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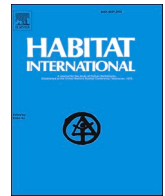
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Capturing public voices: The role of social media in heritage management

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ABSTRACT

Social media platforms have been increasingly used by locals and tourists to express their opinions about buildings, cities, and built heritage in particular. Most recently, scholars have been using social media to conduct innovative research on built heritage and heritage management. Still, the application of artificial intelligence (AI) methods to analyze social media data for heritage management is seldom explored. This paper investigates the potentials of short texts (sentences and hashtags) shared through social media as a data source and artificial intelligence methods for data analysis for revealing the cultural significance (values and attributes) of built heritage. The city of Yazd, Iran was taken as a case study, with the particular focus on windcatchers, key attributes conveying outstanding universal values, as inscribed on the UNESCO World Heritage List. This paper has three subsequent phases: 1) state of the art on the intersection of public participation in heritage management and social media research; 2) methodology of data collection and data analysis related to coding people's voices from Instagram and Twitter into values of windcatchers over the last ten-years; 3) preliminary findings on the comparison between opinions of locals and tourists, sentiment analysis, and its association with the values and attributes of windcatchers. Results indicate that the age value is recognized as the most important value by all interest groups, while the political value is the least acknowledged. Besides, the negative sentiments are scarcely reflected (e.g., critiques) in social media. Results confirm the potential of social media for heritage management in terms of (de)coding and measuring the cultural significance of built heritage for windcatchers and also other attributes in Yazd and other case studies and scales.

1. Introduction

Public participation in heritage planning refers to the active or passive involvement of various stakeholders (e.g., general public and tourism professionals) in decision-making processes related to the conservation and development of heritage properties. This participatory approach emphasizes inclusivity, transparency, collaboration, and empowerment, aiming to incorporate diverse perspectives and local knowledge into heritage planning processes (UNESCO, 2011; Zhou et al., 2018; García et al., 2019).

Academic literature and international organizations support the significance of public participation in heritage planning as a means to achieve sustainable and socially responsible outcomes (Harmon & Viles, 2013; UNESCO, 2016). These references provide insights into the theoretical foundations and practical applications of public participation in heritage planning. They highlight the need for inclusive and transparent processes that allow for meaningful engagement and collaboration between heritage professionals, users, and other

stakeholders.

Radical developments in information and communication technologies (ICT) including social media have widely affected urban sectors, particularly cultural heritage (Panagiotopoulou, et al., 2020). Online communities have been increasingly using social media platforms to share their opinions about their environment and built heritage in particular. These short texts (sentences and hashtags) shared through online conversations in combination with smart technologies (e.g., artificial intelligence) and techniques (e.g., Natural Language Processing) provide opportunities to capture and decode public voices, at an unprecedented pace, which can dynamize the dominant planning power structure (Tayebi, 2013). Besides, social media can reduce cost and increase stakeholders' involvement in urban planning (Chen et al., 2019; Kleinhans et al., 2015; Monteiro et al., 2015; Ye et al., 2021).

Varied scholars have been using social media to conduct innovative research to engage people and interpret their opinions and sentiments. Chen et al. (2019) investigated spatial structures and analyzed social media data to provide insights into urban planning regarding human

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activities contributing to the comprehension of the relationship between social activities and urban space. Afzalan and Muller (2014) investigated the potential of social media (particularly Facebook and Twitter) to facilitate discourses among online participants in participatory green infrastructure planning in the city of Lawrence, Kansas. Das and Zubaidi (2021) analyzed peoples' emotions and politeness in transit-related tweets, assessing peoples' perceptions of the transit system in New York and California. Abdul-Rahman et al. (2021) presented a framework including topic modeling and sentiment analysis to use Twitter to investigate the spatiotemporal dynamism of community challenges (e. g., high rental prices, noise pollution). Alizadeh et al. (2019) performed cluster and sentiment analysis of Twitter posts on specific urban projects to identify citizen concerns on urban issues (e.g., equality, health).

Social media platforms have also been used for participatory heritage management (Silberman & Purser, 2012; Giaccardi, 2012; Monteiro et al., 2015). Decoding cultural significance, by distinguishing attributes (resources to be conserved) and values (the reasons to conserve the resources) is a growing issue in attention by both research and practice, as recommended by UNESCO (UNESCO, 2011). Ginzarly et al. (2019) revealed the cultural significance of the city of Tripoli, Lebanon, attributes (e.g. street, sky) and values (e.g., social, economic) together, when analyzing the geo-tagged photos and tags, shared through Flickr, by online communities. Van der Hoeven (2019) revealed the diverse layers of heritage values attributed to the urban landscapes in 19 Dutch heritage projects and organizations by a qualitative content analysis of the social media activities and policy documents. His research revealed the potential of social media to involve people in heritage management providing insight into the attachments that citizens have to their urban environment.

Social media and artificial intelligence (AI) are yet to be further explored for participatory heritage management. There is a lack of literature on heritage-specific tools targeting the cultural significance of built heritage, distinguishing and relating attributes and values (Bai et al., 2021). In addition, literature often focuses on the scale of country, city, and neighborhood (e.g. Alizadeh et al., 2019; Ginzarly et al., 2019; Monachesi, 2020), rather than specific attributes in the city, such as the windcatchers. Hence, this paper aims to investigate the potential of social media as a data source and artificial intelligence methods for data analysis for revealing peoples' feelings and opinions about the cultural significance (values and attributes) of built heritage. The city of Yazd, Iran was taken as a case study, with a particular focus on windcatchers, key attributes conveying outstanding universal values, as inscribed on the UNESCO World Heritage List.

2. Case study: windcatcher

The Historic City of Yazd was inscribed in the UNESCO World Heritage list in 2017. Yazd is called the city of windcatchers due to having the highest number of windcatchers compared to other cities in Iran (Saadatian et al., 2012). This study focuses on windcatchers of Yazd not only because they convey outstanding universal values but also due to their significance for a range of stakeholders beyond experts and professionals. For local inhabitants, windcatchers are an essential building element, with many historical homes in Yazd possessing at least one. Tourists also frequently highlight the importance of windcatchers, given that they are distinctive architectural features visible from all corners of the historic city, acting as landmarks within the urban landscape. Still, no study was found that investigate people's perspectives on the cultural significance of windcatchers in Yazd.

Windcatchers have been utilized for centuries to provide natural ventilation in buildings by cleverly utilizing wind flow. It consists of a vertical shaft with vents above the roof of a building, which channels desired wind into interior living spaces, providing thermal comfort. Typically, a Windcatcher is employed to cool a house by creating an air conditioning system in one of the main rooms (as depicted in Fig. 1), where air passes over a pool of water, acting as a humidifier. Windows

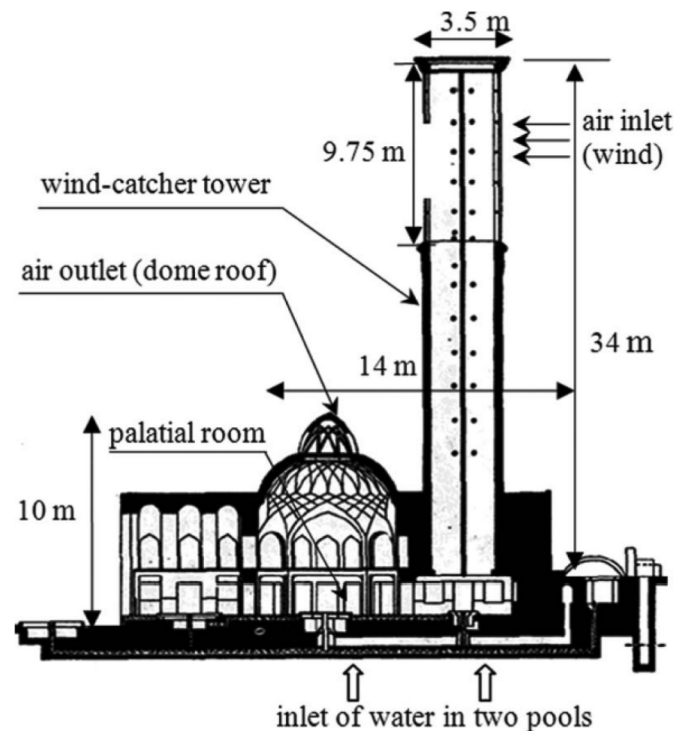


Fig. 1. Wind circulation in the main room with a windcatcher passing by pools, source: Dehghani-sanij et al., 2015.

and doors also play a role in circulating the air (Movahed, 2016).

For efficient functionality, the Windcatcher operates as part of a broader ecosystem that includes other elements in the building, such as courtyards, gardens, pools, thick earthen walls, doors, and windows. Together, these components work in harmony to ensure air circulation at comfortable and healthy levels. Additionally, air passing over humid elements, such as pools and gardens, is cooled down due to the process of evaporation.

3. Method

The process followed in this research entailed four steps. Accordingly, data acquisition, data pre-processing, data analysis, and results (see Fig. 2).

3.1. Data acquisition

All the common social media platforms used in Iran are considered potential data sources for this research. After an initial investigation to find the relevant data on these platforms, it is revealed that Instagram and Twitter contain the main relevant posts. Given that, posts shared on Instagram or Twitter about windcatchers of Yazd were automatically mined using several Persian and English terms (used as hashtags) referring to windcatchers, namely “badgir”, “wind-catcher”, “windcatcher”, “wind-tower”, “windtower”, “بادگیر”, “بادگیره”, “بادگیره‌ها”, “بادگیره‌های یزد”, “بادگیره‌های یزد”. This research used WebHarvey software to retrieve all the posts using these hashtags without applying any time limit to scoping the dataset. WebHarvy is a paid tool that enables scraping Text, HTML, Images, and URLs from various websites and saves the scraped data in various formats.

This research only collects and analyses the textual data due to the research time limitation and Instagram's terms of service which forbids automated retrieval of photographs. Only a few photographs are used in this paper to clarify some aspects of the case study or to support an argument developed in the text. These photographs are reproduced with permission from the photographers.

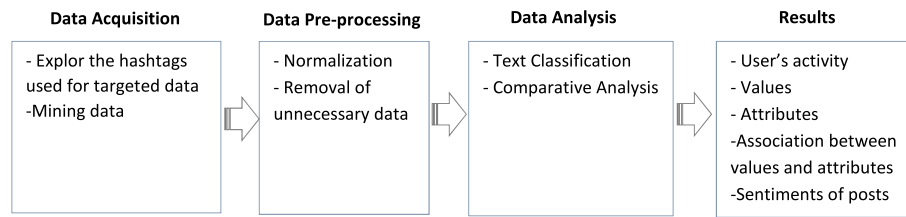


Fig. 2. Overview of the methodological framework.

A total number of 23,899 posts are mined. The content of the data includes username, post content, time (the year that the post was published), and users' biographies. The data do not cover the demographic characteristic of users, including age, gender, education, and professional status, because mostly these are sensitive data that are not provided by the users. In addition to the above statement, this research considers the ethical issues by only processing the hashtags and comments expressing heritage values and attributes and not storing any sensitive personal data. Hence, personal data is not disclosed at any stage of the research, and the users' identities will remain anonymous unless permission is asked. Lastly, to make the data untraceable, the usernames were changed (e.g., user1, user2, etc.) and posts were rephrased.

3.2. Data cleaning and pre-processing

This step took place automatically using Python programming language. All the posts were translated to English using Google API to facilitate the analysis process. The gathered posts which do not mention the words "windcatcher" and "Yazd", in their variations, were excluded. To find these posts, all variations of these two words were normalized to "windcatcher" and "Yazd" (both in Persian and English e.g. "Yazd", "yazd", "یزد"). Moreover, the text cleaning included the removal of unnecessary data (e.g., stop words, personal mentions, emojis, punctuation marks, and website links) to facilitate data analysis. After the exclusion, 3346 sentences and 12,646 unique hashtags were analyzed.

3.3. Data analysis

After data cleaning and pre-processing, the dataset was ready for automatic classification analysis. The data analysis process was conducted in two steps. First, users were classified by nationality (Iranian or foreigner); and by type (general and tourism professionals). The nationality and type of users are considered as independent variables, to better understand the diversity of the stakeholder groups associating the cultural significance (attributes and values) with the windcatchers of Yazd. Each post's content (sentences and hashtags) was analyzed and assessed through automatic quantitative content analysis and qualitative categorical analysis.

3.3.1. User analysis

Preserving heritage properties requires a comprehensive approach that considers the perceptions of various stakeholders. This includes tourism professionals, like hotel owners, tour leaders, and social media influencers (focused on the tourism industry) whose business depends on tourism and tourists. Their insights, combined with the perceptions of the general public, ensure a balanced conservation strategy that respects the cultural significance of the site while optimizing its economic potential through responsible tourism (Swarbrooke & Horner, 2012). Moreover, involving foreigners and locals in the decision-making process enhances inclusive heritage planning. Foreign tourists' perceptions provide cultural sensitivity and authenticity, tailoring the experience for a global audience, while the perceptions of locals maintain the site's authentic identity and ensure the benefits of tourism reach the community. This participatory approach fosters a harmonious balance

between cultural preservation and sustainable tourism, ensuring that heritage properties remain treasured landmarks for different stakeholder groups with various interests (Zbuche et al., 2016).

In this research, the nationality of each user is determined based on the language of posts and biographies, and the user's living location (if provided in users' biographies). If users' location and language do not match, the location will prevail. Besides, users are classified as general or tourism professionals by analyzing the names and biographies of users. Users with any of the words "travel", "trip", "tour", "hotel", "Yazd", "Persia", and "Iran" in their usernames or the term "travel", "trip", "tour", and "hotel" in their biographies are considered as tourism professionals. The rest of the users are regarded as general users. It is worth noting that this research used user-generated data on Instagram and Twitter and there is a chance that users did not provide their true identities and perception including location and profession.

3.3.2. Content analysis

Overall, the analysis of cultural significance and sentiments was undertaken using Python libraries, including Numpy (for performing statistical computations) and Pandas (used for data manipulation and analysis on data frames). Each sentence was analyzed and assessed through quantitative content analysis and qualitative categorical analysis. The qualitative categorical analysis showed the categories of cultural significance and sentiments addressed in the texts. The quantitative analysis revealed the most and least frequent categories of cultural significance and sentiments.

The qualitative analysis in this research is a multi-label text classification task in natural language processing (NLP) where the goal is to assign multiple labels to a given text document. In this research, each label represents a specific class of values or attributes that the document can belong to. BERT (Bidirectional Encoder Representations from Transformers) model is trained using cosine similarity to perform multi-label text classification. The objective was to predict the relevant labels, which represent values, attributes, or sentiments based on a given input text.

BERT (Bidirectional Encoder Representations from Transformers) model is an influential pre-trained language model developed by Google AI Language (Devlin et al., 2018). BERT has revolutionized the field of natural language processing (NLP) with its innovative bidirectional approach to language understanding and generation. BERT captures comprehensive contextual representations of words and sentences, leading to a deeper understanding of language semantics (Devlin et al., 2018).

Cosine similarity measures the similarity between two vectors by calculating the cosine of the angle between them. Higher cosine similarity indicates greater similarity between the pairs of sentences (Li & Han, 2013). Data analysis and modeling are conducted using Google Colaboratory (Colab), an online platform for collaborative coding and computation. The model has been archived in the Github repository (Foroughi, 2023). Lastly, the performance of the model was evaluated using accuracy, precision, recall, or F1 score matrices.

Overall, after acquiring and cleaning the relevant data, the sentiments, values, and attributes conveyed by users were revealed and analyzed. Consequently, a comparative analysis between different users was conducted based on the results found using the above methods and

frameworks. This analysis reveals the conflicts and alignments between the perceptions of these stakeholder groups on windcatchers' cultural significance (values and attributes) and sentiments.

3.3.2.1. Cultural significance analysis. To reveal the cultural significance, a theoretical framework was applied to decode the attributes and values conveyed in the posts (see Fig. 3), conducting a multi-class text classification analysis, using a) the values system developed by Pereira Roders (2007) and b) the attributes ontology by Veldpaus (2015). The general analysis of attributes and values was undertaken using Python libraries, including Numpy (for calculation analysis), Pandas (for research on the data frame), and Bert model (for word embedding). As labels' distribution in the available train dataset was distinct drastically, and there were not enough trained datasets available, this research used the cosine similarity method¹ for the multi-class text classification of the heritage values. The most frequent attributes were classified manually as the accuracy of the cosine similarity method for this classification was not good enough probably because of the numerous categories of the attribute's framework.

3.3.2.2. Analysis of feelings. Posts were then analyzed to assess their overall sentiment on five scales, from very positive to very negative. The sentiment analysis was performed using the transformers library to load a pre-trained transformer model, specifically, the BERT model developed by Devlin et al. (2018), and use it to provide the embedding for text. Word embedding encodes the word's meaning so that the terms that are closer in the vector space are expected to be similar in meaning. The embedding fed into the gated recurrent unit (GRU) model to predict sentiment. Despite the algorithmic limitations, the reliability of the results was confirmed (accuracy: 94%, precision_value: 72%, and F-measure: 77%²).

4. Results

4.1. Cultural significance analysis

4.1.1. The activity of the stakeholder groups in the last decade

The number of posts and active users increased steadily from 2012 until 2019, with a sudden jump in 2017, the same year when the Historic City of Yazd was inscribed on the UNESCO World Heritage List (see Fig. 4). The numbers dropped drastically in 2020 when the COVID-19 virus spread widely around the world. Still, the numbers of posts and active users in 2020 were higher than in 2016. The average number of posts per year is 496. It is worth noting that Instagram was launched in 2010 and the low number of posts from 2012 until 2014 can be because Instagram was not yet popular.

4.1.2. Values of windcatchers in yazd

Concerning the cultural significance of the windcatchers in Yazd, and in particular the values, around two-thirds of the posts (66%) conveyed at least one value. The most frequent values are respectively age (26%), historic (18%), social (16%), aesthetical (14%), economic (10%), ecological (8%), scientific (7%), and political (1%). The frequency of all values grows steadily with the growth of posts over time. While the

frequency of political (1%) and scientific (7%) values remained quite stable, the other values' frequency changed over time (see Fig. 5). The historic value reached its maximum (23%) in 2017, then dropped and remained constant in the following years, even if with a higher share than before 2017. In other words, the historic value was discussed more frequently during and after the same period of the city's inscription on UNESCO's World Heritage List. On the contrary, the age value declined steadily since 2015, except for 2019. The social value also decreased in 2016 and stayed steady afterward. The aesthetical value grew slowly since 2014 (12%), reaching its peak in 2016 (20%), and then declining slightly in 2020 (to 12%). The economic and ecological values have lower frequency in 2014 compared to the following years, in which they played a quite constant role, except for a peak in ecological values in 2018 and economic values in 2020.

Concerning similarities, both interest groupings (Iranians vs foreigners; general vs tourism professionals) mentioned all eight values, at least one time (see Figs. 6 and 7). Ranging from the age (26%) value as the most referenced, to the scientific (7%) and political (1%) values as the least referenced. However, there are also differences. While Iranians convey historic values the most, foreigners address age and economic values the most (Fig. 6). Besides, while general users convey social and age values the most, tourism professionals convey historic values the most. This might mean that Iranian and tourism professionals are more familiar with (or interested in) historic values.

4.1.3. Attributes of windcatchers in yazd

Concerning the cultural significance of the windcatchers of Yazd, and the related attributes in particular (e.g., city, building, architectural element), results reveal that the referenced attributes are mostly tangible. These tangible attributes mostly belong to the asset class, namely the building (house, building, mansion, etc.), the building element (tower, roof, window, etc.), and the natural element (wind, garden, air, etc.). Nonetheless, also intangible attributes are addressed, including architecture and tallest. The intangible attributes mostly belong to the asset-related class, which includes the character (height, size, etc.), concept (architecture, art, etc.), and relation (tallest, small, view, direction, skyline, etc.). Besides, the result shows that users mention these attributes mostly without addressing their values.

4.1.4. Association between the values and attributes

The values of windcatcher, the key attribute, are discussed in Section 4.1.2. This sub-item explores addressed attributes in connection to windcatchers in terms of the values of those attributes, and the relations between those attributes and windcatchers. The frequency analysis between the values and attributes associated with windcatchers in Yazd revealed two clusters. While the aesthetical, age, and historic values of the windcatchers are mostly associated with the "city" scale; the age, ecological, scientific, and economic values are mostly associated with the "building" scale (Fig. 7).

Besides, while some of the most frequent attributes are associated with all eight values (city, house, architecture, and wind) except for the political value, there are attributes associated only with one value (view, tallest, skyline, and pond). View and tallest are only mentioned frequently in posts conveying aesthetical value. Skyline and pond are only mentioned frequently in posts respectively assigning age and economic values.

This relation can be more evident when referring to specific posts (Table 1):

"Beautiful view of windcatchers and Jame mosque of Yazd with a fall sunset in the background ..."

This post conveys the aesthetical value of windcatchers in relation to the city (Fig. 8). Respectively, the aesthetical value of windcatchers was found related to the view of the city with its tall windcatchers, while standing on the rooftop of buildings. This can be interpreted from the words "tallest", "view", and "roof", which are among the most frequent

¹ **Cosine similarity** is one of the most widely used and powerful similarity measures in Data Science. This study uses this method because it does not consider the length of the vector. In other words, the frequency of the word is not taken into account.

² **Accuracy:** $(\text{TruePositives}_1 + \text{TruePositives}_2) / ((\text{TruePositives}_1 + \text{TruePositives}_2) + (\text{FalsePositives}_1 + \text{FalsePositives}_2) + (\text{TrueNegative}_1 + \text{TrueNegative}_2) + (\text{FalseNegative}_1 + \text{FalseNegative}_2))$. **Precision_value:** $(\text{TruePositives}_1 + \text{TruePositives}_2) / ((\text{TruePositives}_1 + \text{TruePositives}_2) + (\text{FalsePositives}_1 + \text{FalsePositives}_2))$. **F-measure:** $(2 * \text{Precision} * \text{Recall}) / (\text{Precision} + \text{Recall})$.

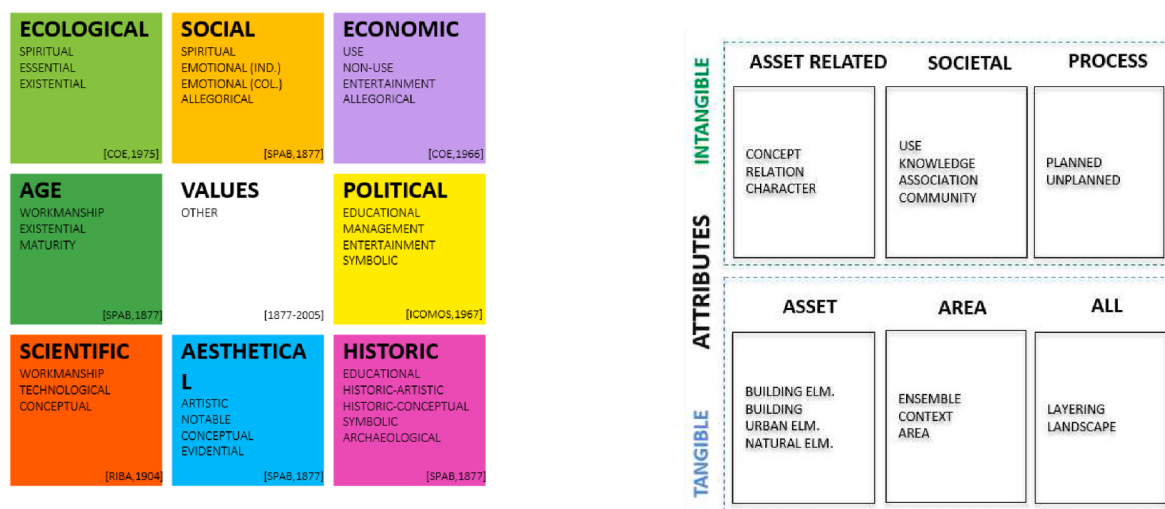


Fig. 3. Theoretical framework on cultural significance; values (Pereira Roders, 2007) and attributes (Veldpaus, 2015).

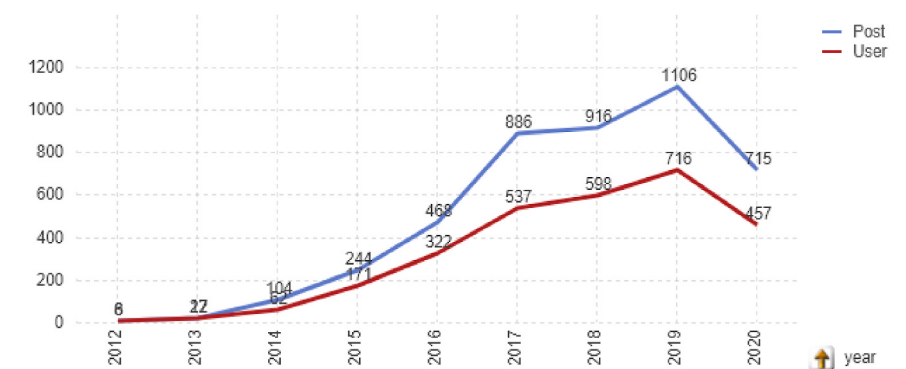


Fig. 4. Total number of posts and active users in each year.

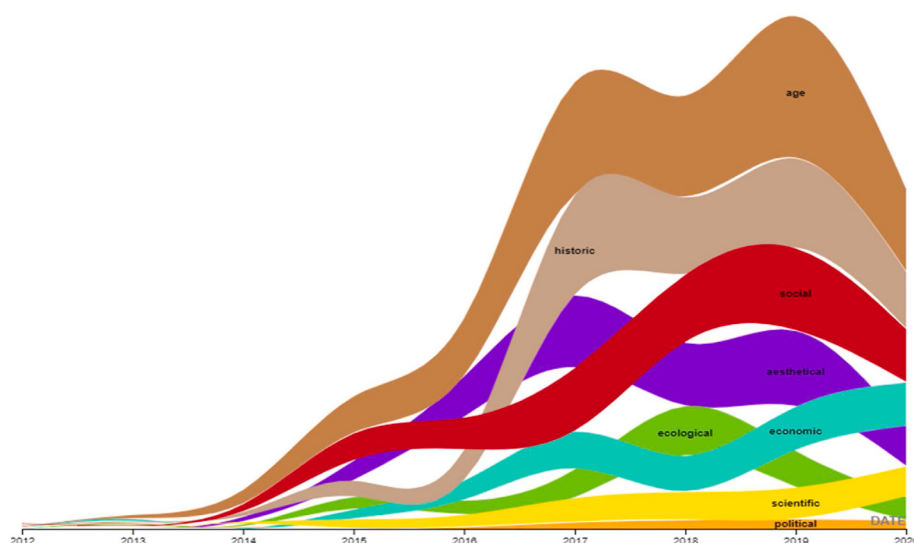


Fig. 5. The frequency of values in each year.

attributes, found in posts conveying aesthetical values (see Table 1).

There are two well-known building complexes with windcatchers mentioned frequently in the posts. These are the Aghazadeh mansion in Abarkuh, Yazd (printed in Iranian cash), and Dolat Abad Garden in Yazd (the tallest windcatcher in Iran). They mostly convey aesthetical,

historic, and political values (see Table 1).

More generally, “home” is frequently stated in posts, when conveying aesthetical and historic values. It indicates that these two values are conveyed to both typical and renowned buildings, and confirms its relation to the city as a whole, rather than individual buildings.

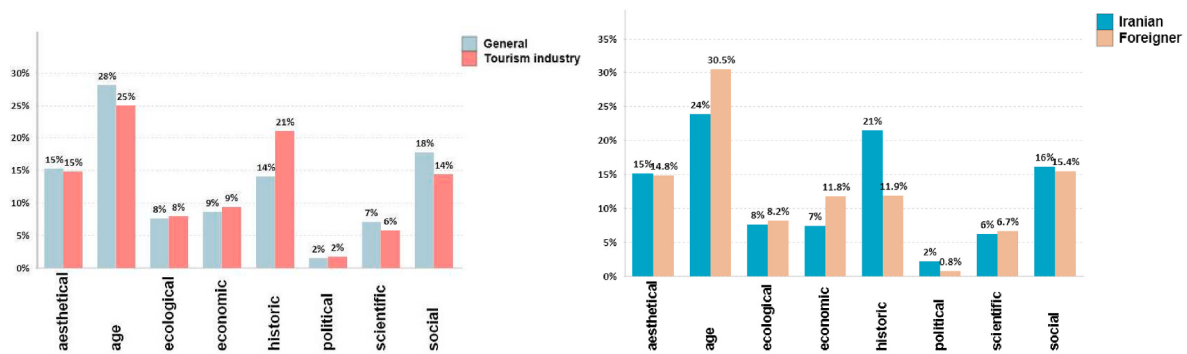


Fig. 6. Comparison between the percentages of various values referred by target groups.

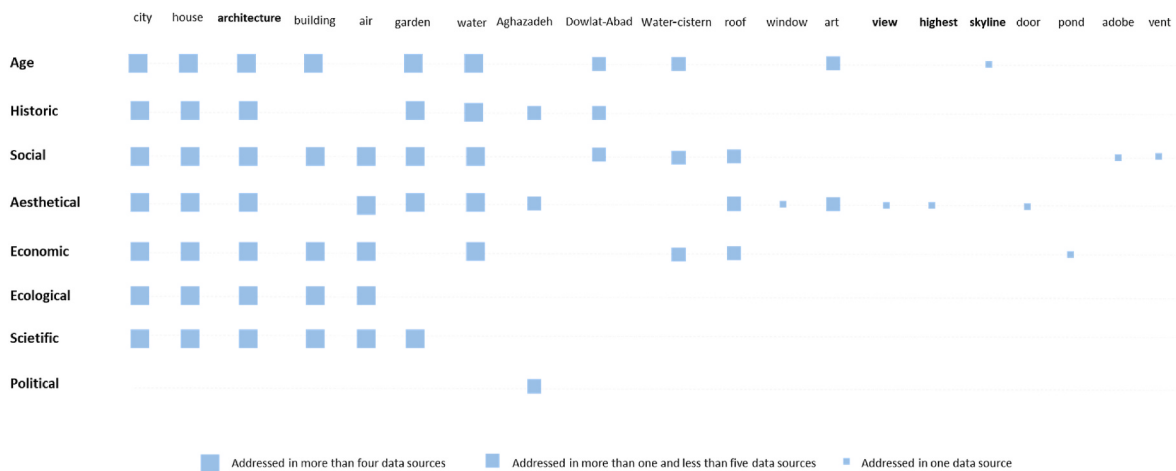


Fig. 7. Most frequent attributes associated with categories of values (tangible: normal font style, intangible: bold font style).

While all categories of values were found conveyed in the collected data, only a few categories of attributes are mentioned (tangible: asset, area; and intangible: asset-related) (see Fig. 9). Several categories of values and attributes have stronger associations, namely the age value with the area, the social value with the natural elements, and the economic value with the building and the natural elements. Moreover, while all the categories of values have associations with three or four categories of attributes, political value is associated only with the building.

4.2. Analysis of feelings

4.2.1. Sentiment analysis

As mentioned earlier, the sentiment analysis of the posts was conducted on five scales, from very positive to very negative. Very positive and positive posts were the dominant feelings (86%) expressed in the posts written by all the users. The rest of the posts described neutral (14%), and only 14 posts showed negative feelings. This showed a different perspective to what some scholars indicate in the literature, that people often use social media to vent out, complain, and generally be pessimistic about urban issues (Resch, Summa, Zeile, & Strube, 2016). Very few posts with negative sentiments show that shows a consensus on the positive values of windcatchers among different stakeholder groups. Given that, it was not meaningful to analyze posts' sentiments based on the stakeholder groups.

As posts with negative feelings were obscured by posts with positive feelings in the last items of this paper, this item focuses on analyzing posts with negative sentiments. The topics of these posts relate to the conflict over the ownership of windcatchers, the lack of interest in using windcatchers, and worn-out windcatchers.

Some of the posts with negative feelings express their concern about the recent activity of the United Arab Emirates (UAE) and Dubai, which involves using windcatchers. They believe that windcatchers are the symbol of Iranian identity, and the UAE is trying to take ownership of windcatchers:

"... But right now some new 49 years old country called "UAE" is constructing copies of the same Iranian wind catchers for its tourism goals and trying to introduce themselves as the first designers and builders of the Iranian ancient wind catchers thanks to their effective global advertisement capabilities and their petro dollars! Can't the @unesco really distinguish the differences between an old country with a very rich history from some new and young small country?! Good people of Iran, please wake up" (fatemezahramam, 2019; see Fig. 10, the left photo)

Only a few posts were found stating that windcatchers do not play their original function in Yazd anymore and the reasons behind it. This indicates that the residents and users of windcatchers do not use social media to explain their critical opinions about windcatchers' functions. The demolition and lack of interest in using windcatchers are discussed in the following posts:

"Fahadan house was renovated according to its new function as a hotel. Some of the changes are the following: Given the technological development and invention of ventilation systems, the windcatchers will not be used. Another reason for the lack of interest in using windcatchers is the dramatic change in people's perceptions of thermal comfort. In other words, people prefer to live more comfortably. Another reason for not using windcatchers is climate change. In the past, there were four seasons, but now there are only two seasons: longer and warmer summers and warmer winters than

Table 1
Exemplary quotes and conveyed values and attributes.

Exemplary quotes	Values	AI logics	Attributes
<i>We're visiting one of the most beautiful viewpoint in the world! From #arhouseyazd you can see a panoramic view of #yazd and it's magic #windcatcher and #dome! #tourguide#privatetour #traveltoiran #privateguidedtours</i>	Aesthetical	Beautiful (aesthetical)	Viewpoint, panoramic view, Yazd, windcatcher, dome
<i>On the roof top in my old city, "Yazd", a windtower above the roof whatching the hole yard & house & city, ...Beautiful view!</i>	Aesthetical, age	Old (age), beautiful (aesthetical)	Roof top, city, Yazd, windtower, roof, yard, house, view
<i>Beautiful rooftop view of the old part of Yazd, with all its badgirs (windcatchers) and blue domes.</i>	Aesthetical, age	Beautiful (aesthetical), old (age)	Rooftop, view, part of Yazd, windcatchers, blue domes
<i>... The traditional wind catchers are visible across the skyline providing natural ventilation for those living inside. ...</i>	Social, age, ecological, economic	Traditional (social, age), natural (ecological), ventilation (economic)	wind catchers, skyline
<i>Aghazadeh Mansion and its windcatcher was built during the Qajar Dynasty and is located in Abarkooh, Iran. The windcatcher in this mansion is one of the most original and beautiful windcatchers in Iran and all the world.</i>	Political, historic, aesthetical	Qajar Dynasty (political, historic), beautiful (aesthetical)	aghazadeh mansion, windcatcher, Abarkooh, original,
<i>... Windcatchers are historic towers that have been built on the roofs of houses in the hot and desert areas of the center of Iran. ...</i>	Historic	Historic (historic)	Windcatchers, towers, roofs of houses
<i>BADGIR(wind-tower), literally "wind catcher," a traditional structure used for passive air-conditioning of buildings.</i>	Social, age, ecological, economic	Traditional (social, age), passive (ecological), air-conditioning (economic)	badgir, structure, buildings
<i>... #Badgir is a #traditional #handmade engineering architectural #masterpiece to deal with the unbearable heat of the central #Iranian desert. ...</i>	Social, age, scientific	Traditional (social, age), engineering (scientific)	badgir, engineering, architectural masterpiece

last years. Probably windcatchers can not function properly as a traditional architectural element."

"Windcatchers which are gone with the wind" (dehghani.pic, 2016; see Fig. S11, the right photo).

Overall, the result item shows that both Instagram and Twitter users have been actively sharing their opinions about how windcatchers are significant (or not). This was made possible by decoding their views into values, attributes, and sentiment classification. The values of windcatchers addressed by different groups of users (Iranian/foreigner; general users/tourism professionals) were analyzed using Pereira Roders' framework (2007). General users working in the Tourism profession referred to the historic value most frequently than other users, which might be related to their knowledge and expertise. A more profound analysis was done to investigate the other attributes associated with windcatchers and their values. This analysis showed the importance of the relation between windcatchers and other attributes and their values

for the conservation of these attributes in the historic city of Yazd. After, the sentiment analysis showed a dominance of posts with (very) positive sentiments. Complementarily, this paper explored the posts with negative sentiments, showing contrasting opinions over the values of windcatchers. This research indicates sentiments could be at the core of value formation. If people attach negative sentiments, they probably associate negative values with attributes.

5. Discussion and conclusion

The results depict a drastic jump in the number of posts in 2017 (the year of Yazd's inscription in the UNESCO list) and a drastic drop in 2020 (the beginning of the COVID-19 virus universal pandemic). This shows potential relations between the inscription of Yazd Historic City, Iran, in the UNESCO list and users' activity on social media. It seems that this relation was stronger among tourism professionals as their activity raised in 2017 more than the other users' groups. This might be because Tourism professionals highlighted the city's inscription to attract tourists to Yazd. The drop in the number of posts of all stakeholder groups in 2020 may be related to the COVID-19 virus pandemic. This decrease was much more among tourism professionals and foreigners compared to general users and Iranians. Given that, probably activities of tourism professionals and foreigners were more associated with tourism issues compared to the other groups. To prove these findings, additional research is necessary.

The main contribution of this paper was to reveal the potential of social media platforms to be applied in heritage management processes through the identification and interpretation of cultural significance (values and attributes) and sentiments that are conveyed to heritage by users.

The paper presents valuable insights for policymakers to preserve windcatchers' cultural heritage in Yazd, Iran, and other case studies. It highlights the cultural significance of windcatchers by identifying key attributes valued by different stakeholder groups. Policymakers can prioritize conservation efforts based on the recognition of the age value as the most important, allocating resources accordingly. Additionally, neglected values, such as political values, warrant attention through awareness initiatives involving different stakeholder groups and educational institutions. Social media emerges as a valuable monitoring tool for understanding public sentiments and perceptions of heritage properties, guiding adaptive management strategies. Engaging different stakeholder groups is crucial for well-informed preservation policies that align with their values. Policymakers can consider long-term monitoring mechanisms to assess changing perceptions and values attributed to heritage properties using an AI-empowered analysis approach. Ultimately, informed decisions will lead to the sustainable conservation of heritage and cultural significance.

More precisely, the utilization of visualizations depicting different stakeholder groups' sentiments in heritage management facilitates proactive decision-making. These visualizations provide valuable insights into different stakeholder groups' feelings, enabling managers to make informed and evidence-based decisions, prioritize user preferences, and identify areas of concern to ultimately preserve heritage properties. Additionally, visualizations aid in evaluating the effectiveness of conservation efforts and promoting collaboration among stakeholders involved in heritage planning. Furthermore, by revealing areas of conflicts, consensus, and concerns, such visualizations can foster effective communication and collaboration among stakeholders, including experts, community representatives, and government authorities, thereby contributing to the preservation and sustainability of heritage properties.

Moreover, this research showed the diversity of social media users, making it possible to categorize them into different groups according to their location (Iranian and foreigners) and profession (general and tourism professionals). Additional research is needed to identify the complexity and diversity of social media users.

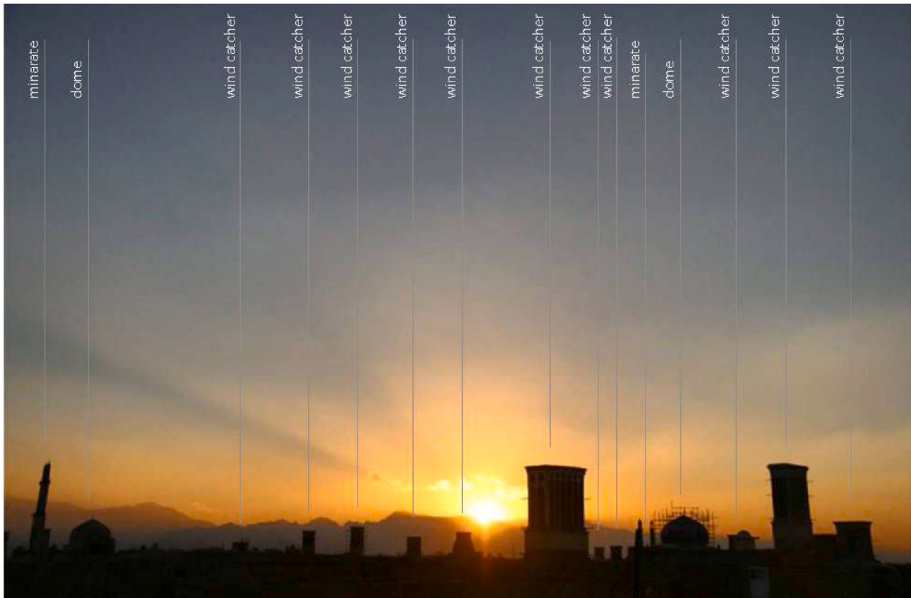


Fig. 8. The picture of a post conveying the aesthetical values of windcatchers in relation to the city of Yazd, (Adapted from ali.sheibani.en (2016), introducing the lines and description of building elements).

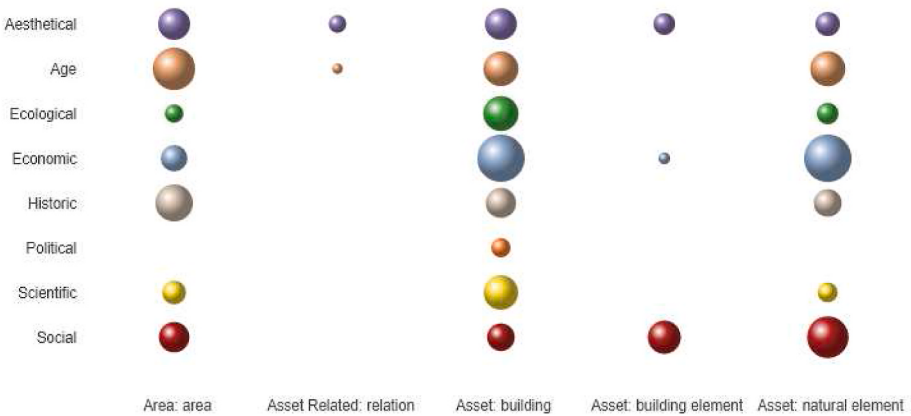


Fig. 9. Matrix of categories of values associated with the most frequent categories of attributes. The bigger the sphere, the higher the number of occurrences.



Fig. 10. Photos related to posts with negative sentiment, the left photo posted by fatemezahramam (2019), the right photo posted by dehghani.pic (2016).

Machine learning and application of the artificial intelligence method were used to extract values and attributes, as well as sentiments on the posts related to the windcatchers of Yazd. Posts mostly addressed (very) positive sentiments, which showed a different perspective to what the literature generally indicates that people mostly use social media to

be pessimistic about urban issues. Still, a lack of posts with negative feelings does not mean that people do not attach negative feelings to windcatchers in Yazd. It may convey that people do not express the negative values of windcatchers on Instagram and Twitter. This analysis reveals that the rate of participation is quite low when

compared to the population of Yazd, yet meaningful. A very small portion of people has so far participated in online conversations about windcatchers. Those who do participate often leave meaningful observations that have the potential to inform the decision-making process regarding the conservation of windcatchers.

An innovative aspect of this work consists in the methodological process developed, which can be applied to other heritage management case studies and different scales. The results of the data analysis provided a better understanding of the public voices around heritage values and attributes of windcatchers in Yazd, Iran. The future steps of this research will be to analyze data from other literature search sources (including policy documents) representing other stakeholders and later facilitate a direct interaction among multiple stakeholders in Yazd, Iran.

Future studies are needed to advance social media data analytics. One possibility is to focus on real-time data to better inform relevant authorities (and the general public) of the immediate effects of their actions and also required actions. Another is to broadcast this study to a larger scale and a larger network of authorities in different historic cities. If anything, the preliminary findings have presented the potential for passive public participation via social media platforms, which enhanced the understanding of the cultural significance addressed by the online public. Building a larger network (of cities and regions) has the potential to enable responsive heritage decision-making based on an informed understanding of public concerns and priorities on a wider scale. This would then enables explicitly online participatory heritage management, socially responsible and respectful to the diversity of public voices, increasingly being expressed online.

Author statement

We the undersigned declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript, and the roles addressed in the credit author statement document have been approved by all of us. We understand that the Corresponding Author is the sole contact for the Editorial process. She is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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