COMMUNICATION

Usability and accessibility-based quality evaluation of Indian airline websites: An MCDM approach

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Abstract

A tourist may be one of the most diverse kinds of consumer, including many people with disabilities. As a technologically driven industry, the tourism industry focused more on providing online services during the COVID-19 pandemic, where physical activity is limited and people practice social distancing. A company's success may be large extend depend on the quality of the website through which they supply their services. The primary goal of the study presented in this paper is to evaluate the overall quality of Indian commercial airline websites. This study evaluated the seven websites of passenger airlines on usability and accessibility parameters using an online diagnostic tool. Page size, load time, response time, broken links, contrast errors were used as the usability parameters, and the TAW tool was used to evaluate the websites' compliance with WCAG 2.0. The paper proposes a system for determining the best website by utilizing the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), The Analytic Hierarchy Process (AHP), and the Fuzzy AHP methods. The result shows that Indian airline websites have many usability issues, and none of the websites adheres to WCAG 2.0 accessibility guidelines. Friedman's test is applied to compare the ranking given by various MCDM techniques, resulting in no significant difference in the various ranking methods adopted.

Keywords Usability · Accessibility · WCAG 2.0 · Airline websites · TOPSIS · AHP · Fuzzy AHP

1 Introduction

The internet has revolutionized the electronic commerce industry and significantly transformed the E-commerce ecosystem in the last decade. Internet and communication technology enables high-quality, time-efficient, and cost-effective operations in all E-commerce industries, including tourism [1]. The globalization of economic activity and the availability of low-cost internet on all mobile devices require the airline industry to do business through websites to provide their services across the globe.

India announced its national tourism policy in 2002, focusing on establishing a solid infrastructure. The presence of online travel portals and low-cost carrier flights boosted the Indian tourism industry. The World Economic Forum's 2019 Travel and Tourism Competitiveness Report ranks India at the 34 position [2], with a GDP contribution of US$ 200 billion. It generates the country's third-largest amount of foreign exchange.

As a result of COVID-19, the aviation industry has been halted, and recovery has been slow in most markets due to travel restrictions. A prolonged recession and poor consumer confidence hampered the recovery even more. According to the survey of the International Air Transport Association (IATA) [3], globally, the revenue passenger kilometers (RPK) declined by 66 percent in 2020. According to the publication *Global Economic Impact and Trend 2021* [4], domestic travel and tour expenditure decreased by 30.7 percent, while overseas travel and tour spending decreased by 61 percent. In 2020, India's travel and tourism GDP fell by

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36.3 percent compared to 2019. As several countries complete their COVID immunization programs, there will likely be an increase in air travel in the first half of 2022. Following COVID, airline businesses would face stiff competition in retaining and attracting new customers.

Airlines' websites serve as the traveler's entry point; these websites should cater to the needs of the abled persons and the needs of disabled travelers in quickly accessing the website. According to the World Health Organization, over a billion people worldwide are disabled in some way [5]. The World Wide Web Consortium has published web content accessibility guidelines (WCAG), with the first version of WCAG 1.0, published in 1999 [6]. The second version, WCAG 2.0, was published in 2008 [7] to ensure that the websites support the inclusion of various assistive technologies. To cover newer web technologies and support for more disabilities, WCAG expanded the WCAG 2.0 guideline and published WCAG 2.1 in 2019 [8]. Including these guidelines during the development phase of websites makes them universally accessible to all.

Unfortunately, most websites fail to take usability and accessibility into account and hence fail to convert website visitors into consumers. Neglecting disabled people's accessibility difficulties exacerbates the situation. As a result, practitioners and scholars are concerned about practical website evaluation [9].

The primary focus of the current study was on the usability and accessibility criteria for evaluating Indian airline websites. We evaluated the websites of seven Indian commercial passenger airlines: Goindigo, Goair, AirIndia, Air Vistara, Jet Airways, Spice Jet, and Truejet. We used MCDM methodologies to evaluate and rank them based on a number of usability and accessibility parameters: website page size, load time, response time, broken links, contrast faults, and accessibility errors concerning WCAG 2.0.

2 Research questions

The research questions of the study are formulated as follows:

- What is the usability level of Indian airline websites in India?
- What is the level of compliance of Indian Airlines' websites with the WCAG 2.0 accessibility guidelines?
- How are Indian airline websites ranked in terms of usability and accessibility?

The remainder of the paper is structured as follows: Sect. 2 summarises numerous studies conducted worldwide, whereas Sect. 3 discusses the approach used in the current study. Section 4 discusses the evaluation results, while the conclusion is presented in the last section.

3 Literature review

In the literature, several researchers employed a variety of methodologies to assess the quality of hospitality and tourism websites. The main approaches followed by researchers were heuristic usability testing of the websites. Website usability refers to how easy it is for a user to operate a website. A usable website should provide equal access to disabled people with the same ease as the regular user. A well-designed, user-friendly website can retain and draw new users [10]. Defects in usability degrade the user experience on the web and prevent the visitors from revisiting the website.

Nielsen's [11] heuristic evaluation is a well-known evaluation approach used by usability specialists to assess the usability of the software. As Nielsen heuristics failed to address all aspects of website usability, Elberkawi created new heuristics for transactional websites. [12].

To evaluate the website of the LATAM airline group, the author performed heuristic performance testing and usability testing with users [10]. According to the findings, the LATAM group's website has dead links and consistency flaws, which are big roadblocks to modernizing the platform. In [13], the author used the end-users to examine the usability of the Emirate airline website. End-users rate the website's performance on various factors, including the amount of time it takes to complete a task, the amount of time it takes for the user to recover from problems, and the number of errors that occur during the web navigation activity. The findings revealed that while the architecture of a device interface can be measured in terms of user interaction, usability alone is insufficient to determine a website's efficacy and efficiency.

In [14], the author investigated the influence and impact of fiscal and non-fiscal online sales promotional techniques on online airline ticket purchase intent. The results showed that these schemes had a different impact on people based on the user level of internet experience. An online discount on ticket sales influenced novice internet users more, while expert users preferred free hotel stays.

In [15], the author developed a set of 12 culturally relevant usability heuristics and evaluated the usability of 64 e-commerce websites (including airline websites) using a cultural-oriented heuristic evaluation model. The result shows that the culturally focused heuristic reported more usability flaws than the traditional Nielsen's usability heuristics. The group of evaluators who used a cultural-oriented heuristic reported more critical usability flaws than Nielsen's group. In [16], the author assessed the impact of website

usability on travellers' attitudes toward low-cost carrier airline adoption in Ireland. The author used three usability testing techniques to access and verify adoption behavior: usability testing, verbal protocols, and focus groups. Results show that the LCC websites were highly usable.

As the quality attributes of a website are multidimensional, the MCDM technique's application in evaluating the website's quality is inexorable. Many researchers have used the MCDM technique to evaluate the website of various domains. Tsai [17] proposed an integrated model for the air transportation industry. The model used the Decision Making Trial and Evaluation Laboratory (DEMATEL) to establish the relationship between the four marketing criteria (price, product, place, promotion) and website quality. Finally, the author used the VIKOR to rank the performance of five airlines of Taiwan.

In [18], Kemal evaluated the performance of 11 Turkish airline businesses websites. They used the two-stage MCDM integrated entropy weight method and grey relational analysis to evaluate and rank the websites on seven quality parameters. Hidalgo in [19] evaluated the airline website quality based on passenger's perception of services provided by the airline website. The author used the fuzzy linguistic model to represent the users' preference on four quality parameters: intrinsic quality, contextual quality, representation quality, and accessibility and interaction quality. In [20], the author employed online web diagnostic tools to assess the five Asian flag carrier websites' quality metrics. The author applied the AHP method to evaluate the website's rank on the quality parameter selected, and the result shows that the airline website quality is low. Umar in [21] used the expert decision to prioritize the web quality criteria and further evaluated the quality of the e-commerce website of Indonesia using the AHP method. In [22], the author evaluated the quality of Asian airline websites using three MCDM techniques and proposed a hybrid model using a linear weightage model and fuzzy analytical hierarchy process. The result shows that the hybrid proposed model performed better than the existing methods. In 2014 [23], Dominic used the AHP and FAHP-based model to evaluate and compare the quality of the Malaysian airline website based on 11 quality criteria. The result shows the significance of MCDM techniques in the small data set.

Another study by Dominic in 2014 [24] measured the customer acceptance of online services of Malaysian airline websites. The author proposed a model based on the technology acceptance model (TAM) to assess the online system's consumer acceptance. Results show that consumers prefer to carry out online transactions on airline websites. In [25], the authors used the hesitant normalized Manhattan distance to develop a hesitant normalized Manhattan metric. They proposed a hesitant fuzzy VIKOR model by integrating the metric with traditional VIKOR. The authors demonstrate the model's effectiveness through a domestic airline's service quality evaluation case study.

4 Methodology

In this research, the websites of airline companies with operating permission from the director general of civil aviation (DGCA) to operate passenger airlines in India were considered for quality assessment. The DGCA website lists seventeen airline operators providing passenger services [26]. Out of these, ten companies providing helicopter services, private jet, operating small capacity charted planes or cargo services were neglected. Thus, the remaining seven airline companies' websites were considered for this study. Online web diagnostic tools were used to collect the six website usability and accessibility parameters: page load time, response time, web page size, dead links on the web page, color contrast issues, and accessibility errors. The Pingdom online tool evaluates a website's page size, load time, and response time [27]. Broken links or dead links of the websites were collected using the websitepulse tool [28]. WAVEAIM's online version was used to identify the color contrast error on the underlying websites[29]. The accessibility errors in airline websites were evaluated using the online tool TAW [30]. This study uses TAW to check the website conformance with WCAG 2.0 guidelines. After analyzing usability and accessibility, Multicriteria decision-making models, namely TOPSIS, AHP, Fuzzy AHP, were applied to evaluate the ranking of the websites on the usability and accessibility criteria. Finally, statistical analysis was done to validate the results obtained.

5 Results

The usability parameters used in this study, namely the web page's loading time, the constituent of page size, broken links, server response time, contrast errors, and accessibility errors as collected by the web diagnostic tool, are shown in Table 1. The table illustrates that the majority of websites under study do not meet the web quality standards. Most websites fail to meet the load time, page size, and response time standards. The majority of the websites have broken links which degrades the website's usability. All the websites under investigation had color contrast and accessibility errors, making them less accessible to disabled individuals using assistive technology.

5.1 TOPSIS results

The TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) decision-making framework is a

Table 1 Airline website's quality parameters

Website	Load time	page size	broken links	response time	cont errors	acc error
www.airindia.com	4.2	5734.4	4	2	11	34
jetairways.com	5.95	1536	3	1.199	31	34
www.goindigo.in	2.81	998.1	1	1.762	82	628
spiceJet.com	6.04	1228.8	0	1.299	9	499
www.goair.in	3.85	1228.8	2	1.526	23	401
airvistara.com	4.56	6246.4	1	7.641	5	330
www.trujet.com	6.25	3276.8	4	0.491	10	115

multicriteria framework. It allows the user to select the best option from a set of alternatives, assuming that the best option has the smallest geometric distance from the best attainable possible values (positive ideal solution) and the greatest distance from the worst attainable value (negative ideal solution).

The process of TOPSIS starts with the initial m x n matrix having 'm' alternatives $A_1, A_2 \ldots A_m$. Each alternative A_i has n criteria $C_1, C_2, \ldots C_n$, represented by positive number C_{ij}. Each criteria C_i has weight W_i such that $\sum_{i=1}^{n} w_i = 1$. We have seven airline website alternatives to choose from, each of which is judged on six quality criteria: page load time, HTML page size, broken links, page response time, contrast problems, and accessibility failures. Table 2 shows the initial TOPSIS table (T).

Each entry t_{ij} of matrix T contains different criteria with the different measuring units, so the initial matrix needs to be normalized using Eq. 1:

$$n_{ij} = \frac{t_{ij}}{\sqrt{\sum_{i=1}^{m} t_{ij}^2}} \tag{1}$$

The normalized values of the matrix are then replaced with weighted normalized values based on the weight of criteria using Eq. 2.

$$t_{ij} = w_i n_{ij} = w_i \frac{t_{ij}}{\sqrt{\sum_{i=1}^{m} t_{ij}^2}} \tag{2}$$

The value of the positive ideal solution (A_+) and the negative ideal solution (A_-) is then calculated using Eqs. 3 and 4. The positive ideal solution maximizes the benefit criteria while minimizing the cost criteria, while the negative ideal solution maximizes the cost criteria while minimizing the benefit criteria.

$$
\begin{aligned}
A_+ &= \left(t_1^+, t_2^+, \ldots, t_n^+\right) \\
&= \{(\min(t_{ij}|i = 1, 2, \ldots m)| \in J_-), \\
&\quad (\max(t_{ij}|i = 1, 2, \ldots m)j \in J_+)\}
\end{aligned} \tag{3}
$$

$$
\begin{aligned}
A_- &= \left(t_1^-, t_2^-, \ldots, t_n^-\right) \\
&= \{(\max(t_{ij}|i = 1, 2, \ldots m)| \in J_-), \\
&\quad (\min(t_{ij}|i = 1, 2, \ldots m)j \in J_+)\}
\end{aligned} \tag{4}
$$

where.

$J_+ = \{ j = 1, 2, \ldots \ldots, n \mid j\}$ associated with positive impact criteria.

$J_- = \{ j = 1, 2, \ldots \ldots, n \mid j\}$ associated with Negative impact criteria.

In the next step, the distance of the ith alternative from the positive and negative ideal solutions is calculated using Eqs. 5 and 6.

$$d_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2} \quad i = 1, 2, \quad m \tag{5}$$

Table 2 Initial TOPSIS data

Weights	0.15	0.15	0.15	0.15	0.15	0.25
Website	Load time	Page size	Broken links	Response time	Cont errors	Acc error
www.airindia.com	4.2	5734.4	4	2	11	34
jetairways.com	5.95	1536	3	1.199	31	34
www.goindigo.in	2.81	998.1	1	1.762	82	628
spiceJet.com	6.04	1228.8	0	1.299	9	499
www.goair.in	3.85	1228.8	2	1.526	23	401
airvistara.com	4.56	6246.4	1	7.641	5	330
www.trujet.com	6.25	3276.8	4	0.491	10	115

$$d_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^- \right)^2} \quad i = 1, 2, \quad m \tag{6}$$

Next, the relative closeness of the alternative to the positive ideal solution is evaluated by formula 7.

$$R_i = \frac{d_i^-}{d_i^- + d_i^+} \tag{7}$$

Finally, the alternatives can be given rank in descending order of the value of R_i, the result of applying TOPSIS is shown in Table 3. The result of TOPSIS shows that the website of jetways airline has performed best on the selected usability and accessibility criteria and has ranked first. In contrast, the website of go indigo Airlines is at the last rank.

5.2 Analytical hierarchy process (AHP) Results

Saaty proposed AHP in 1980 [31], and it has since been widely employed in complicated multicriteria decision problems. AHP finds use where a judgment must be made based on a set of relevant criteria on various alternatives [32]. This paper presents AHP to select the best website from a pool of Indian airline websites. The AHP begins by decomposing the decision problem into a logical hierarchy, with the top-level listing the goal or objective from the decision maker's perspective, the intermediate level listing the criteria that form the basis of the decisions, and the lowest level listing the alternatives among which a decision must be made. After constructing this logical hierarchy, the decision-makers can use pairwise comparisons to systematically evaluate the options by forming the comparison matrix for each criterion. The element a_{ij} in the pairwise comparison matrix A represents the relative importance of ith factor with jth factor.

Satty's nine-point relative scale is used for pairwise comparison. The Saaty scale is shown in Table 4.

The numerical probability of each alternative is calculated once all the comparisons and relative weights of each criterion are determined. AHP is applied on the Indian airline website. The process starts with the construction of the hierarchy, as shown in Fig. 1. The AHP decision model's goal is to identify the best airline website based on quality criteria such as page load time, web page response time, page size, broken links on the website, color contrast errors on the page, and accessibility errors in conformance with WCAG 2.0, with various alternatives presented at the lowest level.

After determining the criteria for which websites need to be evaluated, the preference criteria matrix is evaluated by pairwise comparisons of each criterion to the other. Table 5 shows the results of criterion pairwise comparison. As the importance of load time criteria over broken link criteria is strongly preferred on the websites, the value of the cell in the first row and the third column representing the importance of load time criteria over broken link criteria is given the value 7 on the Saaty AHP measurement scale. In contrast, the cell value in the third-row first column representing the importance of broken link criteria over load-time criteria is given the reciprocal value of 1/7. The rest of the values of the matrix is calculated accordingly. The weight of each criterion is then calculated by normalizing the preference criteria matrix by dividing each cell value by the total of its column values and then computing the row average. Table 6

Table 4 Saaty scale of relative importance

Scale	Numerical Rating	Reciprocal
Extremely preferred	9	1/9
Very strong to extremely	8	1/8
Very strongly preferred	7	1/7
Strong to very strongly	6	1/6
Strongly preferred	5	1/5
Moderate to strongly	4	¼
Moderately Preferred	3	1/3
Equally to moderately	2	½
Equally Preferred	1	1

Table 3 TOPSIS Rank result

| Website	Load time	page size	broken links	response time	cont errors	acc error	si+	si-	R_i	rank
www.airindia.com	0.05	0.09	0.09	0.04	0.02	0.01	0.12	0.22	0.65	3
jetairways.com	0.07	0.02	0.07	0.02	0.05	0.01	0.09	0.22	0.72	1
www.goindigo.in	0.03	0.02	0.02	0.03	0.13	0.16	0.20	0.15	0.43	7
spiceJet.com	0.07	0.02	0.00	0.02	0.01	0.13	0.13	0.20	0.62	5
www.goair.in	0.04	0.02	0.04	0.03	0.04	0.10	0.11	0.18	0.62	4
airvistara.com	0.05	0.10	0.02	0.14	0.01	0.09	0.17	0.16	0.48	6
www.trujet.com	0.07	0.05	0.09	0.01	0.02	0.03	0.11	0.22	0.68	2
v+	0.032	0.016	0.000	0.009	0.008	0.009				
v-	0.071	0.099	0.088	0.136	0.133	0.163				
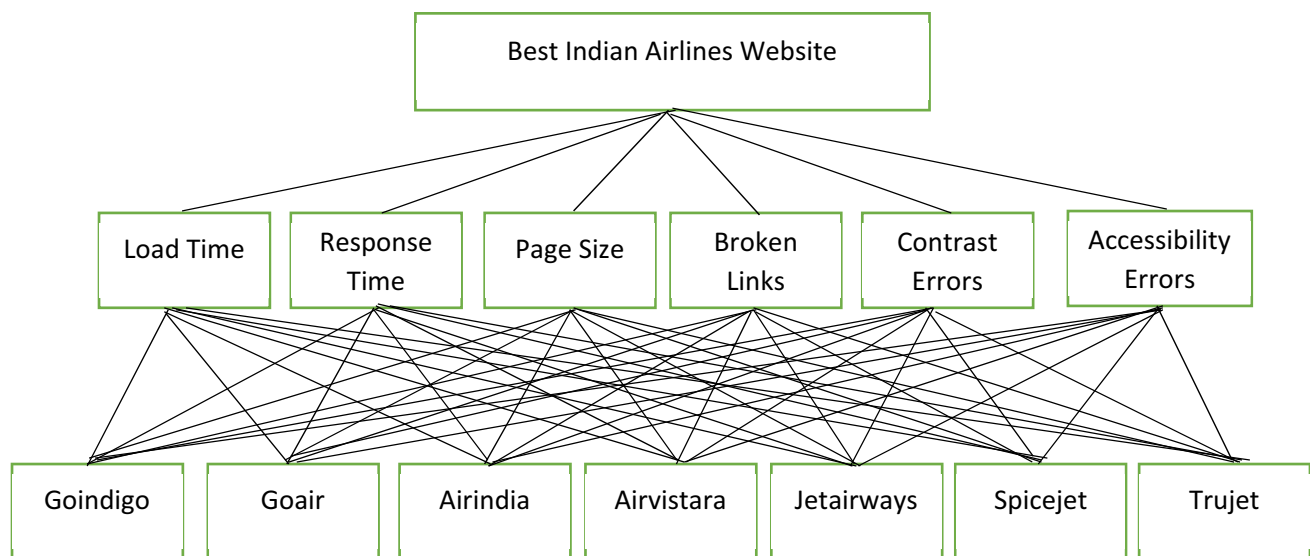
Fig. 1 Indian Airline companies' AHP model

Table 5 Pairwise criteria comparison matrix

Criteria	Load Time	Response Time	Broken Links	Accessi-bilityErrors	Page Size	Contrast Error
Load Time	1.00	3.00	7.00	9.00	5.00	7.00
Response Time	0.33	1.00	7.00	5.00	3.00	7.00
Broken Link	0.14	0.14	1.00	7.00	3.00	3.00
Accessibility Errors	0.11	0.20	0.14	1.00	7.00	3.00
Page Size	0.20	0.33	0.33	0.14	1.00	5.00
Contrast Error	0.14	0.14	0.33	0.33	0.20	1.00
Sum	1.93	4.82	15.81	22.48	19.20	26.00

Table 6 Normalized preference matrix with weights

Criteria	Load Time	Response Time	Broken Links	Accessibility Errors	Page Size	Contrast Error	Weights
Load Time	0.52	0.62	0.44	0.40	0.26	0.27	0.42
Response Time	0.17	0.21	0.44	0.22	0.16	0.27	0.25
Broken Link	0.07	0.03	0.06	0.31	0.16	0.12	0.12
Accessibility Errors	0.06	0.04	0.01	0.04	0.36	0.12	0.11
Page Size	0.10	0.07	0.02	0.01	0.05	0.19	0.07
Contrast Error	0.07	0.03	0.02	0.01	0.01	0.04	0.03
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00

shows the normalized preference matrix with weights of each criterion.

After each criterion's weight is evaluated, the pair-wise evaluation of each alternative based on each criterion is evaluated next. Table 7 shows the original pairwise comparison of airline websites based on the load time of the sites. After the pairwise evaluation, its normalized matrix is calculated by dividing the pairwise comparison value with the respective column sum. The result of the normalized load matrix is shown in Table 8. Finally, the priority vector is calculated by taking the average of each row in the normalized matrix.

Table 7 Original load time matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet
Airindia	1.00	5.00	0.25	7.00	0.33	3.00	7.00
Jetairways	0.20	1.00	0.14	3.00	0.20	0.20	4.00
Indigo	4.00	7.00	1.00	9.00	3.00	5.00	9.00
Spicejet	0.14	0.33	0.11	1.00	0.14	0.14	3.00
Goair	3.00	5.00	0.33	7.00	1.00	4.00	7.00
Airvistara	0.33	5.00	0.20	7.00	0.25	1.00	7.00
Truejet	0.14	0.25	0.11	0.33	0.14	0.14	1.00
Sum	8.82	23.58	2.15	34.33	5.07	13.49	38.00

Table 8 Normalized load time matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet	Priority vector
Airindia	0.11	0.21	0.12	0.20	0.07	0.22	0.18	0.16
Jetairways	0.02	0.04	0.07	0.09	0.04	0.01	0.11	0.05
Indigo	0.45	0.30	0.47	0.26	0.59	0.37	0.24	0.38
Spicejet	0.02	0.01	0.05	0.03	0.03	0.01	0.08	0.03
Goair	0.34	0.21	0.16	0.20	0.20	0.30	0.18	0.23
Airvistara	0.04	0.21	0.09	0.20	0.05	0.07	0.18	0.12
Truejet	0.02	0.01	0.05	0.01	0.03	0.01	0.03	0.02
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 9 Original response time matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet
Airindia	1.00	0.14	0.20	0.20	0.33	9.00	0.20
Jetairways	7.00	1.00	5.00	3.00	5.00	9.00	0.33
Indigo	5.00	0.20	1.00	0.33	0.33	9.00	0.25
Spicejet	5.00	0.33	3.00	1.00	3.00	9.00	0.33
Goair	3.00	0.20	3.00	0.33	1.00	9.00	0.25
Airvistara	0.11	0.11	0.11	0.11	0.11	1.00	0.11
Truejet	5.00	3.00	4.00	3.00	4.00	9.00	1.00
Sum	26.11	4.99	16.31	7.98	13.78	55.00	2.48

Table 10 Normalized Response time matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet	Priority vector
Airindia	0.04	0.03	0.01	0.03	0.02	0.16	0.08	0.05
Jetairways	0.27	0.20	0.31	0.38	0.36	0.16	0.13	0.26
Indigo	0.19	0.04	0.06	0.04	0.02	0.16	0.10	0.09
Spicejet	0.19	0.07	0.18	0.13	0.22	0.16	0.13	0.15
Goair	0.11	0.04	0.18	0.04	0.07	0.16	0.10	0.10
Airvistara	0.00	0.02	0.01	0.01	0.01	0.02	0.04	0.02
Truejet	0.19	0.60	0.25	0.38	0.29	0.16	0.40	0.32
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

In Table 8, the website of Airindia has a priority vector of 0.16, Jetairways has 0.05, Indigo has 0.38, Spicejet has 0.03, Goair has 0.23, Airvistara has 0.12, Trujet has 0.02. The Indigo website has the highest weight of 0.38, and the lowest weight of 0.02 belongs to the website of trujet.

Next, the pairwise comparison concerning the second criterion, i.e., response time, is evaluated. The result is shown in Table 9, representing the original pairwise comparisons of alternate websites based on response time criteria. The result of the normalized matrix, as shown in Table 10, shows

that the website of Airindia airline has a priority vector of 0.05, Jetairways has 0.29, Indigo has 0.09, Spicejet has 0.15, Goair has 0.10, Airvistara has 0.02, Truejet has 0.32. The Truejet website has the highest weight of 0.32, and the lowest weight of 0.02 belongs to the website of Airvistara airline.

Similarly, the original pairwise comparison matrix for each criterion and its corresponding normalized matrix with priority vector was calculated.

Table 11 represents the original pairwise comparisons of alternate websites based on page size criteria. The result of the normalized matrix, as shown in Table 12, shows that the website of Airindia airline has a priority vector of 0.04, Jetairways has 0.11, Indigo has 0.35, Spicejet has 0.22, Goair has 0.19, Airvistara has 0.02, Truejet has 0.08. The Indigo website has the highest weight of 0.35, and the lowest weight of 0.02 belongs to the website of Airvistara.

Table 13 represents the original pairwise comparisons of alternate websites based on Broken Links criteria. The result of the normalized matrix, as shown in Table 14, shows that the website of Airindia airline has a priority vector of 0.22, Jetairways has 0.14, Indigo has 0.12, Spicejet has 0.09, Goair has 0.17, Airvistara has 0.35, Truejet has 0.02. The website of Airvistara airline has the highest weight of 0.35, and the lowest weight of 0.02 belongs to the website of trujet airline.

Table 15 represents the original pairwise comparisons of alternate websites based on errors of color contrast criteria. The result of the normalized matrix, as shown in Table 16, shows that the website of Airindia airline has a priority vector of 0.15, Jetairways has 0.04, Indigo has 0.02, Spicejet has 0.20, Goair has 0.07, Airvistara has 0.34, Truejet has 0.18. The website of Airvistara airline has the highest weight of

Table 11 Original page size matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet
Airindia	1.00	0.20	0.14	0.14	0.14	5.00	0.20
Jetairways	5.00	1.00	0.25	0.33	0.33	9.00	3.00
Indigo	7.00	4.00	1.00	3.00	3.00	9.00	5.00
Spicejet	7.00	3.00	0.33	1.00	2.00	9.00	5.00
Goair	7.00	3.00	0.33	0.50	1.00	9.00	5.00
Airvistara	0.20	0.11	0.11	0.11	0.11	1.00	0.14
Truejet	5.00	0.33	0.20	0.20	0.20	7.00	1.00
Sum	32.20	11.64	2.37	5.29	6.79	49.00	19.34

Table 12 Normalized page size matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet	Priority vector
Airindia	0.03	0.02	0.06	0.03	0.02	0.10	0.01	0.04
Jetairways	0.16	0.09	0.11	0.06	0.05	0.18	0.16	0.11
Indigo	0.22	0.34	0.42	0.57	0.44	0.18	0.26	0.35
Spicejet	0.22	0.26	0.14	0.19	0.29	0.18	0.26	0.22
Goair	0.22	0.26	0.14	0.09	0.15	0.18	0.26	0.19
Airvistara	0.01	0.01	0.05	0.02	0.02	0.02	0.01	0.02
Truejet	0.16	0.03	0.08	0.04	0.03	0.14	0.05	0.08
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 13 Original broken link matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet
Airindia	1.00	7.00	3.00	5.00	2.00	0.33	9.00
Jetairways	0.14	1.00	0.14	0.11	0.14	0.14	5.00
Indigo	0.33	7.00	1.00	3.00	0.50	0.25	9.00
Spicejet	0.20	9.00	0.33	1.00	0.20	0.20	9.00
Goair	0.50	7.00	2.00	5.00	1.00	0.33	9.00
Airvistara	3.00	7.00	4.00	5.00	3.00	1.00	9.00
Truejet	0.11	0.20	0.11	0.11	0.11	0.11	1.00
Sum	5.29	38.20	10.59	19.22	6.95	2.37	51.00

Table 14 Normalized Broken Link matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet	Priority vector
Airindia	0.19	0.18	0.28	0.26	0.29	0.14	0.18	0.22
Jetairways	0.03	0.03	0.01	0.01	0.02	0.06	0.10	0.04
Indigo	0.06	0.18	0.09	0.16	0.07	0.11	0.18	0.12
Spicejet	0.04	0.24	0.03	0.05	0.03	0.08	0.18	0.09
Goair	0.09	0.18	0.19	0.26	0.14	0.14	0.18	0.17
Airvistara	0.57	0.18	0.38	0.26	0.43	0.42	0.18	0.35
Truejet	0.02	0.01	0.01	0.01	0.02	0.05	0.02	0.02
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 15 Original color contrast errors matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet
Airindia	1.00	7.00	9.00	0.50	5.00	0.33	0.50
Jetairways	0.14	1.00	7.00	0.14	0.33	0.14	0.14
Indigo	0.11	0.14	1.00	0.11	0.11	0.11	0.11
Spicejet	2.00	7.00	9.00	1.00	3.00	0.33	2.00
Goair	0.20	3.00	9.00	0.33	1.00	0.20	0.20
Airvistara	3.00	7.00	9.00	3.00	5.00	1.00	3.00
Truejet	2.00	7.00	9.00	0.50	5.00	0.33	1.00
Sum	8.45	32.14	53.00	5.59	19.44	2.45	6.95

Table 16 Normalized color contrast errors matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet	Priority vector
Airindia	0.12	0.22	0.17	0.09	0.26	0.14	0.07	0.15
Jetairways	0.02	0.03	0.13	0.03	0.02	0.06	0.02	0.04
Indigo	0.01	0.00	0.02	0.02	0.01	0.05	0.02	0.02
Spicejet	0.24	0.22	0.17	0.18	0.15	0.14	0.29	0.20
Goair	0.02	0.09	0.17	0.06	0.05	0.08	0.03	0.07
Airvistara	0.35	0.22	0.17	0.54	0.26	0.41	0.43	0.34
Truejet	0.24	0.22	0.17	0.09	0.26	0.14	0.14	0.18
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 17 Original accessibility errors matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet
Airindia	1.00	1.00	9.00	7.00	5.00	5.00	3.00
Jetairways	1.00	1.00	9.00	7.00	5.00	5.00	3.00
Indigo	0.11	0.11	1.00	0.14	0.14	0.11	0.11
Spicejet	0.14	0.14	7.00	1.00	0.14	0.14	0.14
Goair	0.20	0.20	7.00	3.00	1.00	0.33	0.20
Airvistara	0.20	0.20	9.00	7.00	3.00	1.00	0.33
Truejet	0.33	0.33	9.00	7.00	5.00	3.00	1.00
Sum	2.99	2.99	51.00	32.14	19.29	14.59	7.79

0.34, and the lowest weight of 0.02 belongs to the website of Indigo airline.

Table 17 represents the original pairwise comparisons of alternate websites based on accessibility error criteria. The result of the normalized matrix, as shown in Table 18, shows that the website of Airindia airline has a priority vector of 0.29, Jetairways has 0.29, Indigo has 0.02, Spicejet has 0.04, Goair has 0.07, Airvistara has 0.11, Truejet has 0.17. The websites of airindia and jetairways Airlines had the highest

Table 18 Normalized accessibility errors matrix

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet	Priority vector
Airindia	0.33	0.33	0.18	0.22	0.26	0.34	0.39	0.29
Jetairways	0.33	0.33	0.18	0.22	0.26	0.34	0.39	0.29
Indigo	0.04	0.04	0.02	0.00	0.01	0.01	0.01	0.02
Spicejet	0.05	0.05	0.14	0.03	0.01	0.01	0.02	0.04
Goair	0.07	0.07	0.14	0.09	0.05	0.02	0.03	0.07
Airvistara	0.07	0.07	0.18	0.22	0.16	0.07	0.04	0.11
Truejet	0.11	0.11	0.18	0.22	0.26	0.21	0.13	0.17
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 19 Weight of criteria and websites

Websites	Criteria weight	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet
Load Time	0.42	0.16	0.05	0.38	0.03	0.23	0.12	0.02
Response Time	0.25	0.05	0.26	0.09	0.15	0.10	0.02	0.32
Broken Link	0.12	0.22	0.04	0.12	0.09	0.17	0.35	0.02
Acc Error	0.11	0.29	0.29	0.02	0.04	0.07	0.11	0.17
Paze Size	0.07	0.04	0.11	0.35	0.22	0.19	0.02	0.08
Contrast Error	0.03	0.15	0.04	0.02	0.20	0.07	0.34	0.18

Table 20 Final AHP result

Websites	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet
Load Time	0.07	0.02	0.16	0.01	0.10	0.05	0.01
Response Time	0.01	0.06	0.02	0.04	0.03	0.00	0.08
Broken Link	0.03	0.00	0.02	0.01	0.02	0.04	0.00
Acc Error	0.03	0.03	0.00	0.00	0.01	0.01	0.02
Paze Size	0.00	0.01	0.03	0.02	0.01	0.00	0.01
Contrast Error	0.00	0.00	0.00	0.01	0.00	0.01	0.01
Sum	0.15	0.13	0.23	0.09	0.16	0.12	0.12
Rank	3	4	1	7	2	5	6

weight of 0.29, and the lowest weight of 0.02 belongs to the website of Indigo Airlines.

Table 19 shows the weight of each criteria corresponding to every alternative. Table 20 shows the final result obtained from the AHP model. The website of Indigo Airlines has the highest score of 0.23 compared to all other airline websites. The rank of the website as given by the AHP model is: indigo airline (rank 1 with a score of 0.23), Goair airline (rank 2 with a score of 0.16), Airindia (rank 3 with a score of 0.15), Jetairways(rank 4 with a score of 0.13), Airvistara(rank 5 with a score of 0.12), true jet (rank 6 with a score of 0.12), and the last rank is of spice jet airline website with the score of 0.09.
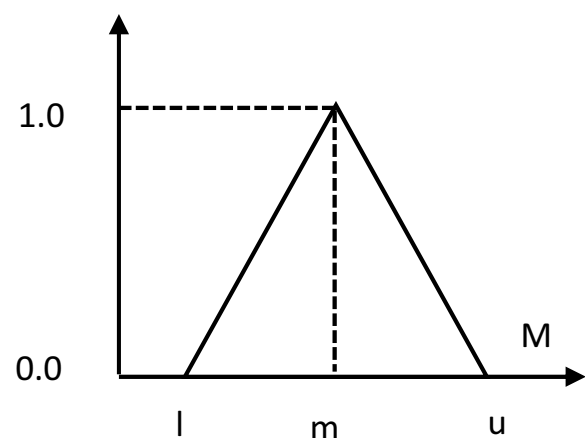
Fig. 2 Fuzzy Triangular numbers

5.3 Fuzzy AHP

Fuzzy sets are a successful tool for decision-making in various real-life applications due to their ability to represent imprecise and uncertain data. This study used fuzzy triangular numbers(TNFs) to represent the fuzzy relative importance. TNF is shown in Fig. 2, and Eq. 8 describes it

$$\mu_N(x) = \begin{cases} \frac{x-l}{m-l}, l \le x \le m \\ \frac{u-x}{u-m}, m \le x \le u \\ 0, otherwise \end{cases} \tag{8}$$

The parameter $l, m, u,$ represents the smallest, the most promising, and the largest possible value, respectively.

Three important operations for the implementation of TNF's based on chang's [33] extent analysis is described as follows. Let X = {×1,×2,.....xn} be an object set and G = {g1,g2,....gn} be a goal set.

The m extent analysis of each object is represented by:

$$M_{gi,}^1 M_{gi,}^2 \dots \dots \dots, M_{gi,}^j i = 1, 2, \dots.n \ and \ j1, 2, \dots., n$$

where all M_{gi}^j are TNFs

The value of fuzzy synthetic extent for the ith object is evaluated using Eq. 9 to calculate Chang's extent analysis:

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1} \tag{9}$$

The fuzzy AHP method's initial objective is to determine the relative importance of each pair of criteria. The fuzzy evaluation matrix $A = (a_{ij})_{nXm}$ is constructed using TNFs for pairwise comparison, where the saaty fuzzy scale is used to represent the element $a_{ij} = (l_{ij}, m_{ij}, u_{ij})$ and must be satisfied. with $a_{ji} = \left(\frac{1}{l_{ji}}, \frac{1}{m_{ji}}, \frac{1}{u_{ji}}\right)$. From the evaluation matrix, the vector of weights under each criterion is evaluated by calculating the degree of possibility of $M_1 = (l_1, m_1, u_1) \ge M_2 = (l_2, m_2, u_2)$ which is defined by

$$V(M_1 \ge M_2) = sup\left[min(\mu_{M1}(x), \mu_{M2}(y))\right] \tag{10}$$

Considering M1 and M2 as convex fuzzy numbers, we have:

$$V(M_1 \ge M_2) = 1 iif m_1 \ge m_2 \tag{11}$$

$$V(M_2 \ge M_2) = hgt(M_1 \cap M_2) = \mu_{M1}(d) = \frac{l_{1-u_2}}{(m_2 - u_2) - (m_1 - l_1)} \tag{12}$$

where d is the ordinate of the highest intersection point between μ_{M1} and μ_{M2}

next, the degree of the possibility for a convex fuzzy number to be greater than k convex fuzzy number $M_i(i = 1,2,3,.....,k)$ is defined by:

$$V(M \ge M_1, M_2, \dots \dots \dots., M_k)$$
$$= V[(M \ge M_1) \ and \ (M \ge M_2) and \ (M \ge M_k)] \tag{13}$$
$$= \min V(M \ge M_i), i = 1, 2, \dots .k$$

Assuming that.
$d'(A_i) = \min V(S_i \ge S_k) for k = 1, 2, \dots n.$ Then the weight vector is given by

$$W' = (d'(A_1), d'(A_2), d'(A_3), \dots \dots .d'(A_n))^T \tag{14}$$

where $A_i(i = 1,2,.....n)$ are n elements. After normalization, the normalized vector is given by

$$W = (d(A_1), d(A_2), \dots \dots d(A_n))^T$$

where W is non fuzzy number.

Based on the FAHP model evaluation, the weights of airlines' websites contributing to each website quality factor are represented in Tables 21 and 22 shows the final FAHP results; the website with the highest score is considered the best. The Indigo airlines website has the highest score of 0.236 compared to all other websites. The rank of the website as proposed by the FAHP model is: Indigo airline website (score: 0.236), Goair airline website (score: 0.175), Airindia airline website (score: 0.140), Jetairways airline website (score: 0.127), Truejet airline website (score: 0.122), Airvistara (score: 0.112), and the last rank is of Spicejet airline website with the score of 0.88.

Table 21 Websites and weight criteria (FAHP)

Website Quality Criteria	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet	weights
Load Time	0.162	0.049	0.390	0.028	0.240	0.111	0.020	0.461
Response Time	0.043	0.271	0.079	0.165	0.100	0.014	0.328	0.271
Broken Link	0.230	0.027	0.127	0.074	0.183	0.343	0.015	0.112
Accessibility Errors	0.303	0.303	0.015	0.030	0.062	0.106	0.181	0.068
Page Size	0.032	0.114	0.346	0.232	0.195	0.015	0.067	0.056
Contrast Error	0.158	0.035	0.014	0.206	0.065	0.336	0.187	0.033

Table 22 Final FAHP result

Website Quality Criteria	Airindia	Jetairways	Indigo	Spicejet	Goair	Airvistara	Truejet
Load Time	0.075	0.022	0.180	0.013	0.111	0.051	0.009
Response Time	0.012	0.073	0.022	0.045	0.027	0.004	0.089
Broken Link	0.026	0.003	0.014	0.008	0.021	0.038	0.002
Accessibility Errors	0.021	0.021	0.001	0.002	0.004	0.007	0.012
Page Size	0.002	0.006	0.019	0.013	0.011	0.001	0.004
Contrast Error	0.005	0.001	0.000	0.007	0.002	0.011	0.006
Sum	0.140	0.127	0.236	0.088	0.175	0.112	0.122
Rank	3	4	1	7	2	6	5

Table 23 Indian airlines website ranking based on MCDM models

	TOPSIS	AHP	FAHP
www.airindia.com	3	3	3
jetairways.com	1	4	4
www.goindigo.in	7	1	1
spiceJet.com	5	7	7
www.goair.in	4	2	2
airvistara.com	6	5	6
www.trujet.com	2	6	5

Table 23 shows the final ranking by three methods. The website of jet airways airlines is ranked first by TOPSIS compared to other websites. The website of indigo airlines is ranked first by AHP and FAHP methods. Finally, statistical analysis is done to check whether there is a difference among the ranking methods as proposed by three MCDM models. The following hypotheses were formulated:

H0: There is no significant difference in the average correlation coefficients between proposed MCDM methods.

H1: There is some significant difference in the average correlation coefficients between proposed MCDM methods.

To check the normality of the data, we used the Shapiro–Wilk test on the ranked data in Table 24. The sig value obtained was less than 0.05, indicating that the data are not normal. To investigate the significant difference

among the ranked data, we used the Friedman test in SPSS, which resulted in an Asymp sig value equal to 0.565. The null hypothesis cannot be rejected because the sig value is greater than 0.05.

6 Conclusion

This paper presented the results of a study evaluating the quality of seven Indian airline websites using online diagnostic tools, and examining the various usability criteria and accessibility compliance with the WCAG 2.0 standard. The result of the study confirmed that the page size of all the websites is considerably large, resulting in slow load time. Only one airline website does not suffer from broken links, while all other websites had broken links. On accessing the broken link user lands on a non-accessible webpage that decreases its usability. All the websites under study suffer from color contrast errors and accessibility errors. The methods proposed for determining and evaluating the airlines' website rank on usability and accessibility include the TOPSIS, AHP, and FAHP techniques. The result of statistical analysis confirmed no difference in the ranking methods on Indian airlines websites. The presence of these errors hinders the use of assistive technology for accessing the webpages for people with disabilities and decreases their usability. This paper suggests that airline website developers have to adopt the WCAG guidelines in the web development phase to make the websites accessible. The limitation of

Table 24 Indian airlines websites ranked data

Original Data	Ranked Data					
	TOPSIS	AHP	FAHP	TOPSIS	AHP	FAHP
Airindia	0.1536	0.1456	0.0649	1	2	3
Jetairways	0.1711	0.1313	0.1269	1	2	3
Indigo	0.1033	0.2255	0.2362	3	2	1
Spicejet	0.1468	0.0902	0.0880	1	2	3
Goair	0.1481	0.1645	0.1754	3	2	1
Airvistara	0.1152	0.1224	0.1124	2	1	3
Truejet	0.1618	0.1204	0.1220	1	3	2

this research is in the use of automated tools for collecting accessibility errors and the limited sample size of data used. Further research could be carried out considering other user-centric web quality parameters.

Data availability Data will be made available on reasonable request.

Declarations

Conflict of Interest The Author (s) declare that there is no conflict of interest.

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