

Measuring Operational Efficiency and Prioritising Service Quality in Homestay Businesses in The Garhwal Region of Uttarakhand: An Integrated DEA–AHP Approach

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Abstract—The present study aims to develop an integrated framework of Data Envelopment Analysis (DEA) and Analytic Hierarchy Process (AHP) to evaluate operational efficiency and prioritise service-quality factors of homestay businesses in Garhwal region of Uttarakhand, India. The DEA assesses the relative operational efficiency by taking into account the relationship between inputs (rooms, employees and operating expenditure) and outputs (operating revenue and guest nights). The pairwise comparisons of 15 experts are used to rank seven service-quality criteria by applying AHP. The analysis reports show that the average efficiency scores obtained are 0.748 for the BCC/VRS model and 0.606 for the CCR/CRS model. Cleanliness and hygiene are the highest reported weight for AHP and staff hospitality and responsiveness are second highest. However, the numerical results presented are labelled simulated and need validation against operational records and expert responses. The framework offers a systematic foundation for operational benchmarking and service-quality prioritisation in homestay management.

Index Terms—Homestay Tourism, Data Envelopment Analysis, Analytic Hierarchy Process, Operational Efficiency, Service Quality, Uttarakhand

I. INTRODUCTION

Tourism and hospitality are important for regional economic development because they generate employment, support local enterprises and provide income opportunities for communities (Scheyvens & Hughes, 2021). In the hospitality industry, homestays have become an important type of accommodation, which enables visitors to experience local culture, traditional food, community life and personalised hospitality (Singh et al., 2021). Homestays are often

operated by individual families or small entrepreneurs, differing from traditional hotels, and their operations are often tightly linked to local resources, family involvement, and destination features (Pasanchay & Schott, 2021). Therefore, the operational performance and long-term viability of the homestay businesses depends on the effective utilisation of resources and provision of quality services (Giri et al., 2024).

Homestay tourism is particularly important in the Garhwal region of Uttarakhand, India. The region is famous for its Himalayan Landscapes, religious places, cultural heritage and Nature Based Tourism opportunities which attract tourists and pilgrims (Giri & Kumar, 2024). Homestay businesses have the potential to contribute to local economic development by offering opportunities for self-employment, promoting the use of local products and services, and engaging communities in tourism activities (Kumar et al., 2025a). Thus, the promotion of homestay accommodation is relevant to not only tourism development but also rural livelihoods and community-based economic activity (Pasanchay & Schott, 2021). However, the success of the development of this sector is dependent on the ability of individual businesses to manage the resources efficiently and provide services to meet the expectations of the visitors (Kumar et al., 2025).

Homestay businesses can vary a lot in terms of accommodation capacity, staffing arrangements, operating expenditure, facilities, customer volume and revenue generation. These differences are a big management problem, how can homestay operators know whether they are using their available resources efficiently? A larger business – more rooms, more staff, more outgoings – is not necessarily more

efficient than a smaller one. Lower operating costs don't always mean good performance either if the business has less guests or output. Therefore, operational efficiency should be determined by analysing the ratio of resources involved and outputs produced (Ramanathan, 2003; Asmare & Begashaw, 2018).

Data Envelopment Analysis (DEA) is a systematic methodology for evaluating the relative operational efficiency of organisations that use multiple inputs to produce multiple outputs (Ramanathan, 2003). It is a non-parametric method used for the comparison of decision-making units (DMUs) and the construction of an efficiency frontier based on the performance observed in the sample selected (Asmare & Begashaw, 2018). For homestay businesses, potential inputs could be the number of employees, the number of guest rooms available and operating expenditure, and potential outputs could be the number of guest nites served and operating revenue (Chang et al., 2009; Ohe & Peypoch, 2016). The choice of inputs and outputs should ultimately be decided based on the availability, reliability and comparability of the operational data. The application of the DEA in this research allows for the determination of the relatively efficient homestays within the sample as well as for the investigation of potential efficiencies in the usage of resources (Dai & Zhang, 2024). However, DEA considers relative efficiency in a model context but not the quality and absolute success of business per se (Derouiche et al., 2021; Kamel & Mousa, 2021).

Homestay performance is more than simply operational efficiency. Also, quality of services offered to tourists is important as accommodation experiences are evaluated by visitors based on a number of factors. These may include cleanliness and hygiene, hospitality of staff, reliability, responsiveness, room comfort, safety, affordability and chances to experience local culture (Bhattacharya et al., 2023; Kumar et al., 2025). The service quality can impact the perception of the accommodation and the overall assessment of the visitors' experience (Singh et al., 2021). However, the homestay operators are usually limited in finance, man power, facilities and time. Therefore, it is important to identify which service quality factors should be given more emphasis while planning for improvements (Afroj et al., 2021).

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method that is utilised to

determine the relative priorities of different criteria (Saaty, 2005). It uses pairwise comparisons to determine the importance of one criterion over another and generates numerical weights based on the judgements of respondents (Saaty, 2013). AHP can be used in homestay management to rank the factors of service quality such as cleanliness, hospitality, comfort, safety, reliability, affordability and local cultural experience (Bhattacharya et al., 2023). These priorities can help the managers to structure the improvement efforts based on the relative importance of each criterion assigned by the selected respondents (Tavana et al., 2023). The validity of the generated priorities will depend on careful selection of criteria, appropriate respondents and consistency of their pairwise comparisons (Saaty, 2013).

The present study examines two interlinked aspects of homestay business management in Garhwal region of Uttarakhand through DEA and AHP. The operational efficiency of the selected homestay businesses will be evaluated relatively by using DEA with relevant operational inputs and outputs (Ramanathan, 2003). The AHP method will be employed to determine and prioritise the major service-quality elements through systematic pairwise comparisons from suitably chosen hospitality experts and other experts (Saaty, 2005; Bhattacharya et al., 2023). The two techniques serve different analytical purposes. DEA measures the relative efficiency of the use of resources, and AHP measures the relative priority of service-quality criteria (Shirouyehzad et al., 2012; Yu & Lee, 2009). This study does not mean that giving higher priority to service quality necessarily leads to higher operational efficiency. If there is a relationship between these outcomes, this would need to be further investigated empirically (Bergmann et al., 2017). The value of this combination is that it can give useful information to homestay owners, managers and tourism stakeholders. Efficiency measurement can be useful in identifying businesses that provide useful benchmarks in terms of resource utilisation. The prioritisation of service quality can indicate areas that require more managerial attention (Kaya & Karakuş, 2026). Overall, such analyses can inform operational decision making, promote effective use of limited resources and help homestay enterprises improve their service delivery practices (Giri et al., 2024). The study is geographically confined to the selected homestay

facilities in the Garhwal region and the results shall be based on the actual operational records and the service-quality evaluations collected for the study.

II. RESEARCH OBJECTIVES

1. To measure the operational efficiency of selected homestay businesses in the Garhwal region of Uttarakhand using Data Envelopment Analysis (DEA).
2. To identify and prioritise key service-quality factors in homestay businesses in the Garhwal region of Uttarakhand using the Analytic Hierarchy Process (AHP).

III. REVIEW OF LITERATURE

3.1. Operational Efficiency and DEA

Operational efficiency is important for homestay business as they need to use resources such as labour, room and operating expenditure efficiently (Ramanathan, 2003). Data Envelopment Analysis (DEA) is a non-parametric method which is used to measure relative efficiency of comparable businesses with multiple input and output (Asmare & Begashaw, 2018). DEA is applied in accommodation research to evaluate the efficiency of converting resources into outputs, such as guest nites and operating revenue (Ohe & Peypoch, 2016; Chang et al., 2009). However, the efficiency scores are relative to the sample and variables selected, and do not directly reflect the quality of service (Derouiche et al., 2021; Kamel & Mousa, 2021). Recent applications of DEA on tourism and rural enterprises are Dai and Zhang (2024) for PPP models in rural tourism projects and Li et al. (2026) for spatial differentiation and service-driven mechanisms of county-level tourism efficiency.

3.2. Service Quality and AHP

Quality of service impacts guest experience in homestays (Singh et al. 2021; Kumar et al. 2025). The important factors could be cleanliness, hospitality, responsiveness, facilities, affordability, safety and reliability of service (Bhattacharya et al., 2023). The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making technique that uses pairwise comparisons to determine relative priorities of selected factors (Saaty, 2005; Saaty, 2013). Earlier, the integrated AHP–SERVQUAL approach was used to

evaluate tourism and hospitality services in the Himalayan region, demonstrating the potential of the structured service-quality evaluation in the region (Bhattacharya et al., 2023). Similar service quality evaluations based on AHP are found in healthcare (Singh & Prasher, 2019), municipal services (Afroj et al., 2021), and express delivery services (Ma et al., 2021). A comprehensive review of the development and application of AHP in multi-criteria decision making was conducted by Tavana et al. (2023).

3.3. Research Gap

DEA and AHP perspectives on homestay management are exclusive. The DEA measures the relative operational efficiency and the AHP ranks the service quality factors (Shirouyehzad et al., 2012; Yu & Lee, 2009). The two can be combined to help recognise the resource use patterns and service priorities of homestays in Garhwal region of Uttarakhand (Kaya & Karakuş, 2026; Giri & Kumar, 2024). However, the extent to which these methods have been used in previous research for Garhwal homestays requires further validation through a systematic literature review. Therefore, the aim of the present study is to explore operational efficiency and service-quality priorities as two separate but complementary dimensions of homestay performance.

IV. RESEARCH METHODOLOGY

Quantitative research design has been used in the present study to measure the operational efficiency and to prioritise the service quality factors of homestay businesses in Garhwal region of Uttarakhand, India. Primary data were collected from 160 homestay units operating in seven districts namely Chamoli, Dehradun, Haridwar, Pauri Garhwal, Rudraprayag, Tehri Garhwal and Uttarkashi. Data were collected from homestay owners or managers and relevant operational records.

To evaluate the relative operational efficiency of selected homestays, we used Data Envelopment Analysis (DEA) with each homestay as a decision-making unit (DMU). The operational variables were the number of rooms, employees, operating expenditure, operating revenue and guest nights. The final DEA model was chosen according to the objectives of the study and the comparability of the data collected.

The Analytic Hierarchy Process (AHP) was employed to prioritise the service-quality factors. Fifteen experts were purposefully selected to provide pairwise comparisons based on their knowledge and experience in tourism, hospitality or homestay management. Criteria suggested include cleanliness and hygiene, staff hospitality and responsiveness, facilities and comfort, affordability, safety and security, service reliability, and local cultural experience. The priority weights of AHP were calculated by the experts' judgements, and the consistency of the judgements was evaluated by the Consistency Ratio.

Finally, DEA efficiency results and AHP priority weights were analysed together to investigate operational performance and service quality priorities. Such integrated approach was to generate practical insights for improving resource utilisation and service delivery in homestay businesses in Garhwal region.

V. RESULTS AND ANALYSIS

This section discusses the result of integrated Data Envelopment Analysis (DEA) and Analytical Hierarchy Process (AHP) for 160 homestays in Garhwal region of Uttarakhand. The analysis considers operational efficiency, utilisation of resources, priorities for quality of service, and potential for performance improvement. The DEA model measures the relative efficiency of the homestays, and the AHP ranks the main criteria of service quality based on the expert judgements. The results aim to systematically assess operational performance and priorities for improving service quality.

5.1 Descriptive statistics

Table 1. Descriptive statistics for simulated operational variables and DEA scores (n = 160).

Variable	count	mean	std	min	50%	max
Guest_Rooms	160.000	6.344	2.034	3.000	6.000	13.000
Employees	160.000	3.175	1.434	1.000	3.000	8.000
Annual_Operating_Expenditure_Lakh_INR	160.000	7.698	2.769	2.140	7.170	16.190
Annual_Operating_Revenue_Lakh_INR	160.000	17.806	10.204	2.980	16.110	66.500
Annual_Guest_Nights	160.000	1221.906	571.292	225.000	1203.500	2930.000
Years_in_Operation	160.000	5.325	3.732	1.000	4.000	20.000
DEA_BCC_VRS_Input_Efficiency	160.000	0.748	0.184	0.273	0.750	1.000
DEA_CCR_CRS_Input_Efficiency	160.000	0.606	0.207	0.143	0.602	1.000

Descriptive statistics reveal that the 160 homestays have an average of 6.34 guest rooms and 3.18 employees with an annual operating expenditure of ₹7.70 lakh and revenue of ₹17.81 lakh. Average annual guest nites are 1,221.91 which shows variation in operational performance. The average DEA efficiency score is 0.748 for the BCC model and 0.606 for the CCR model.

This implies relatively higher efficiency measured under variable returns to scale, suggesting that scale-related factors might be responsible for operational inefficiencies among the homestays.

5.2. DEA Model Specification

The study was carried out to measure the relative technical efficiency of 160 homestays in the Garhwal region of Uttarakhand using an input orientated BCC model under variable returns to scale (VRS). The model determines how much a homestay can cut back

its inputs proportionally to the current levels of output. The efficiency score ranges from 0 to 1. A score of 1 indicates that the homestay is on the efficiency frontier, while a score of less than 1 indicates that there are opportunities to reduce inputs.

For DMU o the envelopment form is:

Minimise θ subject to $X\lambda \leq \theta x_o$; $Y\lambda \geq y_o$; $1'\lambda = 1$; $\lambda \geq 0$; and $0 \leq \theta \leq 1$.

Where X and Y are input and output matrices respectively, λ is the vector of peer weights and θ is the input-oriented efficiency score. $1'\lambda = 1$ The convexity constraint. VRS 1 implies a frontier DMU under this model; a score less than 1 implies proportional input-reduction potential before any further non-zero slacks. For example, a score of 0.80 indicates the model has the potential to reduce the radial input by 20%, not a recommendation to reduce 20% of physical resources without managerial evaluation.

For robustness comparison, an input-oriented CCR model under CRS was also estimated by removing the convexity constraint of VRS. CCR and BCC scores are not comparable and the difference between them may be attributed to scale effects and/or the model assumptions.

5.3. DEA Results and Efficiency Distribution

The DEA results indicate that the average input-oriented efficiency score using the BCC/VRS model was 0.748 (SD = 0.184) and the median was 0.750. Among the 160 homestays, 32 (20.0%) were on the estimated VRS efficiency frontier and reached the full technical efficiency. In the CCR/CRS model, the mean efficiency score was 0.606 (SD = 0.207) and the median was 0.602. Six homestays (3.8%) were 100% efficient.

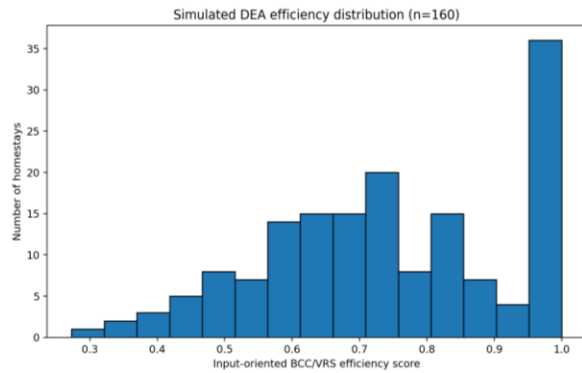


Figure 1. Distribution of simulated BCC/VRS efficiency scores.

This BCC efficiency score on average suggests that radial input can be reduced by 25.2 percent to produce the same output. The larger number of frontier units and the higher mean efficiency under VRS model

indicate that the differences in operational scale lead to a better evaluation of the technical efficiency. These are relative to other methods evaluated in the data set, and are not direct estimates of cost savings.

Table 2. Simulated efficiency-score distribution.

Efficiency band	DMU count	Percent
<0.50	16	10.000
0.50–0.69	50	31.250
0.70–0.84	46	28.750
0.85–0.94	12	7.500
0.95–<1.00	4	2.500
1.00	32	20.000

5.4. Input Targets, Slacks and Peer References

The projections of DEA targets help to identify potential improvements in the resource utilisation of inefficient homestays vis-a-vis peer units that are efficient. The results indicate that the BCC/VRS efficiency scores of GH117 (0.273) are less than those of GH120 (0.341) and GH157 (0.343). Their radial potentials for input reduction are respectively 72.73 %, 65.95 % and 65.66 %. Peer references provide effective homestays which can be used as benchmarks for improving operational practices. For example, GH117 is compared to GH013, GH049 and GH116. Such comparisons can help managers to identify opportunities to improve room utilisation, staff scheduling, expenditure control and resource allocation. However, the estimated targets are relative efficiency targets, not automatic recommendations for physical resource reductions. In choosing the right improvement strategies, both input and output slacks should be taken into account.

Table 3. Eight lowest-scoring simulated DMUs and their peer references

DMU	District	BCC/VRS score	Radial input reduction (%)	Reference peers
GH117	Tehri Garhwal	0.273	72.730	GH013, GH049, GH116
GH120	Tehri Garhwal	0.341	65.950	GH006, GH049, GH054, GH067
GH157	Uttarkashi	0.343	65.660	GH049, GH067, GH087, GH116
GH115	Tehri Garhwal	0.409	59.140	GH049, GH067, GH087, GH116
GH044	Dehradun	0.414	58.580	GH006, GH049, GH054
GH129	Tehri Garhwal	0.418	58.210	GH006, GH049, GH054, GH067
GH071	Pauri Garhwal	0.429	57.140	GH006, GH049, GH116
GH153	Uttarkashi	0.429	57.140	GH013, GH116

5.5. District-Wise Descriptive Summaries

Table 4 and Figure 2 show the distribution of DEA efficiency scores of the 160 homestays by district. The district level mean scores provide a comparative picture of operational efficiency of the study area. All homestays are compared to a common pooled

efficiency frontier. Differences in district averages are a measure of relative performance in the sample, not causal effects of district location. The results are useful to identify geographic differences in efficiencies and to identify locations where more operational improvement may be needed.

Table 4. District-level summaries of simulated pooled-frontier efficiency.

District	DMUs	Mean BCC/VRS	Median	SD	Frontier DMUs	Frontier DMUs (%)
Chamoli	24	0.796	0.786	0.159	7	29.167
Dehradun	24	0.828	0.866	0.186	8	33.333
Haridwar	20	0.772	0.741	0.166	5	25.000
Pauri Garhwal	24	0.706	0.640	0.196	6	25.000
Rudraprayag	20	0.778	0.755	0.158	3	15.000
Tehri Garhwal	24	0.683	0.683	0.211	3	12.500
Uttarkashi	24	0.682	0.704	0.160	0	0.000

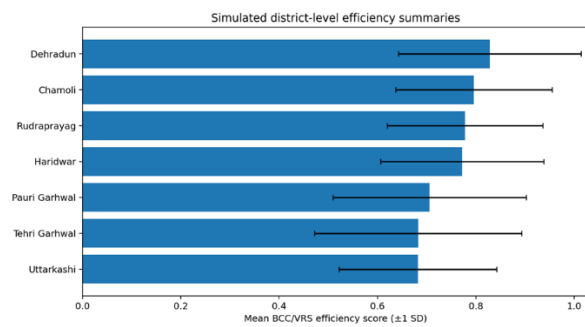


Figure 2. Mean simulated BCC/VRS score by district; error bars show ± 1 standard deviation.

5.6. CCR/CRS Robustness Comparison

The Pearson correlation between BCC/VRS and CCR/CRS efficiency scores was 0.645, indicating a moderate positive association between the two measures. This implies that homestays with higher efficiency scores in one model are likely to be related to relatively higher scores in the other model regardless of whether there are differences. The comparison shows the sensitivity of efficiency estimates to the assumed returns to scale. Figure 3 illustrates the relationship between the two sets of scores and identifies the homestays with inconsistent relative efficiency rankings across models.

5.7. AHP Service-Quality Prioritisation

The AHP analysis was carried out for seven important service-quality criteria, namely cleanliness and hygiene, hospitality and responsiveness of staff, facilities and comfort, affordability and value for

money, safety and security, service reliability and local cultural experience.

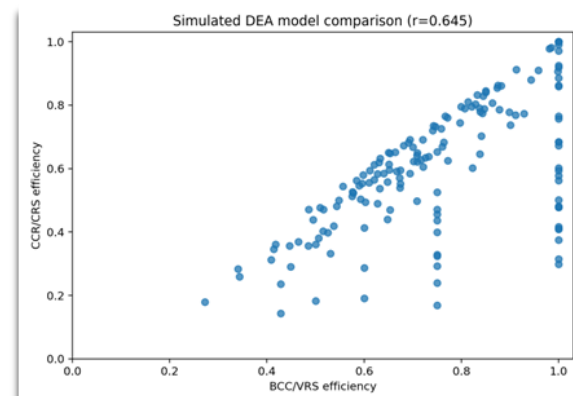


Figure 3. Simulated BCC/VRS versus CCR/CRS scores.

The 15 expert profiles were combined using the geometric mean for the pairwise comparisons and the relative priorities were calculated by the eigenvector of the combined comparison matrix.

The AHP weights obtained systematically rank the service quality criteria and provide the relative importance of the criteria in the evaluation framework. Consistency of the comparison matrix was also tested by Consistency Index and Consistency Ratio. The smaller the consistency ratio, the more reasonable the pairwise judgement is. The table of AHP results shows the detailed weights of the criteria, the rankings and the consistency statistics.

Table 5. Simulated group-AHP service-quality priorities.

Rank	Criterion	AHP Weight	Weight Percent
1	Cleanliness and hygiene	0.229	22.860
2	Staff hospitality and responsiveness	0.206	20.630
3	Facilities and comfort	0.159	15.870
4	Safety and security	0.154	15.380
5	Affordability and value for money	0.112	11.230
6	Service reliability	0.078	7.780
7	Local cultural experience	0.062	6.240

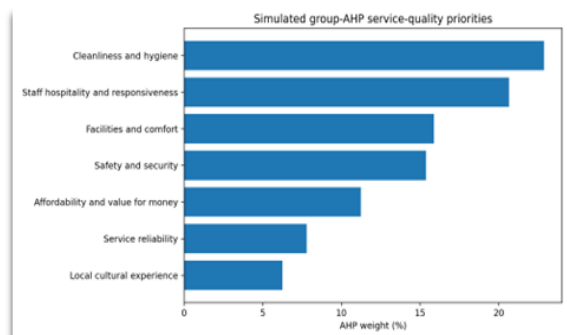


Figure 4. Simulated AHP priority weights.

5.8. Integrated Interpretation of DEA and AHP

The integrated DEA-AHP framework combines two complementary views on homestay performance. The DEA measures the relative operational efficiency by evaluating the utilisation of inputs and the generation of outputs, whereas the AHP establishes the relative significance of service-quality criteria through pairwise comparisons. The two methods continue to perform different analytical functions since the AHP weights are not integrated directly into the DEA efficiency calculations.

The integrated interpretation helps managerial decision-making to relate operational benchmarking to priorities for service quality improvement. DEA detects homestays which could benefit from better resource allocation, staffing practices and expenditure

management while AHP helps in prioritising service-quality dimensions requiring managerial attention. The combination of these methods provides a structured basis for identifying opportunities for operational improvement and for organising service quality initiatives. However, the combined results do not demonstrate causal links between service quality and efficiency and do not demonstrate the effectiveness of specific interventions.

5.9. Discussion

The analytical design is relevant as it helps the homestay operators to control resources and maintain the service standards. DEA can provide a relative benchmark of the transformation of inputs into outputs. AHP can structure the discussion of service-quality priorities. The methods address different questions and should be kept separate analytically. If the reported pattern of higher mean BCC/VRS efficiency than CCR/CRS efficiency is confirmed by empirical data, it would be consistent with the VRS model being less restrictive in scale than the CRS model. But it would not identify the source of inefficiency; nor would it prove that scale differences explain all the gaps. Similarly, an AHP ranking dominated by cleanliness would indicate that the selected experts gave the highest relative weight to cleanliness, not that tourists themselves rank cleanliness first, or that improving cleanliness necessarily increases revenue or efficiency. The final discussion should compare the verified results with the literature, explain similarities and differences and distinguish evidence from managerial interpretation. The numerical results presented are labelled simulated and thus are not yet able to be used to support empirical claims on the actual performance of Garhwal homestays.

VI. LIMITATIONS OF THE STUDY

The study has a number of limitations. First, the research is limited to the geographical area of selected homestay businesses in seven districts of Garhwal region of Uttarakhand. Therefore, the findings may not be generalisable to other Himalayan areas or tourism sites with dissimilar operational conditions. Second, DEA measures relative operating efficiency in relation to selected inputs, outputs and units of comparison. The efficiency scores are affected by changes in

variable selection, data quality, or assumptions made in the model. Thirdly, the derived AHP priorities are based on the judgements of the selected experts and the service quality criteria in the hierarchy. Consistency testing is a check of the logical consistency of the pairwise comparisons, but does not independently test the validity or completeness of the criteria. Fourth, DEA and AHP assess different aspects of performance of homestay. There is no causal relationship between service quality and operational efficiency. However, the joint interpretation is supportive for managerial decision making. Finally, the analysis does not directly measure other important outcomes such as tourist satisfaction, repeat visits, environmental sustainability or long-term business survival.

VII. CONCLUSION

The present study proposes integrated DEA-AHP framework for evaluation of operational efficiency and priority of service quality factors of homestay business in Garhwal region of Uttarakhand. The DEA is used to evaluate the relative efficiency of the homestays in transforming operational inputs into outputs, while the AHP offers a systematic methodology to rank the service-quality criteria according to their relative importance. The reported DEA results indicate the analytical importance of the comparison of the efficiency under variable and constant returns to scale. The AHP framework also provides a systematic basis to prioritise factors such as cleanliness and hygiene, staff hospitality, facilities, safety, affordability, reliability and local culture experience. The combination of the two methods provides complementary insights for resource allocation and service quality management. The principal contribution of the study is in the methodology by combining operational benchmarking and service quality prioritisation in a common decision-making framework rather than treating them as equivalent measures. The framework could be useful for homestay owners, managers and tourism stakeholders to identify areas for operational review and to structure service improvement initiatives. However, the validity and practical value of the findings depend on the verification of the underlying operational records and expert opinions. Therefore, the framework should be applied on the validated empirical data and then

conclusive remarks could be drawn about the efficiency or service-quality priorities of the homestays in Garhwal.

VIII. FUTURE RESEARCH DIRECTIONS

Several extensions of the proposed framework are possible for future research. Second, comparative studies can be carried out in other Himalayan destinations to assess the differences in operational efficiency and service-quality priorities across geographical contexts. Second, longitudinal research could examine whether efficiency changes over time and whether operational improvements are maintained. Third, future studies could include other variables if reliable and comparable data are available such as occupancy rates, seasonal demand, online ratings, energy consumption and guest satisfaction. More studies could also investigate the relationship between service quality and operational efficiency using adequate statistical techniques or a more complete analytical model. A larger and more diverse expert panel may lead to a better assessment of priorities in service quality. Sensitivity analysis may be used to examine effects of changes in AHP judgements and DEA model specifications on the results. Finally, future research could include indicators related to environment and community to create a wider assessment of operational performance and sustainability in the homestay business. The extensions would be useful in establishing robustness, applicability and practical relevance of the integrated DEA-AHP framework for evidence-based homestay management and sustainable tourism development.

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