfall In Mm	Temperature In °C
January	13.89	8.12	10.16	17.39	17.03	11.97
February	20.16	12.28	20.34	19.67	21.25	15.98
March	47.97	15.55	46.34	23.46	72.17	19.51
April	132.89	18.67	129.82	26.32	181.36	22.5
May	371.67	19.79	248.98	27.77	428.33	23.78
June	631.45	20.85	598.44	28.62	724.95	24.74
July	867.59	21.72	865.26	29.41	896.43	25.57
August	659.89	21.98	634.66	29.82	698.28	25.9
September	556.24	19.99	487.21	27.44	611.73	23.72
October	167.39	18.37	145.99	26.69	176.69	22.53
November	36.96	15.69	38.98	23.03	42.97	19.36
December	10.88	11.98	11.46	19.21	12.67	15.6

Source: *Tea Planters' Association, Darjeeling.*

4. Database and Methodology

4.1 Schedule Survey: The perception data has been collected through schedule survey after interaction with 106 respondents from different locations, who are directly or indirectly stakeholder of this project (**Annexure 1**). Random Sampling has been followed to select the respondent; however, the location of survey was chosen as per the hot-spots of tourism industry of Sikkim (**Plate 2**). Google Form has been used here as an easiest way of paper-less data collection as well as management techniques with automatic tabulation and tally (**Annexure**

2). However, same form has been also used in hardcopy for those locations where internet facility is not available.

Plate 2: Survey team member (left) and conducting perception survey with local shopkeepers at Rongpo, Sikkim (left)

4.2 Preparation of Maps and Diagrams: Different secondary sources have been examined for preparing importance maps for the study area. **Table 3** shows the details of such sources. Different diagrams have been prepared using Microsoft Excel based on the data collected in field.

Table 3: Sources of different maps and techniques to draw

Theme of the Map	Source(s)	Use Techniques/Software
Geomorphology	Bhuvan-ISRO	Web GIS, QGIS
Geology	bhukosh.gsi.gov.in, Geological Society of India	Vector Mapping in QGIS
Land Use Land Cover	Bhuvan-ISRO	Web GIS, QGIS
Landslide Inventory	bhukosh.gsi.gov.in, Geological Society of India	Vector Mapping in QGIS

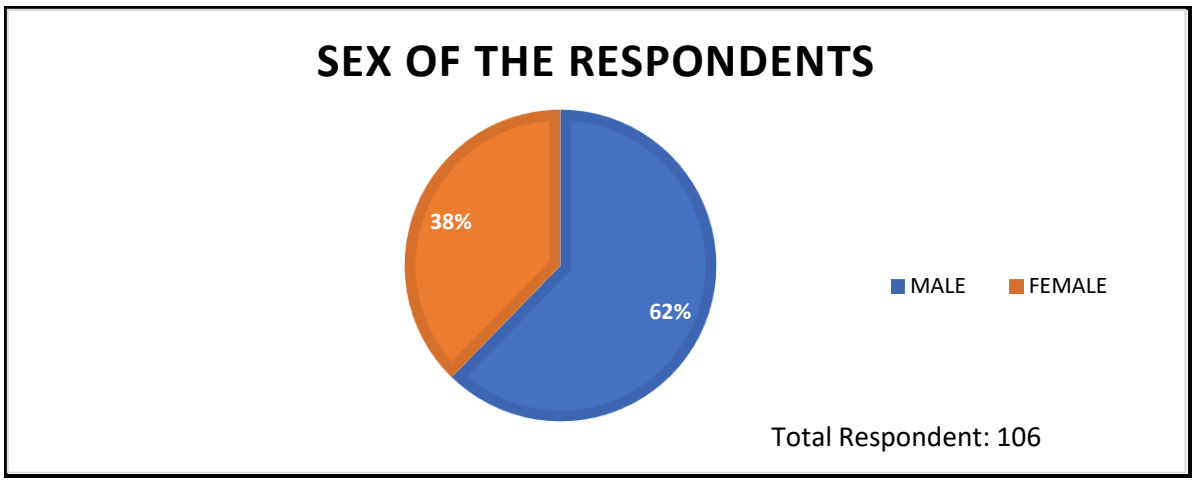
5.Result and Discussion

5.1 BASIC CHARACTERISTICS OF RESPONDENTS

5.1.1 SEX AND AGE COMPOSITION

- **SEX**

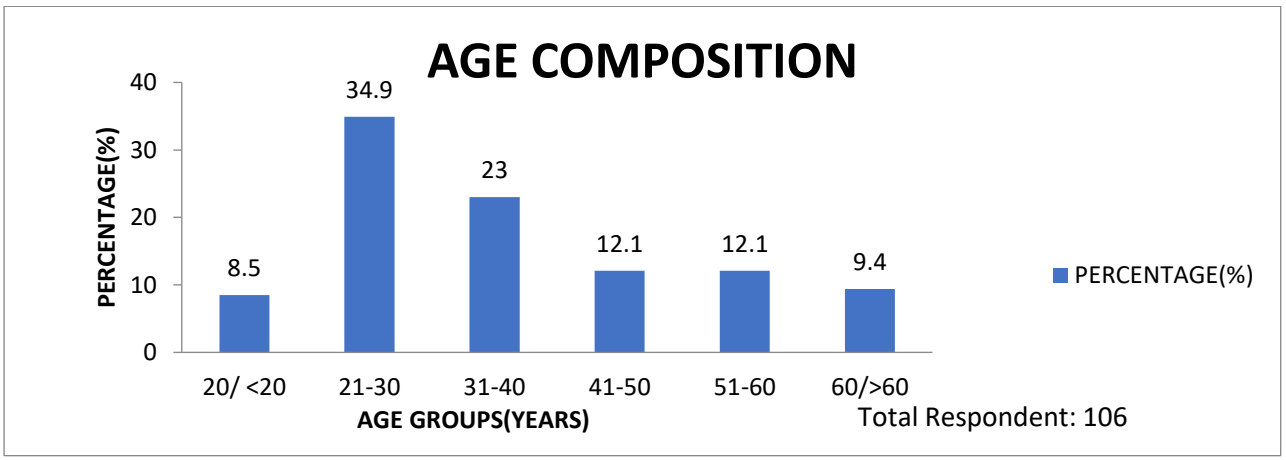
Sex	Male	Female
No. of Respondents	66	40
Percentage (%)	62.3	37.7



From the above table and diagram, it can be observed that 62.3% of the respondents were Male and 37.7% of the respondents were Female.

- **AGE**

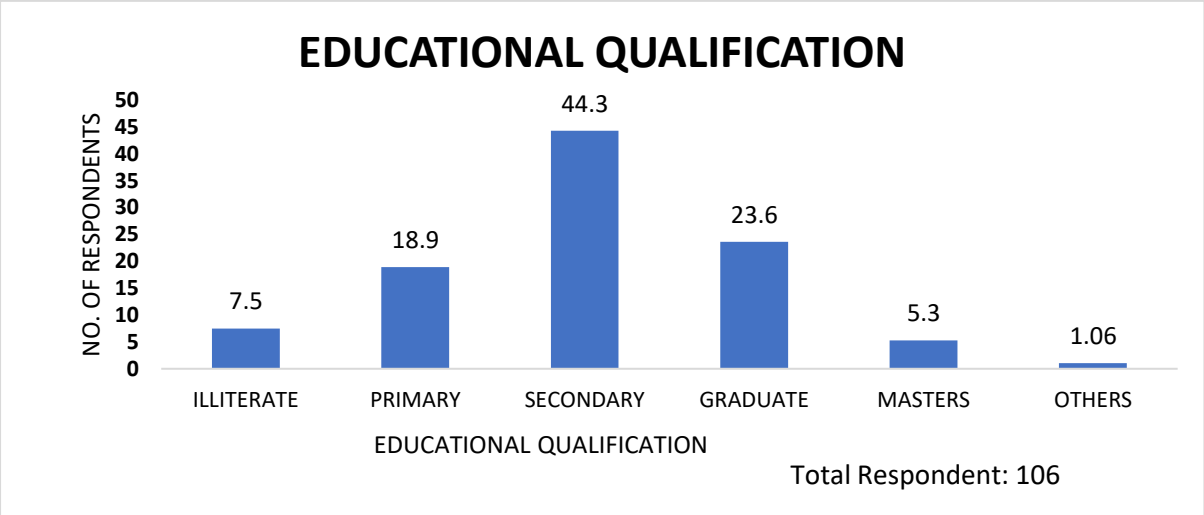
Age Groups (Years)	≤20	21-30	31-40	41-50	51-60	≥60
No. of People	9	37	24	13	13	10
Percentage (%)	8.5	34.9	23	12.1	12.1	9.4



According to the table and diagram, it has been seen that most of the respondents are in the age group of 21-30 years (34.9%). Among the rest, 23% respondents belong to the age group of 31-40 years, 12.1% respondents are coming in each group of 41-50 and 51-60 years. Out of 106 respondents 9.4% respondents are 60 or more than 60 years. And only 8.5% respondents belong to the age group of 20 or less than 20 years.

5.1.2 EDUCATIONAL QUALIFICATION

Educational Qualification	Illiterate	Primary	Secondary	Graduate	Masters	Others
No. of Respondents	8	20	47	25	5	1
Percentage (%)	7.5	18.9	44.3	23.6	5.3	1.06

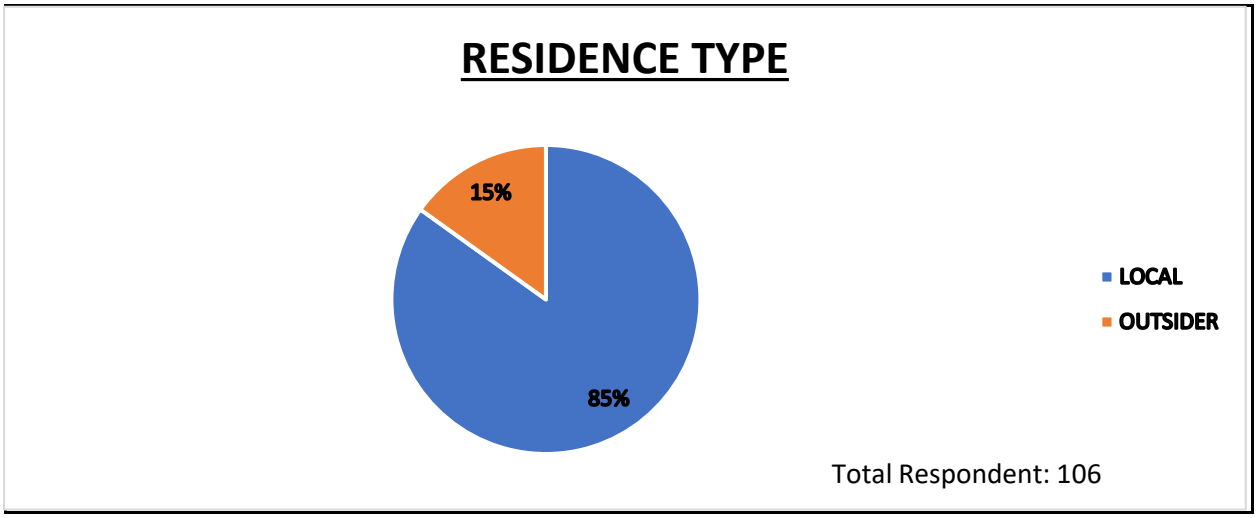


Out of 106 respondents, it has been seen that most of the respondent's educational qualification is Secondary (44.3%), and among the rest of the respondents 23.6% are Graduate, 5.3% of people are completed Master's Degree, 18.9% of people have got Primary Education, 7.5% respondents were Illiterate, and the rest 1.06% people have other Educational Qualifications.

5.1.3 RESIDENTIAL TYPE AND DISTANCE FROM RAILWAY PROJECT

- **RESIDENTIAL TYPE**

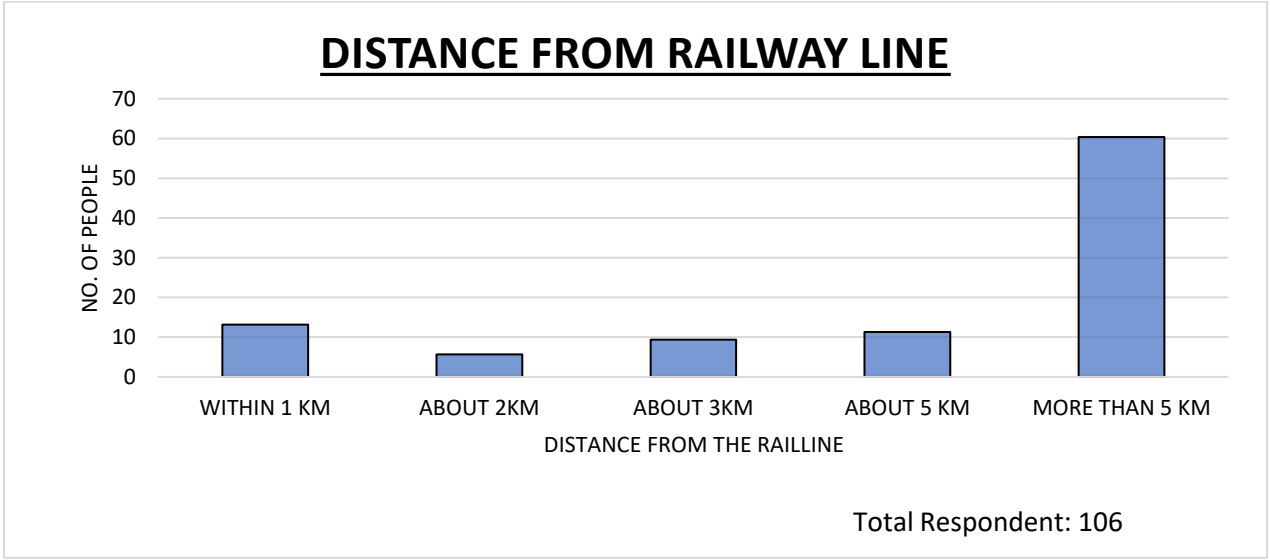
Residence Type	Local	Outsider
No. of People	90	16
Percentage (%)	84.9	15.1



According to our perception survey, it is observed that 84.9% respondents are Local and the rest of the 15.1% respondents are Outsider. Most of the outsiders were came to Sikkim for tourism or business purpose. However, most of the respondents are locals who have been lived for many years.

- **DISTANCE OF RESIDENTS**

Distance From the Railway Line	Within 1 km	About 2 km	About 3 km	About 5 km	More than 5 km
No. of People	14	6	10	12	64
Percentage (%)	13.2	5.7	9.4	11.3	60.4



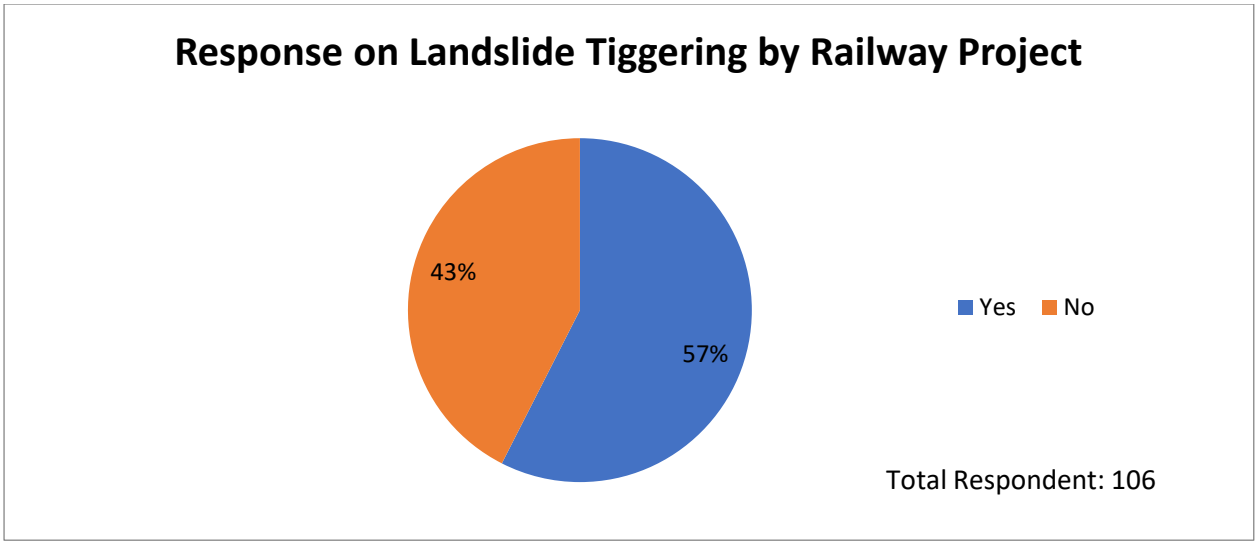
From this above table, it has been seen that the majority of the participants are living within 5 km distance from the Railway Line (60.4%). Among this 13.2% of participants are living within

1 km of distance, 11.3% of participants reside at about 5 km distance, and 9.4% of the respondents are reside within about 3 km distance. Only 5.7% respondence are living at about 2 km distance from Railway Line.

5.2 PERCEPTION ON THE ROLE OF ONGOING RAILWAY PROJECT ON LANDSLIDE:

5.2.1 POSSIBLE EFFECT ON LANDSLIDE TRIGGERING

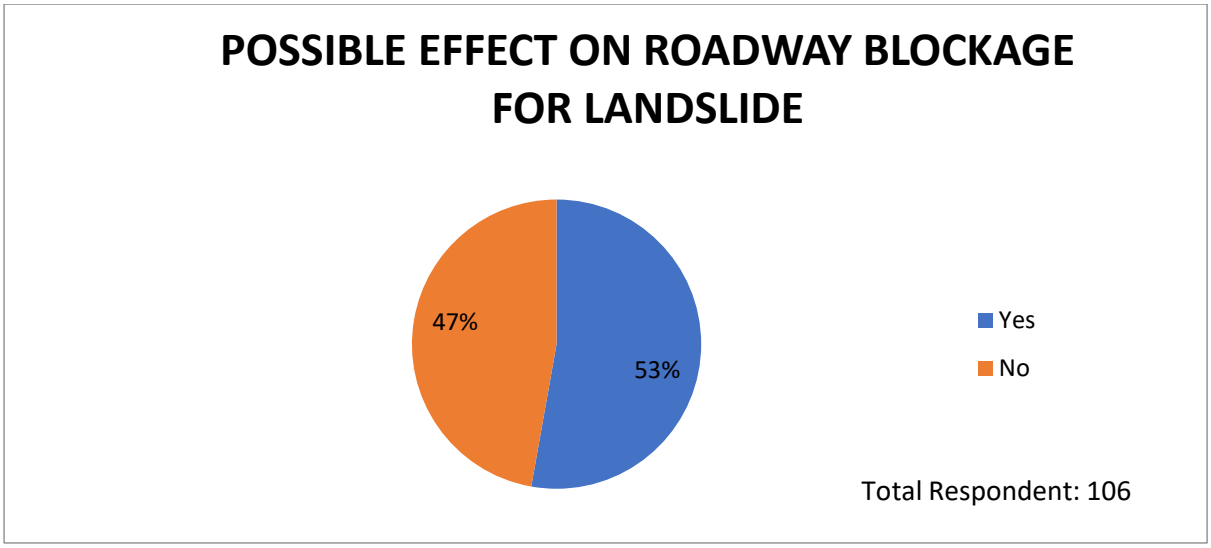
Railway Project Can Trigger Landslide	YES	NO
No of People	60	45
Percentage of People (%)	57.5	42.5



According to our perception survey, out of 106 respondents, 57.5% people said that the railway project can trigger landslide, whereas, 42.5% people think railway project cannot trigger any major landslide.

5.2.2 POSSIBLE EFFECT ON ROAD BLOCKAGE FOR LANDSLIDE

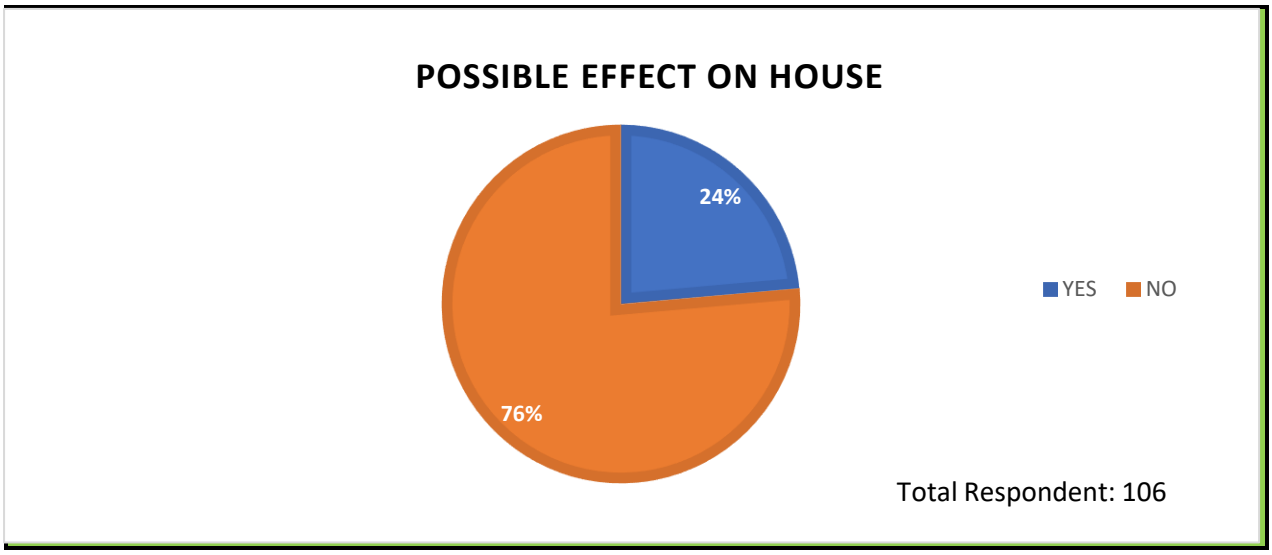
Road Blockage by Landslide Increase after this Project	YES	NO
No of People	56	50
Percentage of People (%)	52.8	47.2



According to our perception survey on 106 respondents, 52.8% people said road blockage by landslide might be increased after this project, whereas, 47.2% people are not clear about the role of this project on road blockage by landslide.

5.2.3 POSSIBLE EFFECT ON HOUSE

Possible Effect on House	YES	NO
No. of Respondents	25	81
Percentage (%)	23.6	76.4

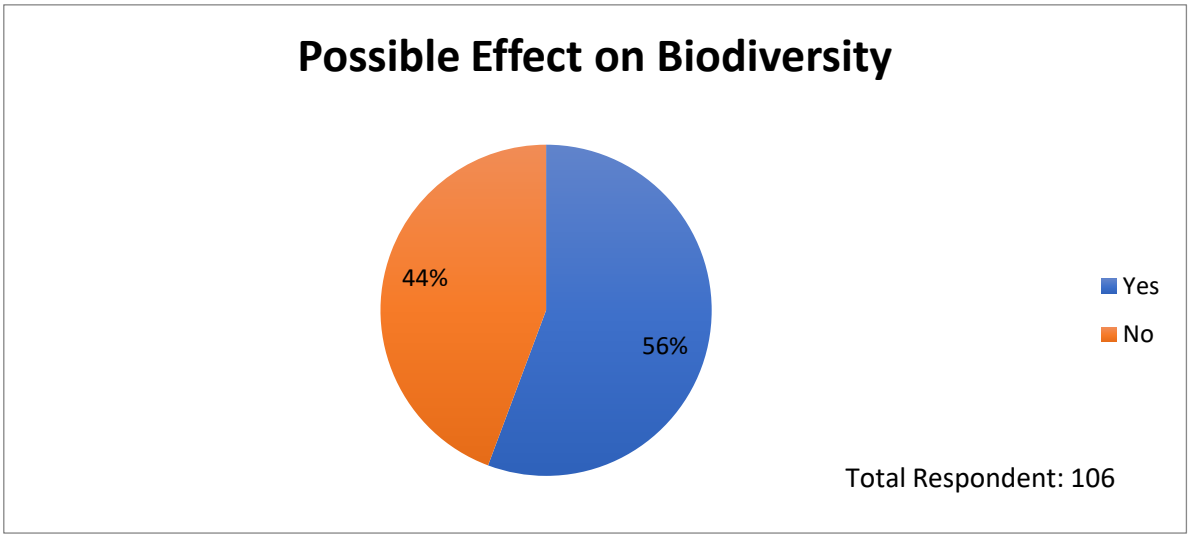


According to the table and diagram, it has been seen that most of the respondents (74.4%) say that there will be no significant effect on their house by his rail project. However, the rest of 23.6% people think that there might be some possibility of house damage by this project.

5.3 PERCEPTION ON THE EFFECT OF ON-GOING RAILWAY PROJECT ON ENVIRONMENT

5.3.1 POSSIBLE EFFECT ON BIODIVERSITY

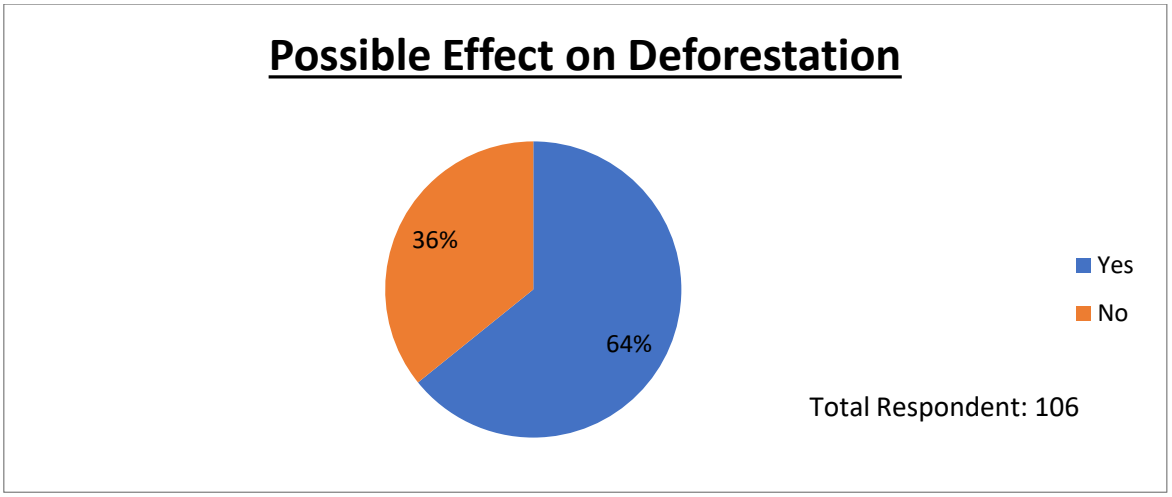
Effected on Biodiversity	Yes	No
No of Respondents	59	47
Percentage (%)	55.7	44.3



Out of 106 respondents of our survey, 55.7% respondents were said the Railway Project can affected Biodiversity, however, 44.3% respondents are not think that the Railway Project can affected on Biodiversity.

5.3.2 POSSIBLE EFFECT ON DEFORESTATION

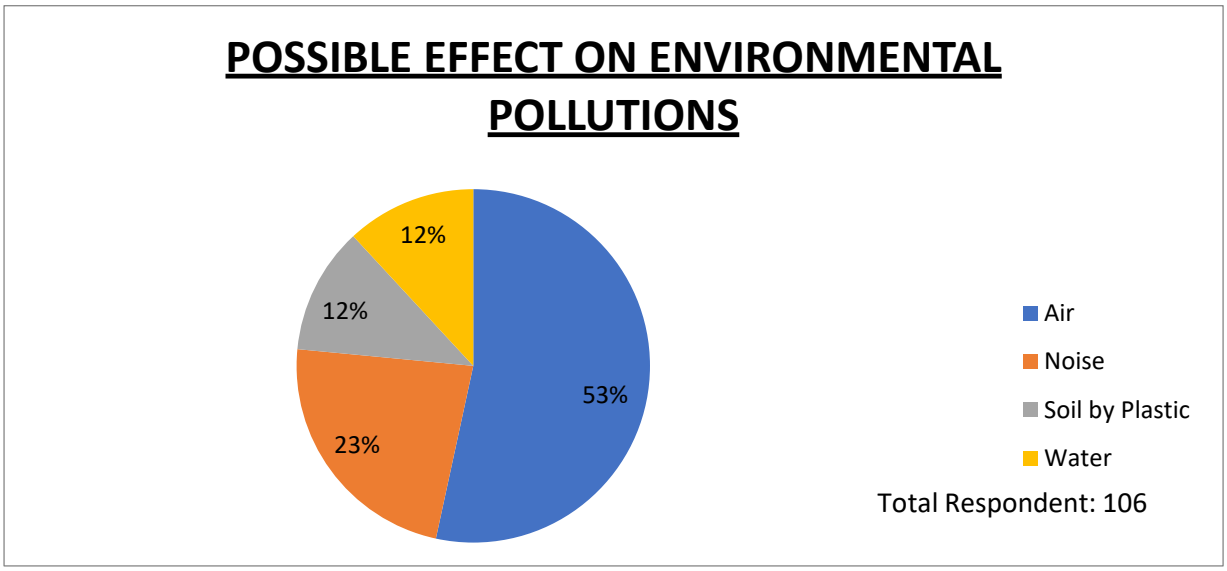
Any Deforestation After Starting this Project	Yes	No
No of Respondents	68	38
Percentage (%)	64.2	35.8



According to our survey on 106 respondents, 64.2% respondents said that deforestation has taken place and 35.8% respondents said that no trees were cut down for this Railway Project.

5.3.3 POSSIBLE EFFECT ON ENVIRONMENTAL POLLUTIONS

Pollution Name	Air	Noise	Soil By Plastic	Water
No of Respondents	60	26	13	7
Percentage (%)	56.6	24.5	12.3	6.6

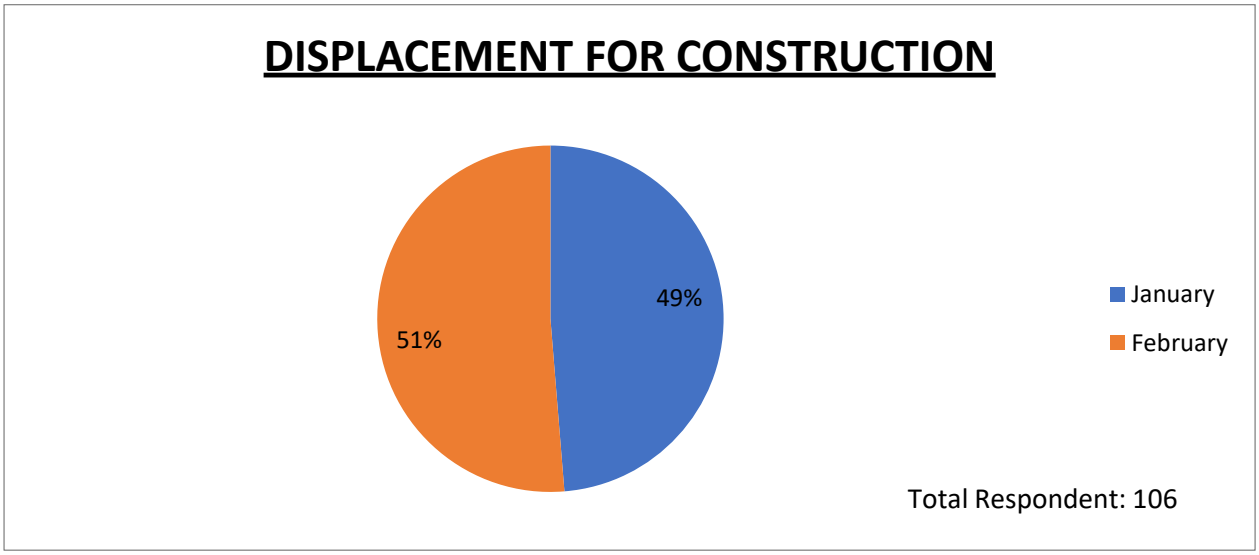


According to our perception survey on 106 respondents, this project could affect the local environment by increasing pollution like Air (56.6%), Noise (24.5%), Water (12.6%) and Soil by plastic (12.3%). Overall, 56.6% of participants suspected air pollution increased very much.

5.4 PERCEPTION ON THE ROLE OF GOVERNMENT AS PROBLEM SOLVING

5.4.1 DISPLACEMENT FOR CONSTRUCTION

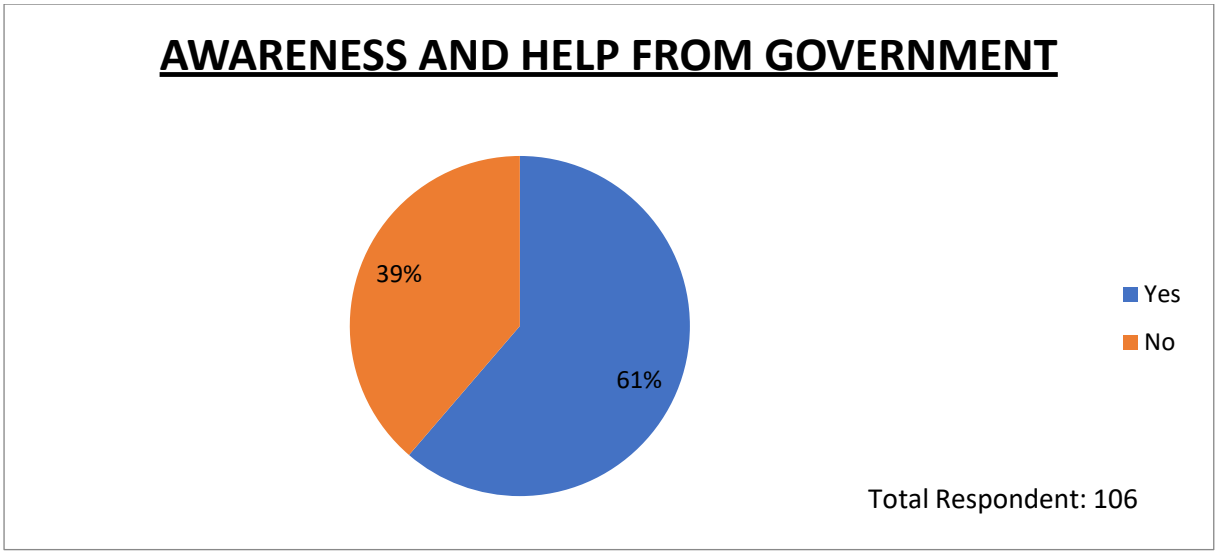
Weather Any Displacement of People for This Project	Yes	No
No of Respondents	59	47
Percentage (%)	55.7	44.3



According to our survey on 106 respondents, 55.7% of the respondents said that people were displaced and 44.3% respondents said that people were not displaced for this railway construction.

5.4.2 AWARENESS AND HELP FROM GOVERNMENT

Do You Think Government Take Any Initiative to Solve Problem Arise for This Project	Yes	No
No of Respondents (%)	65	41
Percentage (%)	61.3	38.7

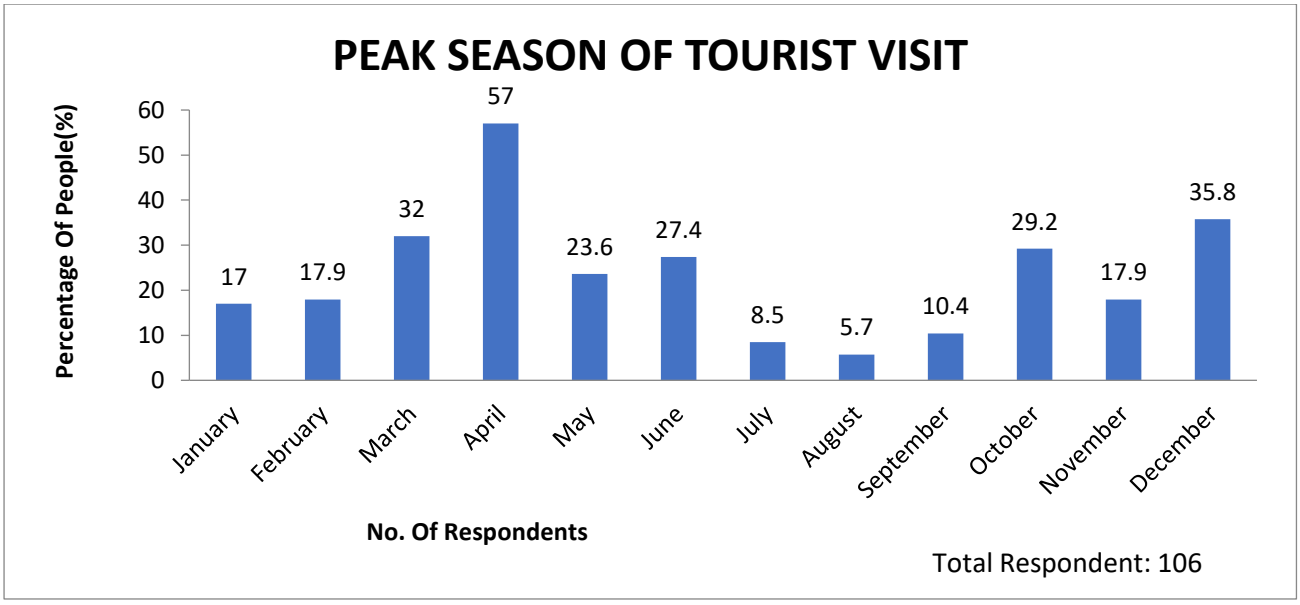


Out of 106 respondents of our survey, 61.3% respondents said that Government taken initiative to solve problem arise for this project and 38.7% respondents said that Government did not take any initiative to solve problem arise for this railway project.

5.5 PERCEPTION ON THE FUTURE PROSPECT OF ONGOING RAILWAY PROJECT ON TOURISM INDUSTRY

5.5.1 PEAK SEASON FOR TOURISM

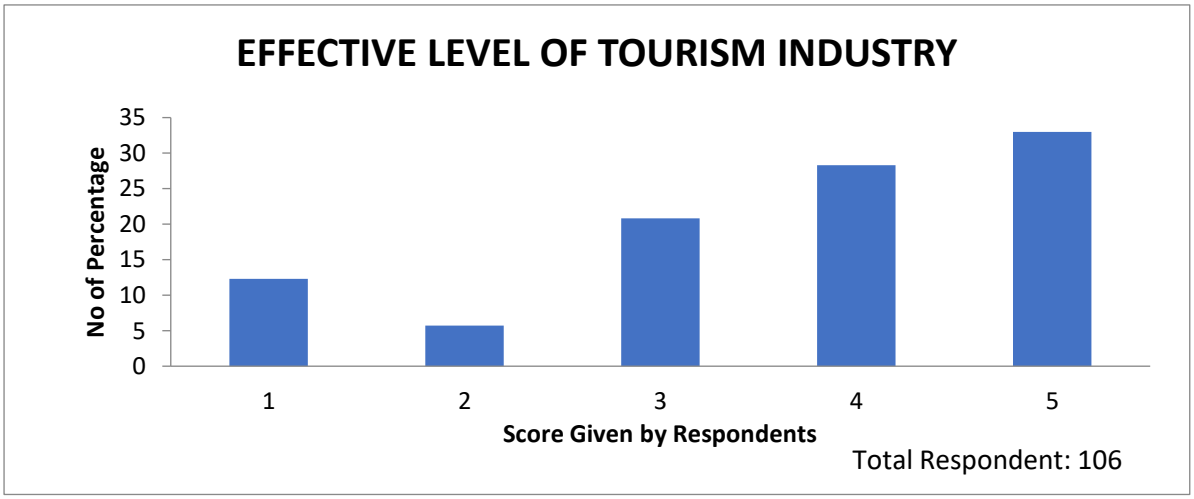
Peak Season	January	February	March	April	May	June	July	August	September	October	November	December
No of Respondents	18	19	34	61	25	29	9	6	11	31	19	38
Percentage of People (%)	17	17.9	32	57	23.6	27.4	8.5	5.7	10.4	29.2	17.9	35.8



As per the response collected, April month is the Peak Season of tourists in this area with 57% response, and August (5.7%) month is experiencing least tourist in this area. However, a deviation has been observed in response regarding the peak reason of this region, in particular, month wise response shows January (17%) February (17.9%), March (32.1%), May (23.6%), June (27.4%) and November (17.9%) and December (35.8%).

5.5.2 POSSIBLE INFLUENCE ON TOURISM INDUSTRY OF SIKKIM

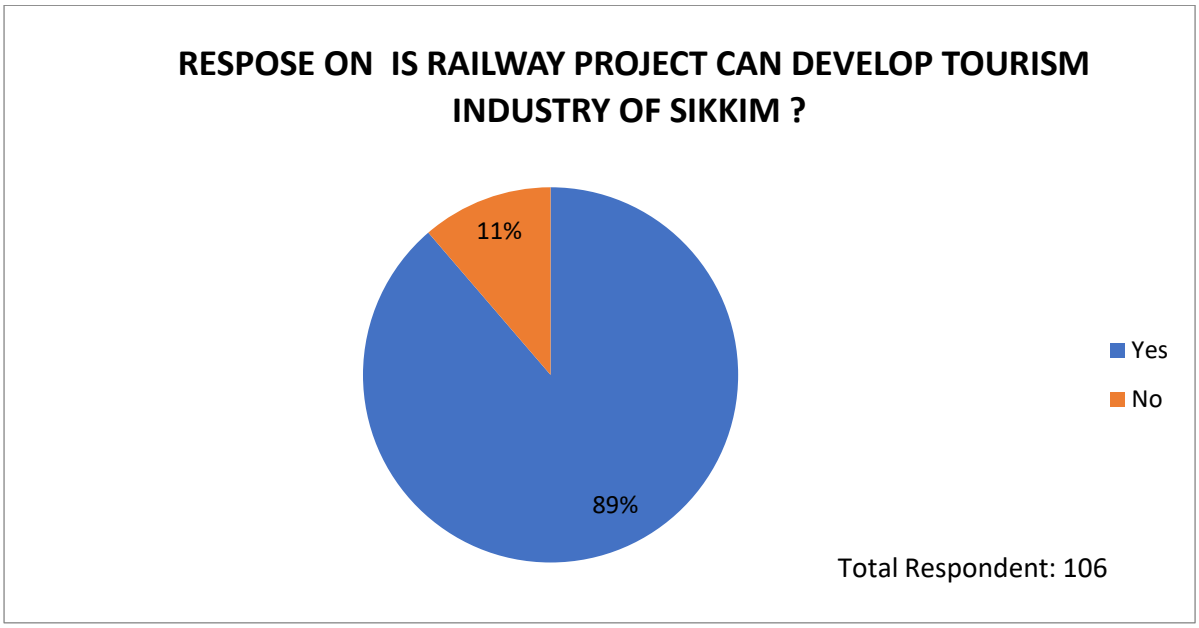
Effective Level of Tourism Industry	Perception based Score				
	1	**2**	**3**	**4**	**5**
No of Respondents	13	6	22	30	35
Percentage (%)	12.3	5.7	20.8	28.3	33



A rating scale of 1-5 was used to take response, where level of 5 indicated a very high effect of tourism industry and 2 indicated very low level of effect of tourism industry. Out of 106 respondents of our survey, 33% respondents think that the level of influence of this railway project on tourism industry is very high, whereas. 28.3% respondents also think that effect of tourism industry level is high, 20.8% respondents think that this level is moderately high, 12.3% respondents said that the level of effect of tourism industry is moderately low and only 5.7% respondents think that effect level is low.

5.5.3 MAJOR FIELD OF IMPROVEMENT POST RAILWAY PROJECT

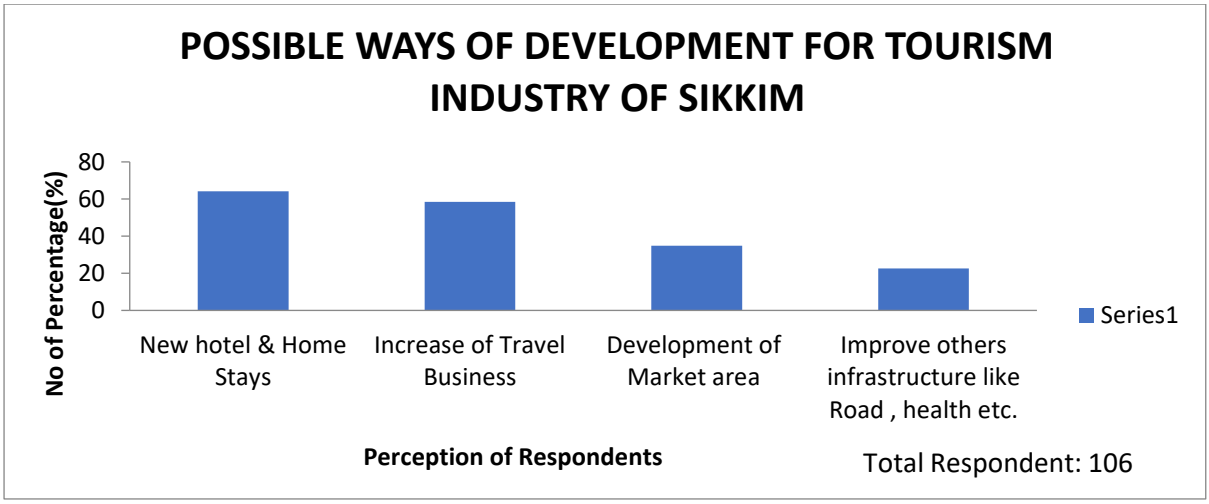
Do You Think This Railway Project Can Develop Tourism Industry of Sikkim?	Yes	No
No of Respondents	94	12
No of Percentage (%)	88.7	11.3



Out of 106 respondents of our survey 88.7% respondents think that this Railway project can develop Tourism Industry of Sikkim and 11.3% respondents think that this Railway Project can't develop tourism industry of Sikkim.

5.5.4 POSSIBLE WAYS OF DEVELOPMENT FOR TOURISM INDUSTRY OF SIKKIM

Possible Ways	New Hotel & Home Stays	Increase Of Travel Business	Development Of Market Area	Improve Others Infrastructure Like Road, Health Etc.
No Of Respondents	68	62	37	24
No Of Percentage (%)	64.2	58.5	34.9	22.6



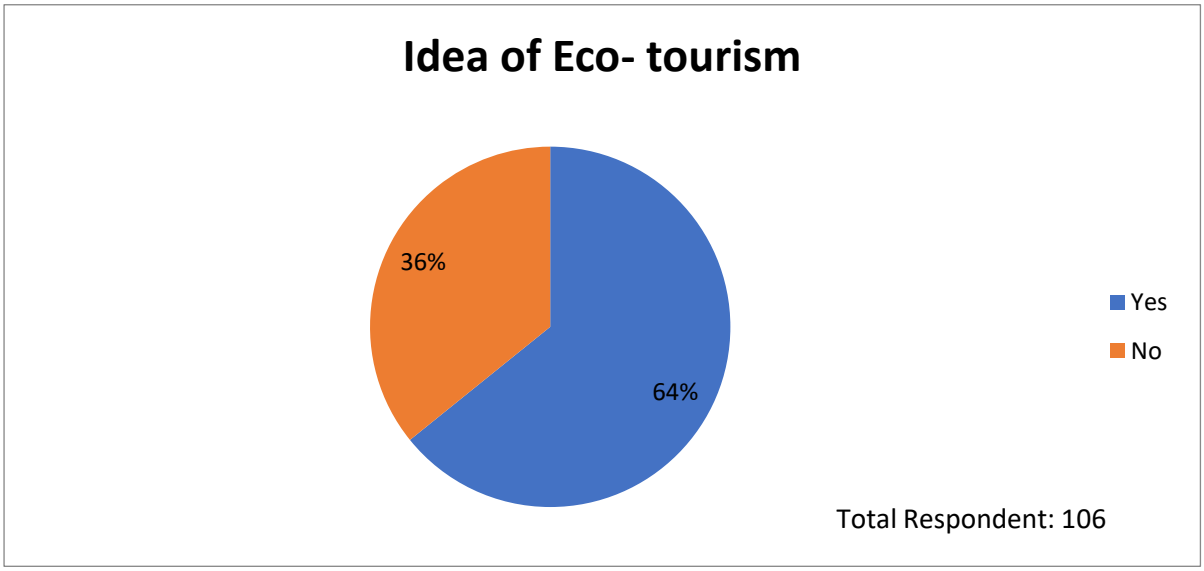
According to our survey of 106 respondents 64.2% respondents said that there are ideas about Eco- Tourism and 35.8% respondents said they had no ideas about Eco- Tourism. Most of the people said that New Hotels and Homestays are the possible way to improve the tourism industry (64.2%) and Number of 62 respondents said that Increase of Travel business is the possible way, 37 respondents said that improvement of Market area is possible way and few respondents (24) said that Road and Health related infrastructure is the possible way to improve the Tourism industry (**Plate 3**).

Plate 3: Construction of new hotels on the hillslope of Aritar, Eastern Sikkim

5.5.5 PERCEPTION ON ECO- TOURISM AND ADVENTURE TOURISM

❖ **ECO TOURISM**

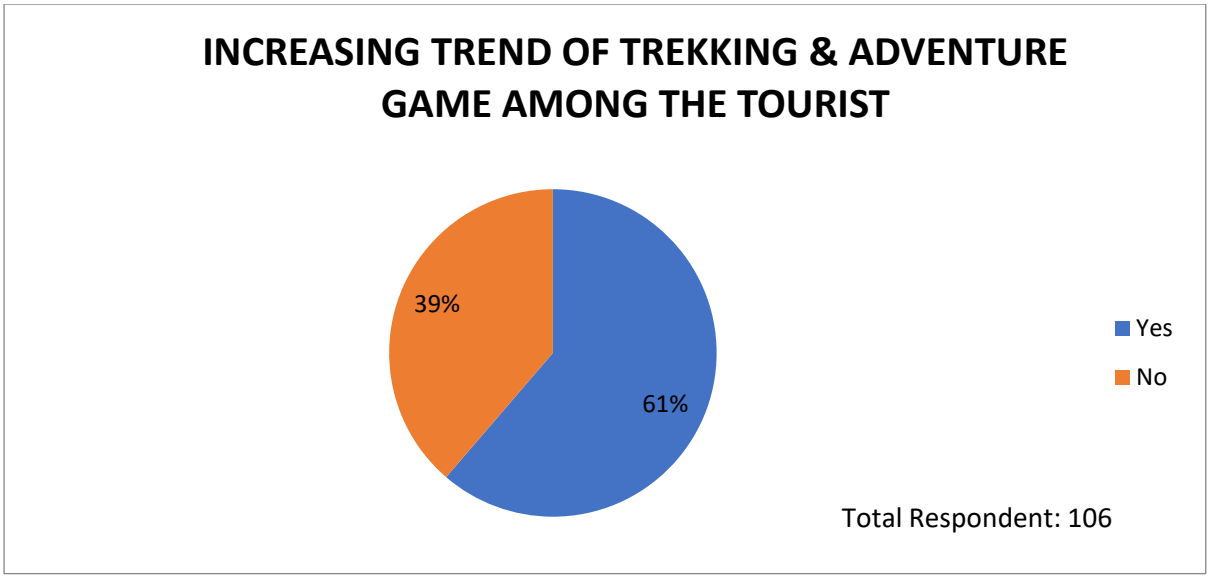
Weather Any Idea of Eco-Tourism	Yes	No
No Of Respondents	68	38
No Of Percentage (%)	64.2	35.8



According to our survey of 106 respondents 64.2% respondents said that they have ideas about Eco- Tourism and 35.8% respondents said they have no ideas about Eco- Tourism.

❖ **ADVENTURE TOURISM**

Do You See Increasing Trend of Trekking & Adventure Game Among the Tourist	Yes	No
No Of Respondents	65	41
No Of Percentage (%)	61.3	38.7



Out of 106 respondents of our survey 61.3% respondents said that they saw an increased trend of trekking and adventure game among the tourists and 38.7% respondents said that they did not see any increasing trend of trekking and adventure game among the tourists.

5. Conclusion

The overall study highlights that Sivok – Rangpo Railway Project is an important project of infrastructure development in Eastern India by connecting Sikkim State through an all-weather railway line for quick transport service of people and goods. However, a major concern is generated among the local people and environmentalists for the possibility of landslide triggering and disturbing local biodiversity for this project. In particular, 58% people are concern about possible influence of this project on tiggering new and old landslides around the railway line, as it is a very sensitive zone of landslide due its soft geological structure and rock composition. People are also concerned about the problem of disturbance on road transportation by frequent road blockage after starting this project, however, they are less aware about the subsequent effect on the possibility house damage due to this project. However, they were also acknowledging the help of local government on issues related to the railway project.

From environmental perspective, peoples are also concern with the negative effect on local biodiversity due to deforestation in and around the railway project to the project itself and corresponding development in tourism industry. They are also suspecting of increasing environmental pollution in form of air pollution, noise pollution, plastic pollution etc.

Nevertheless, local stakeholders of this project are strongly believed that this project will significantly help to increase the tourism industry of Sikkim by attractive new tourists and

corresponding development of new hotels and homestays, essential infrastructure, travel business etc. The concept of eco-tourism is also slowing introducing among the local people and adventure tourism is now also gaining attraction by the tourists.

References

Dash, A.J. 1947: Bengal District Gazetteers, Darjeeling, Govt. of W. B. Publication, Calcutta.

Anbalagan, R., Singh, B., Chakraborty, D., Kohli, A. (2007). A Field Manual for Landslide Investigation. Department of Science and Technology, Govt. of India, Technology Bhawan, New Delhi.

USGS (2023). What is a landslide and what causes one? Retrieved from https://www.usgs.gov/faqs/what-landslide-and-what-causes-one on 20th May, 2023.

Roy, S. (2022). Role of transportation infrastructures on the alteration of hillslope and fluvial geomorphology. The Anthropocene Review, 9(3), 344–378.

Websites

https://bhuvan.nrsc.gov.in/home/index.php

https://bhukosh.gsi.gov.in/Bhukosh/Public

https://wbiwd.gov.in/

Appendixes

Annexure 1: Google Form used for the Perception Survey

Annexure 2: Data Matrix of all Collected Responses