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Demand and User Willingness for Helicopter Services in Mountainous Regions: The Moderating Role of Cost, Economic Factors, and Accessibility

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Abstract: This study investigates the feasibility of commercial helicopter services in the mountainous regions of northern and northeastern India. The study examines the effect of cost and affordability, accessibility and convenience, economical factors and alternative transportation options on the relationship between topography and the demand and user willingness. Qualitative method approach is employed, data is gathered from 546 respondents and SEM modelling is used for analysis purpose. The findings reveal that cost and affordability, accessibility and convenience, alternative transportation options and economical factors have significant mediating effect on the relationship between topography and the demand and user willingness. These findings are valuable for the aviation sector and policymakers.

Keywords- Helicopter services, Structural equation modelling, Mountainous region

Introduction:
Mountainous regions, with their severe topography and scarce inhabitants, pose particular challenges in terms of infrastructure for transportation and connection. Helicopter services have arisen as an important answer to these issues, offering an essential link for the transportation of products and people. Cost, financial circumstances, and accessibility all have an impact on the requirement for helicopter transportation in such places. This study investigates these elements to assess the market for helicopter services in hilly areas, with a particular emphasis on the role of cost, economic issues, and accessibility.

Traditional transportation infrastructure in mountainous places such as India's Himalayas is difficult to build and maintain. Road and railway construction is more expensive and technically hard than in flat terrains due to steep slopes, landslides, and restricted expansion space. Furthermore, the difficult terrain, dispersed population, and numerous sociopolitical variables complicate the construction of transportation networks in these areas.

The economic feasibility of transportation infrastructure in mountainous areas is dependent on solving these problems. Air transportation, despite being more expensive than land and sea transportation, provides unequaled speed and accessibility, particularly for critical and time-sensitive commodities. The expansion of air freight services has allowed enterprises to participate more freely in global supply chains, benefiting regional economies by attracting investment and creating job possibilities.

Helicopter services, in particular, have proven to be game changers for boosting connectivity in remote and inaccessible alpine areas. It was found that helicopters can play an important role in improving communication between rural settlements, allowing products and people to move more easily. This is evident in Himachal Pradesh and Uttarakhand, where the introduction of helicopter services has enhanced connectivity while also boosting tourism, resulting in socioeconomic advantages for local populations.

The introduction of helicopter services in mountainous terrain provides various benefits, including the ability to access remote areas, shorter trip times, and the option to select landing sites. This is especially critical for regions that lack connectivity, limiting access to markets, healthcare, and education. Furthermore, the rugged geography of these places frequently makes it impossible to establish and maintain traditional transportation infrastructure, emphasizing the need of helicopter services.

Connectivity concerns frequently impede economic and social progress in hilly places. Poor transportation infrastructure impedes market access, healthcare and education delivery, and overall regional development. Helicopter services can alleviate these issues by providing a dependable and efficient means of transportation. Improved connectivity has numerous economic benefits, including increased trade, tourism, and socioeconomic integration.

However, the construction of airports and helipads in mountainous areas is limited by the tough topography, which frequently lacks adequate flat land. The building and administration of these facilities require significant financial inputs and involve a number of technological challenges. Furthermore, many airports and helipads in these areas lack modern infrastructure and equipment required for safe and efficient operations.

PPPs provide a feasible operational framework for developing and maintaining helicopter services. Such cooperation can divide costs and advantages between private businesses and government agencies, ensuring the long-term viability of these services. Furthermore, combining the skills and resources of both sectors might result in more inventive and effective solutions to the unique issues encountered in mountainous locations.
Finally, the demand for helicopter services in hilly areas is determined by a complex interaction of factors such as price, economic conditions, and accessibility. Due to the unique problems given by the topography of these locations, helicopter services are an integral component of the transportation infrastructure. Helicopter operations can have a significant impact on the socioeconomic development of mountainous areas by boosting connectivity, promoting economic development, and providing access to important services. The success of such projects, however, is dependent on extensive planning, enough money, and supportive government policies that meet the regions' unique issues.

Literature Review
According to the transportation theory, the term "transportation" comes from the Latin words "trans" (across) and "portare" (to carry), referring to the movement of people and products over long distances via various vehicles and infrastructural networks [8]. Transportation is both an economic and social value, allowing people to commute to work, participate in recreational activities, and run daily errands [20]. Well-developed transportation networks, particularly those that facilitate commerce, market access, and regional integration, contribute significantly to economic growth by lowering costs and enhancing market entry capacities [22].

Efficient transportation systems cut costs, speed up delivery times, and improve supply chain reliability. Improved transportation networks are significantly linked to higher trade volumes and economic growth. For example, improvements in airplane technology have dramatically shortened shipping times, promoting international trade [11]. In mountainous areas, a dependable and efficient transportation system is critical for resource development. Despite the high potential for commodity exports from these areas, customary infrastructure for transportation, such as roads and railways, face major obstacles due to steep slopes, avalanches, and restricted expansion space, resulting in greater expenses than flat terrain [4].

Mountainous regions of India, notably the Himalayas, present severe challenges in developing and maintaining transportation infrastructure. Rugged terrain, dispersed people, land acquisition delays, social instability, environmental permits, and a scarcity of high-quality construction materials all provide substantial hurdles [9]. Environmental constraints frequently entail detailed assessments of potential consequences and the installation of mitigation measures, resulting in increased costs and time delays [16]. Road development in mountainous places can be much more expensive per kilometer than in level regions, putting local governments under financial duress [4].

The construction of connecting infrastructure in India's Northeastern Region (NER) is critical for sustainable regional socioeconomic growth and integration. However, the difficult terrain and other variables discussed above impede this process. The necessity for appropriate air transportation modes to support agricultural and industrial growth is clear [9].

Air travel, despite being more expensive than land and sea transportation, provides unequaled speed and accessibility, especially for time-sensitive commodities. The increased availability of air freight services has allowed enterprises to engage more freely in global supply chains. Airports help to boost regional economic growth by attracting investments and creating job opportunities, which promotes both domestic and international trade [15].

The introduction of helicopter services in Himachal Pradesh and Uttarakhand has enhanced connectivity, increased tourism, and offered socioeconomic benefits to local populations [18]. Helicopter operations in mountainous environments have various advantages, including the ability to access remote places, shorter travel durations, and a variety of landing site alternatives [19]. Poor connectivity typically stifles economic and social progress in these locations, limiting access to markets, medical care, and education [1].

Government policies and subsidies significantly impact the economic viability of helicopter operations. Expedited regulatory processes and incentives for initial investments, fuel, and maintenance can enhance project feasibility. The Indian government's UDAN (Ude Desh ka Aam Naagrik) scheme aims to improve regional connectivity, including offering helicopter services [17]. Public-private partnerships (PPPs) can also promote infrastructure growth and ensure the long-term viability of helicopter services [6].

The development of airports and airstrips in mountainous regions is limited by the challenging topography, which lacks sufficient level land. Installing and maintaining such facilities pose technological challenges and require significant financial investment [5]. Many airports and helipads suffer from a lack of modern facilities and equipment essential for secure and effective operations. This lack of maintenance and upgrades hinders the progress of air services [7].

Aviation's environmental impacts, such as noise and pollutants, are major problems in mountainous terrain. Efforts to mitigate these effects include enforcing strict environmental standards and employing innovative technologies to reduce noise and pollution. Helicopter operations can also provide societal advantages by increasing access to isolated places, facilitating emergency medical services, and assisting with disaster relief efforts [21].

Research Objectives

1. To examine the association between Demand and User Willingness and various independent factors (Cost and affordability, Alternative transportation options, Topography, Economic factor, and Accessibility and Convenience).
2. To investigate the moderating effect of various factors (Cost and affordability, Alternative transportation options, Economic factor, and Accessibility and Convenience) on the relationship between Topography and Demand and User Willingness.

Research Design

This study uses an empirical research design to collect and analyze data. Empirical investigation is appropriate for this form of social science research as it depends on tangible, verified evidence. Data was collected using qualitative methods to ensure a thorough understanding of the aspects that impact the demand and user willingness for commercial helicopter services.

Sample and Sampling Technique

The participants in this study are individuals residing in the northern and northeastern region of India. Participants were selected using convenience sampling. A total of 585 responses were received and after the data cleaning process the final sample size for this study is 546.

Data Collection Technique

An organized questionnaire was created to collect data through online survey. Data was gathered to evaluate participants' understanding and opinions on different aspects, including Demand and Usage Willingness, Cost and Affordability, Accessibility and Convenience, Alternative Transportation Options, Topography, and Economic Factors. The questionnaire consisted of 35 inquiries, using a 5-point Likert scale that ranged from 1 (strongly disagree) to 5 (strongly agree).

Data Analysis

Analyzed data was to investigate the relationship of Demand and User Willingness with the independent variables of Cost and affordability, Alternative transportation options, Topography, Economic factor, and Accessibility and Convenience. Furthermore, this study examined how these factors influence the link between Topography and Demand and User Willingness.

Analysis and Interpretation

The Kaiser-Meyer-Olkin (KMO) test is a statistical technique employed to assess the sufficiency of the sample. This assessment evaluates the adequacy of the data for factor analysis and the acceptability of the sample for each specific variable and the overall model. A KMO test value greater than 0.5 is necessary to ensure the sufficiency of the sample (Kaiser, H.F.,1974). The Bartlett's test of Sphericity is performed to assess the presence of multicollinearity among the variables included in component analysis 2. The KMO test value is 0.916 (>0.5) which indicates that the sample is adequate for the factor analysis and the Bartlett’s test of sphericity has the approx. chi-square value 10677.988 with degree of freedom 2775 and significant p- value 0.000 (<0.001) which indicates that there is no multicollinearity among the variables and we can apply the factor analysis.

Using the Principal Component Analysis according to recommendation of 13, 6 variables out of 35 variables, are extracted with eigenvalues greater than 1, with 62.670 % of the variability explained by these extracted variables.

TABLE 1: EXTRACTED FACTORS WITH THEIR EIGENVALUES, % OF VARIANCE AND CUMULATIVE

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.251	29.290	29.290	10.251	29.290	29.290	5.679	16.227	16.227
2	3.289	9.397	38.687	3.289	9.397	38.687	3.443	9.837	26.064
3	2.585	7.385	46.071	2.585	7.385	46.071	3.410	9.743	35.807
4	2.476	7.076	53.147	2.476	7.076	53.147	3.232	9.234	45.041
5	1.990	5.686	58.833	1.990	5.686	58.833	3.166	9.045	54.086
6	1.343	3.837	62.670	1.343	3.837	62.670	3.004	8.584	62.670

Factor loadings refer to the simple relationships between variables and factors. Factor loadings reveal the extent to which the items are able to represent the underlying factor. The factor matrix contains the factor loadings of each variable on each extracted factor. The investigation employed principal components extraction and factor analysis to see if they represent identifiable elements linked to factors influencing demand and user willingness. Below table, provides the loadings of the various factors.

TABLE 2: LOADINGS OF FACTORS BY ROTATED COMPONENT MATRIX

Latent variable	Latent variable Name		Variable	Loading
Demand_Usage (Dependent)	Demand and Usage Willingness	←	Demand_A	0.813
		←	Demand_I	0.700
		←	Demand_G	0.689
		←	Demand_D	0.674
		←	Demand_B	0.657
		←	Demand_E	0.657

		←	Demand_C	0.645
		←	Demand_H	0.640
		←	Demand_J	0.637
		←	Demand_F	0.616
Economical_Factor (Independent)	Economical Factor	←	Economical_A	0.859
		←	Economical_E	0.811
		←	Economical_D	0.800
		←	Economical_B	0.796
		←	Economical_C	0.765
Topography_Factor (Independent)	Topography Factor	←	Topography_A	0.869
		←	Topography_D	0.786
		←	Topography_B	0.776
		←	Topography_C	0.761
		←	Topography_E	0.755
Accessibility_Convenience (Independent)	Accessibility and Convenience	←	Accessibility_A	0.885
		←	Accessibility_E	0.746
		←	Accessibility_C	0.737
		←	Accessibility_D	0.735
		←	Accessibility_B	0.723
Alternative_Transportation (Independent)	Alternative Transportation Options	←	Alternative_C	0.762
		←	Alternative_A	0.761
		←	Alternative_D	0.759
		←	Alternative_E	0.742
		←	Alternative_B	0.725
Cost_Affordability (Independent)	Cost and Affordability	←	Cost_A	0.773
		←	Cost_C	0.764
		←	Cost_B	0.698
		←	Cost_E	0.669
		←	Cost_D	0.627

Several model fit indices are employed to assess the overall fit of the model. The AMOS-SEM model estimation results, including the values of several criteria such as CMIN/DF, CFI, SRMR, RMSEA, and GFI. These criteria are evaluated against a set threshold for the approximation fit indices. Regarding the CMIN/DF, values over 5 are taken to be unacceptable, values exceeding 3 are considered acceptable, and values beyond 1 are regarded as excellent. CFI values below 0.90 suggest a poor fit, values below 0.95 are considered acceptable, and values over 0.95 are considered excellent. Regarding the SRMR, values above 0.10 are considered to be unacceptable, values above 0.08 are considered to be acceptable, and values below 0.08 are considered to be excellent. RMSEA values exceeding 0.08 suggest an unacceptable fit, values surpassing 0.06 are taken as acceptable, while values below 0.06 are considered excellent. Finally, for GFI, values below 0.80 are considered unacceptable, values above 0.85 are considered acceptable, and values above 0.90 are considered excellent 10.

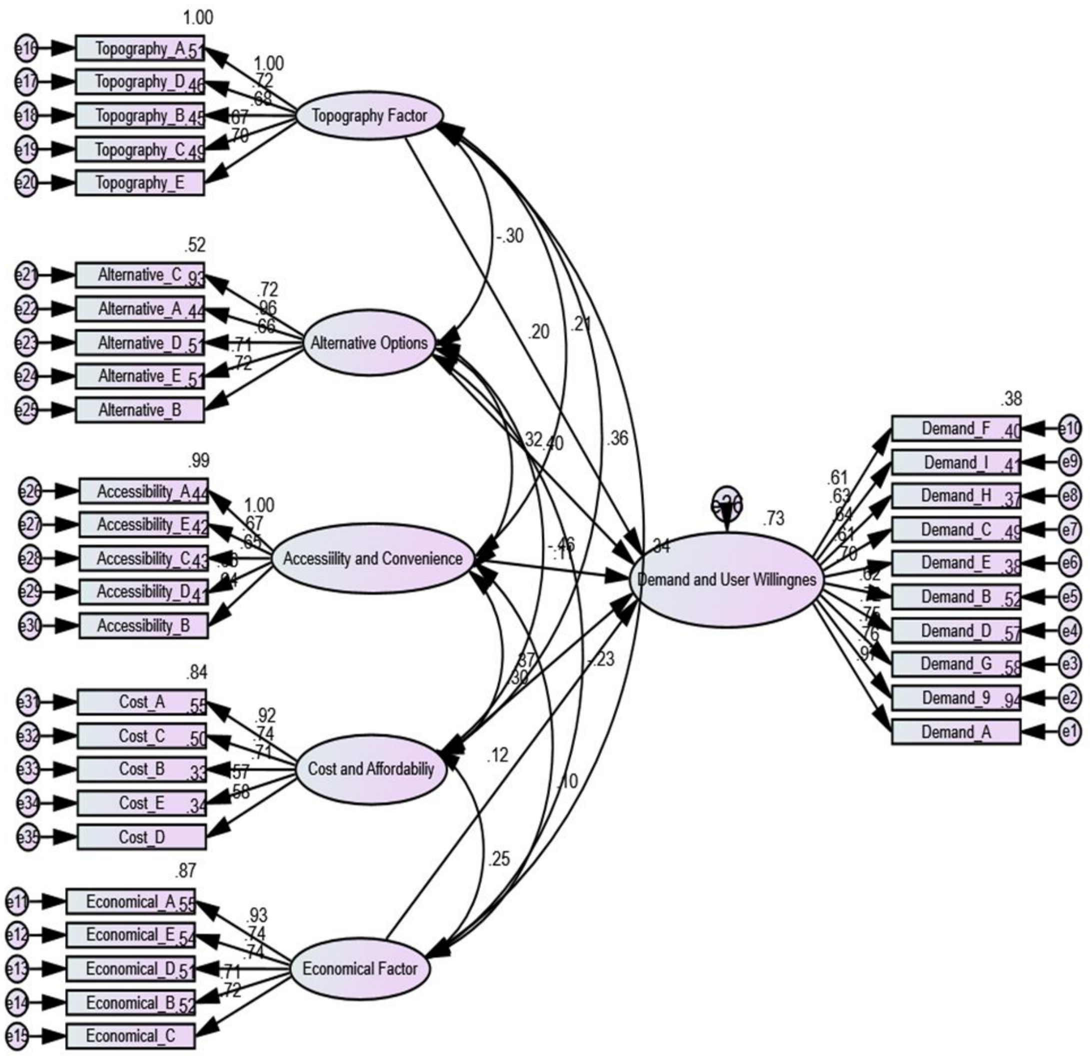
TABLE 3: GOODNESS OF FIT INDICES

Measure	Estimate	Threshold	Interpretation
CMIN	737.117	--	--
DF	545	--	--
CMIN/DF	1.353	Between 1 and 3	Excellent
CFI	0.981	>0.95	Excellent
SRMR	0.039	<0.08	Excellent

RMSEA	0.025	<0.06	Excellent
GFI	0.927	>0.90	Excellent

The estimated value for CMIN/DF is 1.353 which falls within the range of 1 to 3, indicating an excellent fit between the model and the data. The CFI value of 0.981 exceeds the threshold of 0.95, indicating an excellent fit. Further, the estimated value of SRMR is 0.039 which is below the threshold of 0.08, indicating an excellent fit between the model and the data. The estimated value of RMSEA is 0.025 which is below the threshold of 0.06, indicating an excellent fit. The estimated value of GFI is 0.927 which exceeds the threshold of 0.90, indicating an excellent fit. In conclusion, we can state that the model fit is excellent.

The internal consistency of the factors is measured by Composite reliability (CR), ranging from 0.836 to 0.908, indicating a strong reliability. Similarly, the Average Variance Extracted (AVE) values, which assess the proportion of variance explained by variables relative to measurement error, are also moderate, ranging from 0.503 to 0.599. This suggests that a significant portion of the variability in the observed variables may be accounted for by the factors. Discriminant validity is determined by analysing Maximum Shared Variance (MSV) values, which should be lower than the corresponding Average Variance Extracted (AVE) values. This suggests that each element is distinct and evaluates a distinct topic. In addition, the MaxR(H) values, which indicate advanced reliability metrics, are exceptionally high, ranging from 0.894 to 0.996. This provides more evidence of the robustness and uniformity of the factors.



Regression weights, also known as path coefficients, estimate the magnitude and direction of the associations between Endogenous variable Demand and User Willingness and various Exogenous variables (Cost and Affordability, Alternative options, Economical Factors and Accessibility and Convenience) within a structural equation model. They quantify the extent to which the endogenous variable varies when the exogenous variable increases by one unit, while taking into consideration other variables in the model. Here, Critical ratio (C.R.) for all connections exceeds the threshold of 1.96 (p-value <0.001) shows a significant connection for each path.

TABLE 4: ESTIMATES OF STRUCTURED MODEL

A. Regression Weights						
Endogenous variable		Exogenous Variable	Estimate	Standardised Estimate	C.R.	P
Demand	<---	Accessibility	0.101	0.113	4.145	***
Demand	<---	Alternative	-0.466	-0.398	-11.426	***
Demand	<---	Cost	0.434	0.373	11.108	***
Demand	<---	Topography	0.185	0.2	6.965	***
Demand	<---	Economical	0.121	0.12	4.214	***
B. Covariance of exogenous variables						
Exogenous Variable			Covariance	C.R.	P	
Topography	<-->	Alternative	-0.252	-6.225	***	
Topography	<-->	Accessibility	0.23	4.707	***	
Topography	<-->	Cost	0.303	7.381	***	
Economical	<-->	Topography	0.337	7.221	***	
Alternative	<-->	Accessibility	-0.279	-6.59	***	
Alternative	<-->	Cost	-0.311	-8.453	***	
Economical	<-->	Alternative	-0.176	-4.693	***	
Accessibility	<-->	Cost	0.263	6.28	***	
Economical	<-->	Accessibility	0.105	2.287	0.022	
Economical	<-->	Cost	0.199	5.221	***	

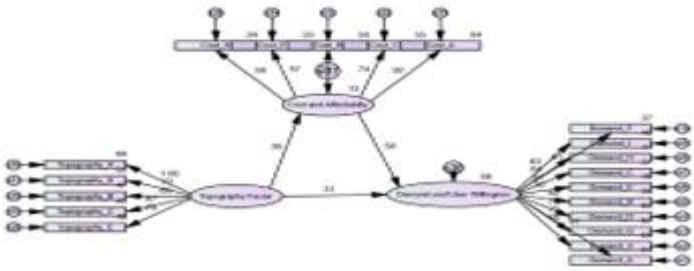
Further, Covariance indicates the extent to which two variables exhibit a simultaneous change. It estimates the magnitude and degree of the linear correlation between sets of exogenous variables. A positive covariance signifies a direct relationship between two variables, where an increase in one variable corresponds to an increase in the other variable. Conversely, a negative covariance shows an inverse relationship, where an increase in one variable corresponds to a decrease in the other variable. The relationship between topography and alternative transportation options is strongly negative (estimate = -0.252, $p < 0.001$). On the other hand, topography has a positive relationship with accessibility.

Regression analysis was conducted to examine the mediating effect of Cost and affordability in the relationship between the Topography and Demand and User Willingness. Table and Figure explains that the direct effect between Topography and Cost is significant (Standardised estimate = 0.355, C.R. = 8.142, p<0.001). Also, there is significant relationship between Topography and Demand and User Willingness (Standardised estimate = 0.308, C.R. = 9.039, p<0.001). Additionally, there is significant relationship between Cost and Demand and User Willingness (Standardised estimate = 0.583, C.R. = 15.436, p<0.001).

TABLE 5: MEDIATING EFFECT OF COST AND AFFORDABILITY

Predicted Relationship	Standardised Estimate	C.R.	p-value	Indirect Effects	Total Effects
Topography ---> Cost	0.355	8.142	***	-	0.355
Topography ---> Demand	0.308	9.039	***	0.207**	0.515
Cost ---> Demand	0.583	15.436	***	-	0.583

Thus, the direct effects explained a significant relationship between the variables. Moreover, the indirect effect with a value of 0.207 ($p<0.01$) also shows a significant relationship with a total effect of 0.515 ($p<0.01$) between Topography and Demand and User Willingness. Hence, it concludes that Cost and Affordability are found to be mediating (0.207) between the Topography and Demand and User Willingness

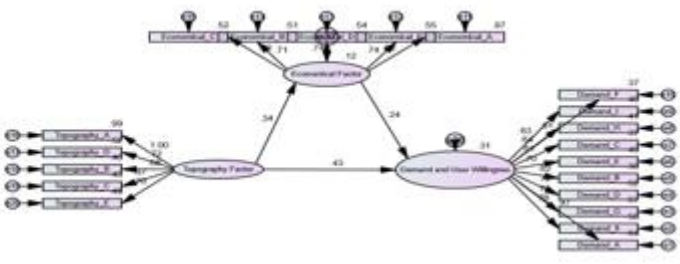


Regression analysis was conducted to examine the mediating effect of Economical Factors in the relationship between the Topography and Demand and User Willingness. Table and Figure explains that the direct effect between Topography and Economical Factors is significant (Standardised estimate = 0.341, C.R. = 7.941, $p<0.001$). Also, there is significant relationship between Topography and Demand and User Willingness (Standardised estimate = 0.435, C.R. = 10.797, $p<0.001$). Additionally, there is significant relationship between Economical Factors and Demand and User Willingness (Standardised estimate = 0.236, C.R. = 5.721, $p<0.001$).

TABLE 6: MEDIATING EFFECT OF ECONOMIC FACTORS

Predicted Relationship	Standardised Estimate	C.R.	p-value	Indirect Effects	Total Effects
Topography ---> Economical	0.341	7.941	***	-	0.341
Topography ---> Demand	0.435	10.797	***	0.081**	0.515
Economical ---> Demand	0.236	5.721	***	-	0.236

Thus, the direct effects explained a significant relationship between the variables. Moreover, the indirect effect with a value of 0.081 ($p<0.01$) also shows a significant relationship with a total effect of 0.515 ($p<0.01$) between Topography and Demand and User Willingness. Hence, it concludes that Economical Factors are found to be mediating (0.081) between the Topography and Demand and User Willingness.



Regression analysis was conducted to examine the mediating effect of Accessibility and Convenience in the relationship between the Topography and Demand and User Willingness. Table and Figure explains that the direct effect between Topography and Accessibility and Convenience is significant (Standardised estimate = 0.207, C.R. = 4.874, $p<0.001$). Also, there is significant relationship between Topography and Demand and User Willingness (Standardised estimate =

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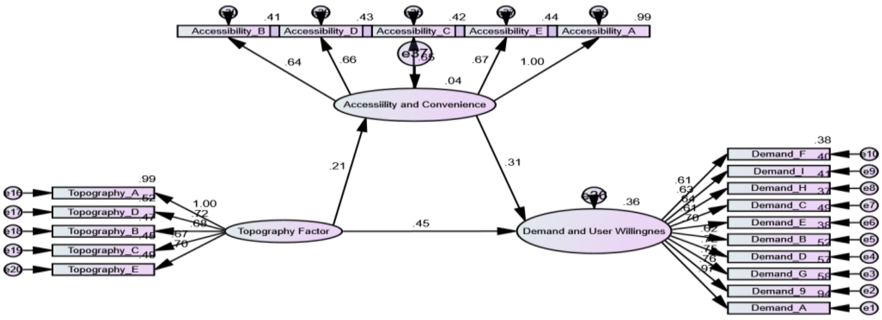
0.45, C.R. = 12.041, p<0.001). Additionally, there is significant relationship between Accessibility and Convenience and Demand and User Willingness (Standardised estimate = 0.312, C.R. = 8.378, p<0.001).

TABLE 8: MEDIATING EFFECT OF ACCESSIBILITY AND CONVENIENCE

Predicted Relationship	Standardised Estimate	C.R.	p-value	Indirect Effects	Total Effects
Topography ---> Accessibility	0.207	4.874	***	-	0.207
Topography ---> Demand	0.45	12.041	***	0.064**	0.515
Accessibility ---> Demand	0.312	8.378	***	-	0.312

Thus, the direct effects explained a significant relationship between the variables. Moreover, the indirect effect with a value of 0.064 (p<0.01) also shows a significant relationship with a total effect of 0.515 (p<0.01) between Topography and Demand and User Willingness. Hence, it concludes that Accessibility and Convenience are found to be mediating (0.064) between the Topography and Demand and User Willingness.



Result

A. ***Factor analysis***

The study commenced by conducting a factor analysis to ascertain the fundamental elements that influence the demand and consumer inclination towards commercial helicopter services in the northern and northeastern regions of India. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.916, indicating that the sample was sufficient for the analysis. Furthermore, the Bartlett's test of sphericity yielded a significant result (p < 0.001), indicating that the data was appropriate for conducting factor analysis. There were six components identified with eigenvalues larger than 1, which accounted for 62.670% of the variation. These characteristics were determined to be crucial in comprehending the intricacies of demand and user willingness.

B. Regression analysis

A regression analysis was performed to ascertain the direct impacts of different exogenous variables on demand. The findings revealed that accessibility (Estimate: 0.101, p < 0.001), cost (Estimate: 0.434, p < 0.001), topography (Estimate: 0.185, p < 0.001), and economic variables (Estimate: 0.121, p < 0.001) exhibited positive and statistically significant associations with demand and user willingness. These findings indicate that enhancements in accessibility, cost-effectiveness, good topographical circumstances, and economic variables might greatly increase the demand and user willingness for commercial helicopter services. In contrast, the availability of alternative transportation choices had a detrimental effect on demand (Estimate: -0.466, p < 0.001), suggesting that the presence of other feasible transportation options decreases the inclination towards using helicopter services.
Covariance of exogenous variables

The analysis shows significant correlations were found among all these variables. For example, there were strong associations between topography and alternative transportation alternatives (Estimate: -0.252, $p < 0.001$), accessibility (Estimate: 0.230, $p < 0.001$), cost (Estimate: 0.303, $p < 0.001$), and economic variables (Estimate: 0.337, $p < 0.001$). In addition, there were strong correlations between accessibility and both cost (Estimate: 0.263, $p < 0.001$) and alternative transit alternatives (Estimate: -0.279, $p < 0.001$). These findings emphasize the intricate interaction among these components, indicating that alterations in one variable might result in a series of consequences on other variables.

C. Mediating Effects

The findings demonstrated that economic factors play a crucial role in mediating this association, suggesting that enhancements in economic conditions can amplify the positive influence of attractive topography on demand. Furthermore, it was discovered that cost and accessibility had a direct and positive influence on demand, whereas alternative transportation options had a detrimental effect. The results suggest that economic reasons, accessibility, and cost are all significant factors in influencing the relationship between topography and demand. This emphasizes the need to address these elements in order to increase the demand for helicopter services.

Discussion

The study unveils key factors that influence the demand and user willingness for commercial helicopter services in the hilly regions of northern and northeastern India. Significant positive correlation is highlighted between cost and affordability, accessibility and convenience, topography, and economical factors. The findings highlight that superior service and competitive pricing are necessary to attract passengers, considering the adverse effects of alternative transportation options.

The interrelationship between these external factors suggests the requirement for a holistic strategy in planning helicopter services. Cost and affordability, accessibility and convenience, and economic conditions play mediating roles, indicating that enhancing these aspects can facilitate the benefits of attractive topography, thereby boosting the demand and user willingness.

In summary, this study emphasizes the importance of thorough planning and strategical implementation for commercial helicopter services. By focusing on these key influencing factors, it is feasible to increase demand and offer a sustainable transportation solution in the mountainous regions.

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