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In Praise of Diversity in Participatory Heritage Planning Empowered by Artificial Intelligence: Windcatchers in Yazd

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Abstract

Heritage planning is changing, in both theory and practice. There is greater attention to the cultural significance (values and attributes) conveyed to a heritage property, rather than focusing on the property alone. Identifying and revealing this cultural significance has become a critical step in heritage planning. Moreover, international guidelines increasingly encourage public participation in defining the cultural significance of heritage sites. However, effectively involving diverse stakeholders and capturing the cultural significance they attribute to heritage remains a challenge, particularly when dealing with extensive datasets and multiple stakeholders. Although automated methods have shown potential in fields like digital humanities, their application in heritage planning is still limited. This article explores the innovative use of artificial intelligence (AI), particularly text classification analysis, to analyze unstructured textual data (e.g., policy documents, literature, and social media) to uncover the cultural significance of built heritage. Focusing on Yazd, Iran, and specifically on windcatchers—a key cultural attribute recognized for its "outstanding universal value" by UNESCO—this study integrates AI to enhance both urban and socio-cultural planning. This article, as the concluding piece of a broader research project, synthesizes the project's findings to highlight AI's potential for inclusive heritage planning, referencing related publications of the same project to provide context while remaining concise. The research is structured in three phases: first, a literature review on AI applications in participatory heritage planning and value-based heritage planning; second, the methodology for data collection and analysis, including coding and comparing values and attributes of windcatchers conveyed by different stakeholders; and third, findings on the values and attributes, and their interrelationships as revealed through the data. The results confirm that while there are both conflicts and alignments in the cultural significance attributed to windcatchers in Yazd among various stakeholders, the theoretical framework presented here offers a valuable tool for heritage planning. By decoding and measuring cultural significance from diverse perspectives, this framework aids in identifying conflicts and alignments and in better aligning stakeholder perspectives. This model can be adapted to other key attributes in Yazd and other case studies, offering broader applications in heritage planning. Additionally, the

findings underscore the potential of AI to evaluate the legislative framework's effectiveness in enhancing public engagement.

Keywords
artificial intelligence; cultural heritage; cultural significance; Iran; public participation; Yazd

1. Introduction

Heritage studies are shifting from a focus on the heritage property alone to its cultural significance (Silva & Roders, 2012). Cultural significance includes what motivates the listing of a particular resource as heritage (attributes) and why these resources are listed as heritage (values). In parallel, a value-based approach to heritage planning is introduced, which considers heritage planning as a "dynamic process of change management" (ICOMOS Australia, 1987). Accordingly, a city is addressed as a "living heritage" with dynamic associative values that differ based on the time period and the different perspectives of stakeholders (Ginzarly et al., 2019; Poulios, 2014).

This dynamic approach to heritage planning acknowledges that each community and its members can convey different meanings to heritage as a whole, even if some attributes or values overlap (Bonet et al., 2020). Even the same community—due to aging and growth of knowledge and experiences—could evolve in their perspective of heritage. Given this diverse character of heritage, the participation of varied stakeholders, experts, and non-experts in determining heritage cultural significance has been strongly recommended, both in academia (Bonet et al., 2020; Ginzarly et al., 2019; J. Li et al., 2020; Palma & Díaz-Puente, 2024; Rêgo & Almeida, 2022; Yung et al., 2017) and by international recommendations (e.g., UNESCO, 2011, 2016). However, what happens when communities disagree on what is significant and why? How could then the cultural significance of heritage be defined? Through a broader statement, even if potentially contradictory, returning to the tradition of one narrative, only including what met consensus? Or no statement at all, as full consensus could not be reached?

Participatory practices applied to heritage planning also aim for consensus-building on the cultural significance of heritage (Den, 2014; García et al., 2019; Harmon & Viles, 2013; Rêgo & Almeida, 2022; UNESCO, 2011; Van Assche & Duineveld, 2013; Zhou et al., 2018). Consensus and conflict are intertwined concepts and cannot be addressed without each other in an inclusive decision-making process. Varied literature considers conflict as a challenge of consensus-building yet to be solved (e.g., Kaya & Erol, 2016; Lin & Geertman, 2015; Raynor et al., 2017; Rêgo & Almeida, 2022), and that further research discussing the issues, reasons, and conflict resolution methods (e.g., mediation, facilitation, negotiation, collaboration, and consensus-building) is needed.

Still, few scholars argue that conflict is as important and beneficial as consensus in participatory practices because conflict contributes to the generation of new ideas and solutions (Bailey et al., 2011; van Ewijk, 2011). This controversy about heritage may contribute to the formulation of more sustainable urban development and management practices (Antweiler, 1998; Corburn, 2005; Skoglund & Svensson, 2010). Accordingly, a balance between consensus and conflict is considered essential. It is the role of leaders and policymakers to demonstrate a genuine commitment to participation by embracing community diversity and conflict (Fahmi et al., 2016; Maginn, 2007; Purbani, 2017).

Some studies explore and cherish stakeholders' conflicts to reach a consensus. Yu et al. (2019) organized interviews with key stakeholders, reviewed project documents, used a model to analyze stakeholders' conflicts, and developed action schemes accordingly. Besides, García et al. (2019) presented a methodology to consider the majorities and consensus, as well as the minorities and controversial interests, to construct a holistic but integrated decision, in which all values are considered as equally important. As such, it is important to holistically understand the views of various types of stakeholders, to make integrated decisions.

Currently, studies that explore public participation in heritage planning are using various manual conventional methods (e.g., Bonet et al., 2020; J. Li et al., 2021). Nevertheless, this process can be costly and time-consuming, especially on built heritage, when many stakeholders are involved (J. Li et al., 2020; Morrison & Xian, 2016). While the automation of methods has proven to mitigate such restrictions in fields such as digital humanities (e.g., Bouzguenda et al., 2019; Horgan & Dimitrijević, 2019; Melica et al., 2018), their application in heritage planning, practice, and theory is still scarce. Hence, this research aims to investigate the potential of artificial intelligence (AI) models (e.g., multi-label text classification analysis) in analyzing available unstructured textual data from multiple sources (e.g., policy documents, literature, and social media), to reveal values and attributes conveyed to built heritage by different stakeholders, to build a foundation to align various values for making integrated decisions.

By comparing the different stakeholders' perspectives, discovered using an AI approach from multiple unstructured data sources, this research develops an approach to reveal alignments and conflicts between academic experts, policymakers, and users to shed light on the conflicts and alignments embedded in the multi-stakeholder setting and as a step further towards inclusive data-supported heritage planning. To provide empirical evidence of such an approach, this research explores various stakeholders' perspectives on the cultural significance conveyed to a specific case study, the city of Yazd, Iran. The focus of research is on windcatchers, which are Yazd's key attributes conveying outstanding universal value (OUV), as inscribed on the UNESCO World Heritage List (UNESCO, 2017). This research discusses alignments and conflicts in the attributes and values, by comparing the perspectives of policymakers, users, and academic experts. Based on the analysis, a critical reflection on the changes expected in heritage planning is discussed.

This article is part of a broader research project, with its findings contributing to a series of related publications. Throughout the text, we reference these works to offer readers additional context and in-depth analyses, allowing the article to remain concise while including essential information. As the concluding article, it synthesizes the findings from the other sections of the project to highlight the potential of AI for inclusive heritage planning. This study offers a comprehensive methodology with a customized AI-supported tool to detect alignments and conflicts in participation processes applied to heritage planning. Besides, this study reveals a critical gap that requires more reflection on the changes expected in heritage planning, by considering how different stakeholders may grow in their contribution to the definition of cultural significance in heritage planning, given the rising importance of public participation. Considering the increasing significance of public participation, Section 2 delves into the concepts explored in this research, such as value-based heritage planning practices, the definition of cultural significance, and how AI has been applied in participatory heritage planning.

2. Literature Review

2.1. Value-Based Heritage Planning and Cultural Significance

A value-based heritage planning process recognizes heritage as a whole that can be defined differently by various stakeholders (Bonet et al., 2020). Given this dynamic character of heritage, the participation of multi-disciplinary stakeholders, beyond experts, has been strongly recommended to determine heritage cultural significance (e.g., Bonet et al., 2020; Ginzarly et al., 2019; J. Li et al., 2020; UNESCO, 2011; Yung et al., 2017).

Value-based management processes are recommended to start with a cultural significance assessment (with a statement of cultural significance as outcome), followed by policy development, policy management, and vulnerability assessment of cultural significance (Clark, 2001; ICOMOS Australia, 1987; Kerr, 2013). As such, in the entire process of value-based heritage planning, the statement of cultural significance becomes the key reference (ICOMOS Australia, 1999). Specifically, the Statement of Outstanding Universal Value (UNESCO, 2008) is the statement of cultural significance detailing the cultural significance of OUV conveyed to heritage properties, justifying the selected criteria and supporting the process of the properties' nomination for inscription in the UNESCO World Heritage List (UNESCO, 2005). As stated in the 2005 operational guidelines, the OUV and the conditions of authenticity of the properties should be maintained or enhanced from the time of inscription onwards (UNESCO, 2005). This value-based management process has been extensively applied in practice in countries such as Australia and the United Kingdom, either by changing the legislation or drafting new conservation guidelines (Silva & Roders, 2012).

As mentioned earlier, cultural significance includes what motivates the listing of a particular resource as heritage (attributes) and why these resources are listed as heritage (values). The theoretical frameworks of cultural significance used in this study are composed of (a) values, as developed by Pereira Roders (2007), and (b) attributes, as developed by Veldpaus (2015). Value classes presented by Pereira Roders include eight primary values and sub-classes (Silva & Roders, 2012). The attributes framework consists of tangible attributes (asset-related, societal, process) and intangible attributes (asset, area, all).

2.2. AI in Participatory Heritage Planning

AI has emerged as a valuable tool for participatory heritage planning, especially for analyzing available data sources (e.g., social media platforms), as evidenced by previous studies (e.g., Abeysinghe et al., 2018; Afzaal et al., 2019; Qiu & Zhang, 2021). Using these tools for public participatory heritage planning has been gaining significant attention from both researchers and practitioners, in line with UNESCO's recommendations (UNESCO, 2011).

For instance, Abeysinghe et al. (2018) introduced a social media analytics platform that utilizes machine learning techniques and a visualization tool to identify discussion pathways, aspects, and their corresponding sentiment and deeper emotions. This platform enables decision-makers to gain valuable insights into the most talked-about topics related to a particular entity. Additionally, the analysis of associated sentiments and emotions assists in identifying feedback related to these topics. Similarly, the research of Afzaal et al. (2019) distinguishes the opinions or sentiments of people about heritage properties. Furthermore, Qiu and

Zhang (2021) conducted a study that explored the structure and connections between cognitive elements associated with intangible cultural heritage tourism. They analyzed data from Weibo, a prominent social media platform in China, employing matrix construction, dimension classification, and semantic network analysis as the primary analytical processes. These scholars highlighted the potential of social media for engaging citizens and gaining insights into their emotional attachments to the urban environment.

However, the exploration of social media and AI for participatory heritage planning is still in its nascent stage. Existing literature lacks heritage-specific tools that specifically address the cultural significance of built heritage and the explicit connection between attributes and values (Bai et al., 2021). Furthermore, previous studies have often focused on broader geographical scales, such as countries, cities, or neighborhoods, rather than delving into specific attributes within a city, such as windcatchers (e.g., Ginzarly et al., 2019; van der Hoeven, 2020). Therefore, the present study aims to investigate the potential of available data sources and employ AI methods for data analysis to uncover individuals' perspectives regarding the cultural significance (values and attributes) of built heritage on the scale of the building element, the windcatcher.

3. Case: Windcatchers in Yazd

A windcatcher is a traditional building element that has been used for passive cooling/natural ventilation in buildings, over time and place. Windcatchers are widely used in North Africa and West Asia. Iran and other countries around the Persian Gulf have used windcatchers for the past 3,000 years (Saadatian et al., 2012). Windcatchers rely on local weather and microclimate conditions, and their design is often adapted to the local context (Ford, 2001) in shape, size, and direction. Windcatchers can be circular, octagonal, polygonal, square, or oblong. They can be unidirectional, bidirectional, or multidirectional (Movahed, 2016). In different climate zones, six types of windcatchers have been identified (see Figure 1).

Windcatchers are usually vertical shafts with vents above the roof of the main room(s) in a building. The main goal is to enable passive cooling/natural ventilation, by channeling the desired wind to the interior of the living spaces, where air often passes over a pool of water (acting as a humidifier) and provides thermal comfort to the building users (see Figure 2). Other elements such as windows and doors are also important elements of this ecosystem, contributing to the wind circulation, together with the windcatcher (Movahed, 2016).

Yazd is called the "city of windcatchers" because the city has the highest number of windcatchers among cities in Iran (Saadatian et al., 2012). The windcatcher is selected as a case study as it is an important attribute for various stakeholders, from Yazd and beyond. The windcatcher is an important element for locals, as many

Figure 1. Various types of windcatchers in different climate zones. Source: Jomehzadeh et al. (2017).

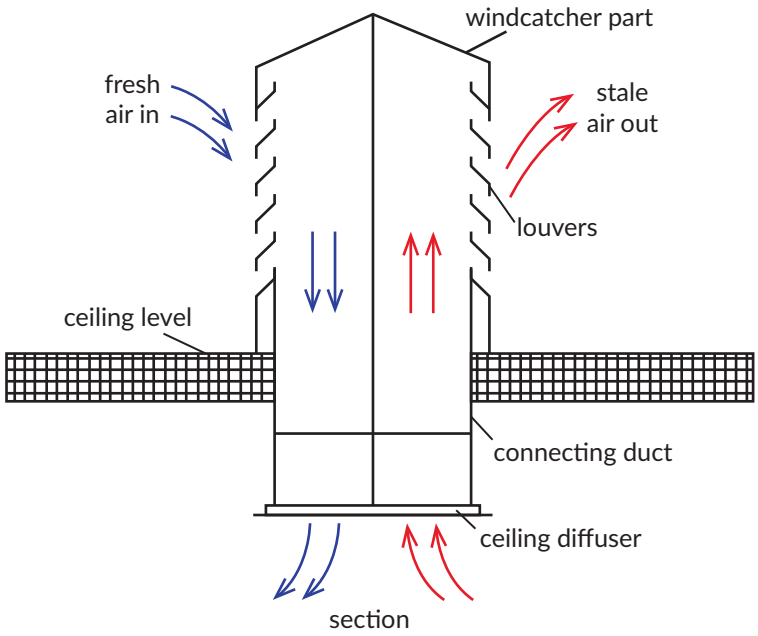

Figure 2. Section view to demonstrate the structure and mechanism of windcatchers. Source: L. Li and Mak (2007).

houses in the historic city of Yazd have at least one windcatcher. Tourists often write about windcatchers since they are unique building elements that can be seen from everywhere in the historic city of Yazd, due to their height difference within the urban context, acting as landmarks in the urban landscape. Scientists have done much research on windcatchers, mainly due to their main goal of natural ventilation, exploring ways to redesign and develop traditional windcatchers for the modern era (e.g., Moghaddam et al., 2011; Zafarmandi & Mahdavinejad, 2021). Lastly, windcatchers are mentioned in various local, national, and international policy documents as an attribute conveying cultural significance.

4. Methods

The process followed in this research entails three steps, namely data acquisition, data pre-processing, and data analysis (see Figure 3).

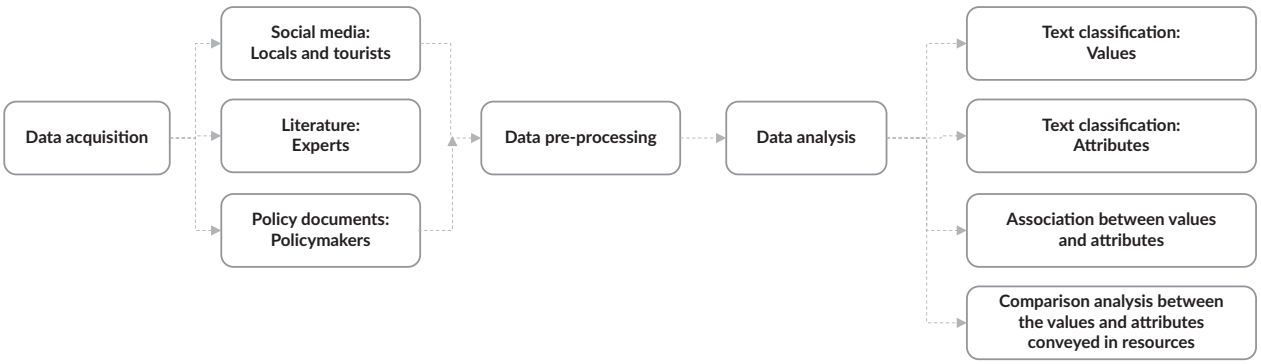

Figure 3. Overview of the methodological framework.

4.1. Data Acquisition

This study reveals and compares the cultural significance conveyed by three stakeholder groups to the windcatchers. These groups are academic experts, policymakers, and users, based on the theoretical framework by Pereira Roders (2019). The relevant resources for each stakeholder were collected from various sources (Table 1). They are, respectively, the literature, policy documents, and social media posts (only Instagram and Twitter) referring to windcatchers and Yazd. All the paragraphs in these documents referencing the windcatchers of Yazd were collected and analyzed. All the data were collected manually, except for the social media data which was retrieved using the WebHarvy web scraping software due to its large volume.

All sub-national, national, and supra-national policy documents related to the city of Yazd addressing windcatchers in any part of the whole document were collected as data sources. Overall, seven documents were used as datasets: three sub-national, one national, and three supra-national policy documents. All the paragraphs in these documents addressing windcatchers were elicited, structured, and analyzed. Additional insights into policy makers' perspectives on the windcatchers of Yazd are provided in Foroughi (2023).

Three peer-reviewed academic databases—Scopus, ScienceDirect, and SID (Iranian Scientific Information Database)—were initially selected as primary data sources for their comprehensive coverage, relevance, and regional insights. However, these databases may not include all journals or languages, potentially introducing bias. To expand the search, the snowball method was employed, using references from identified papers (e.g., Asadi et al., 2016; Vahdatpour & Ariaei, 2020). In total, two book chapters and 92 papers were identified (Foroughi et al., 2024), and all sentences mentioning windcatchers were extracted for analysis. Future research should consider additional databases like Google Scholar and JSTOR to ensure a more thorough review and reduce regional or linguistic biases. Additional insights into experts' perspectives on the windcatchers of Yazd are provided in Foroughi et al. (2024).

Social media platforms commonly used in Iran during this research, specifically Instagram, Twitter, Facebook, and LinkedIn, were also evaluated as potential data sources. After an initial review, Instagram and Twitter were identified as the primary platforms containing relevant posts. Consequently, posts related to the windcatchers of Yazd were automatically mined using WebHarvy, a paid tool capable of extracting text, HTML, images, and URLs from various websites and saving the data in multiple formats. A total of 23,899 posts were mined, including information such as usernames, post content, publication time, and users'

Table 1. The stakeholders and relevant resources.

Stakeholders	Definition	Resources
Policymakers	Those developing the plans and tools to manage local resources	Relevant local, national, and international policy documents
Academic experts	Those working in academia, e.g., researchers	Academic databases: Scopus, ScienceDirect, and SID
Users	Community in general, e.g., local, regional, and national population, tourists, educators	Social media: Instagram and Twitter

Note: SID is the Iranian Scientific Information Database.

biographies. However, demographic characteristics of the users were not captured. Ethical considerations were prioritized by only processing hashtags and comments related to heritage values and attributes, without storing any sensitive personal data. Personal information was not disclosed at any stage of the research, and users' identities were kept anonymous unless explicit permission was obtained. To further ensure anonymity, usernames were altered (e.g., user1, user2) and posts were rephrased to make the data untraceable. Additional insights into public opinions on the windcatchers of Yazd shared on social media are provided in Foroughi et al. (2023).

4.2. Data Pre-Processing and Data Analysis

In order to facilitate data analysis, data pre-processing was conducted. All variations of "windcatcher" and "Yazd" were normalized to "windcatcher" and "Yazd" (both in Persian and English, e.g., "Yazd," "yazd," "یزد"). Moreover, unnecessary data including stop words, references, punctuation marks, and website links were removed. After data cleaning and pre-processing, the dataset was ready for text analysis. To reveal the cultural significance conveyed in texts, two theoretical frameworks were used to decode the attributes and values conveyed in the literature, policy documents, and social media (see Figure 4). The theoretical frameworks of cultural significance used in this study are composed of (a) values, as developed by Pereira Roders (2007), and (b) attributes, as developed by Veldpaus (2015).

Overall, the analysis of attributes and values 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 quantitative analysis revealed the most and least frequent attributes and values, and identified patterns of the relation between attributes and values. The qualitative categorical analysis showed the categories of values and attributes addressed in the texts.

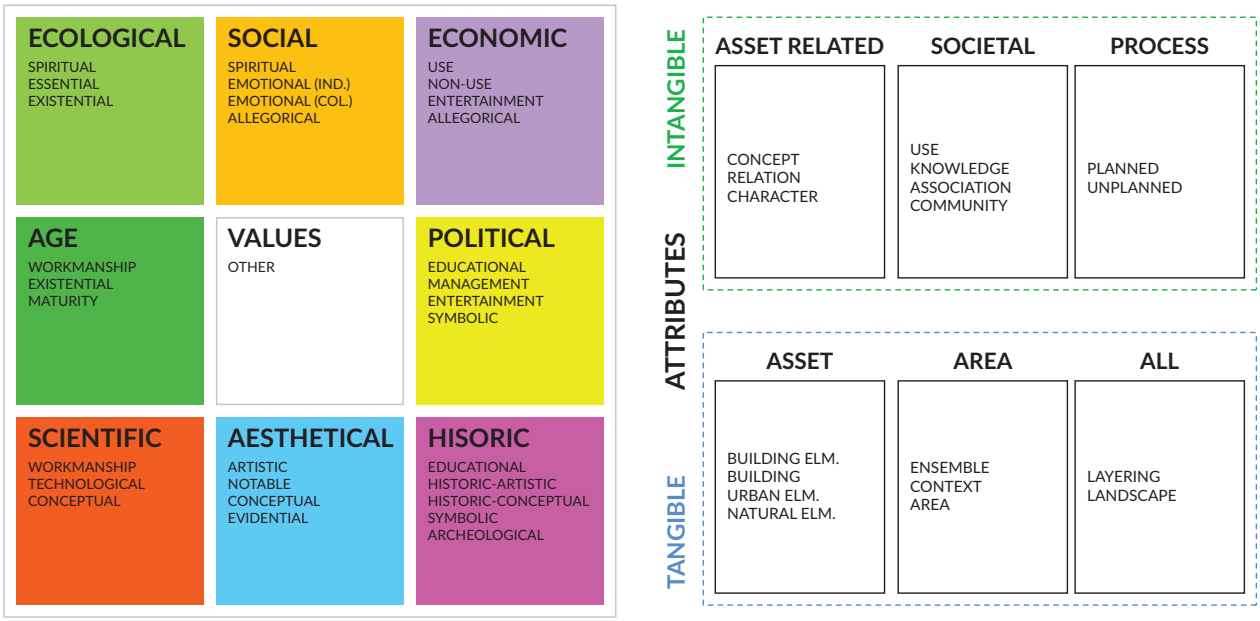

Figure 4. Theoretical framework on culturally significant values and attributes. Sources: Pereira Roders (2007) and Veldpaus (2015).

The qualitative analysis in this research is a multi-label text classification task used in natural language processing 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. We trained the BERT (bidirectional encoder representations from transformers) model to perform multi-label text classification. The objective was to predict the relevant labels, which represent either values or attributes, based on a given input text.

The BERT model is an influential pre-trained language model developed by researchers of Google (Devlin et al., 2018). BERT has revolutionized the field of natural language processing with its innovative bidirectional approach to language understanding and generation. Unlike previous models that rely on unidirectional processing, BERT leverages a bidirectional context understanding by considering both preceding and following words simultaneously. This unique capability allows BERT to capture comprehensive contextual representations of words and sentences, leading to a deeper understanding of language semantics (Devlin et al., 2018).

To measure the similarity between the words used in the sentence and the classes of values (social, historical, aesthetic, etc.), cosine similarity was applied. 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 (B. Li & Han, 2013). A higher cosine similarity indicates a stronger association between the sentence and the corresponding value class, facilitating the classification process. Data analysis and modeling are conducted using Google Colaboratory (Colab), an online platform for collaborative coding and computation. Lastly, the performance of the model was evaluated using accuracy, precision, recall, or F1 score metrics.

Overall, after acquiring the relevant data related to the three stakeholder groups, the values and attributes conveyed by these groups were revealed and analyzed. Consequently, a comparative analysis between the data sources was conducted based on the results found using the above methods and frameworks. This analysis reveals the conflicts and alignments between the perspectives of the stakeholder groups on windcatchers' cultural significance (values and attributes).

5. Results

5.1. Cultural Significance Analysis

As explained in Section 2, cultural significance is analyzed using two frameworks for both values and attributes. This section compares the frequency of mentions of values and attributes in all three types of sources. The reliability of the multi-label text classification model developed was tested and confirmed by the methods mentioned in Section 3 (accuracy: 94%; precision value: 77%; F-measure: 76%).

5.1.1. Values of Windcatchers in Yazd

Concerning the cultural significance of the windcatchers in Yazd, and in particular the values, the data sources referenced all eight categories of values. The most referenced are the economic values (24%), followed by age (15%), ecological (15%), historic (12%), social (11%), scientific (11%), aesthetical (10%), and

political (3%) values (see Figure 5). Still, there are some differences and similarities in the most and least addressed values, per data source. While economic and ecological values are the most conveyed values in both literature (academic experts) and policy documents (policymakers), age and historic values are the most addressed values in social media (users). Political values are the least conveyed values in all data sources.

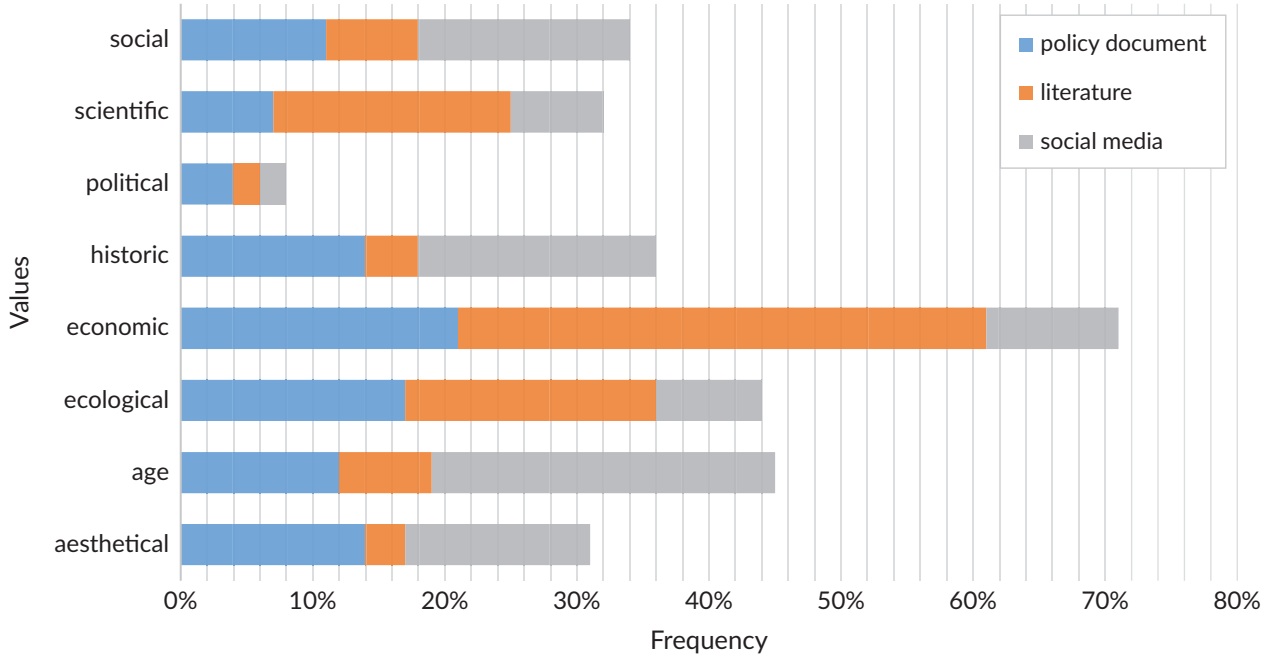

Figure 5. The frequency of values conveyed in different data resources.

5.1.2. Attributes of Windcatchers in Yazd

While all the data sources address all eight categories of values, only a few categories of attributes were found conveying these values. Results reveal that the tangible attributes were referenced more frequently than the intangible attributes (see Figure 6). Respectively, the most frequent tangible attributes belong to the asset class, namely the building (e.g., house, building), the building element (e.g., room, window, roof), and the natural element (e.g., garden, courtyard).

Nonetheless, also intangible attributes were addressed, including more generic attributes such as architecture and design. Social media data convey the most intangible attributes, followed by the literature, and lastly the policy documents. The referenced intangible attributes mostly belong to the asset-related

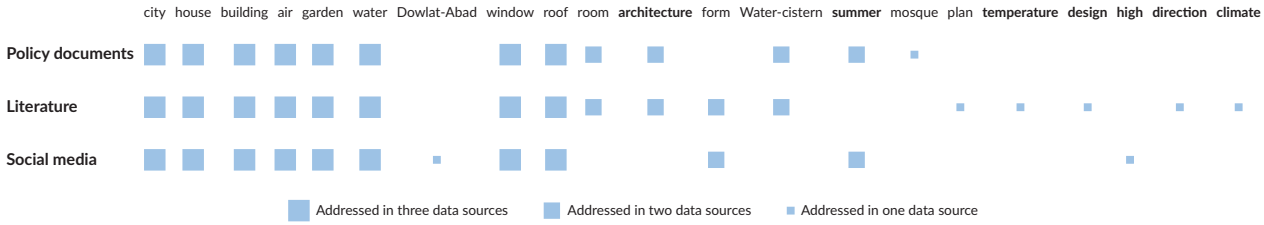

Figure 6. The 20 most frequent attributes in each of the data sources. Notes: The frequency decreases from left to right; tangible: normal font style; intangible: bold font style.

class, which includes the character (e.g., summer, heat, temperature), concept (architecture, design), and relation (e.g., direction, high). To be more precise, temperature, climate, summer, and heat are natural elements and not attributes but they convey the intangible character of windcatchers. They are used in sentences addressing the windcatchers' intangible character that makes a pleasant microclimate in a hot and arid climate in summer by decreasing the indoor temperature.

Among the 20 most frequent attributes in each data source, there are seven common attributes, namely city, house, building, water, air, garden, window, and roof. This shows the importance of the relationship between the windcatchers and their buildings (houses), as well as the city, according to all the stakeholders. Besides, the close relationship between the windcatchers and water, air, garden, windows, and roofs is often mentioned, by all the stakeholders (see Table 2).

Still, some attributes are only frequently mentioned by specific stakeholders. The intangible attributes of windcatchers making a pleasant microclimate (e.g., temperature, climate) and the windcatchers' design concept and plan are mainly discussed by academic experts. The relation of windcatchers with other building elements as per the height difference (and their role in the skyline of the city) is only addressed by users. Besides, only users mention explicit buildings with windcatchers, namely Aghazadeh and Dowlat-Abad buildings.

Table 2. Exemplary quotes.

Reference	Exemplary quote
Conservation Plan of the Historic City of Yazd	*Windcatchers* are closely connected to the *main room*, *porch*, *pool*, and *basement*, creating a condition for the *air* to *ventilate* the *building*, and while the air passes by the *moisture*, elements like the *pool*, *garden*, *tree*, and *basement's wall* compensate the lack of moisture in the *earth* and create a pleasant environment in *hot summer* days for residents.
Windcatcher: Iranian Engineering Masterpiece	*Evaporative cooling* is an important function of *windcatchers*. In Yazd, usually there is a *water pond* in one of the *rooms*, with a *windcatcher* on top of that. This *water pond* contributes to *evaporative* cooling (Bahaodori Nejad & Dehghani, 2018).
Numerical simulation of cooling performance of wind tower (Baud-Geer) in hot and arid region	This figure shows that, by using the logical amount of *water* in the *evaporating system* of the *windcatcher*, the *temperature* decreases a lot and the relative *humidity* increases, both of which are suitable *for hot and dry regions* of a city like Yazd in Iran (Kalantar, 2009).
ID_Post 895	This *room* receives the *air* from the *windcatcher* above it, which pushes *air* from the surrounding environment down to the *pool*, *cooling* it. This *cooled air* is then circulated into the surrounding *rooms*, bringing the *temperatures* down. These *rooms* are beautifully decorated with coloured glass *windows* and *doors* and some of them have their own little *pools*. The *colored lights* streaming from these *windows* get reflected in these *pools* and create a visual experience that is just spellbinding.
ID_Post 4739	Small beautiful *windows* for *air circulation*, facing away from the *sun*. *Windcatchers* are designed in combination with traditional *water reservoirs* on lower levels, capable of storing *water* at near-freezing *temperatures* during *summer*. These are the reasons that made living in the desert possible. This *cooling system* effect is strongest in the *driest climate* and they have done it in the most beautiful way.

Table 2. (Cont.) Exemplary quotes.

Reference	Exemplary quote
ID_Post 1606	...The *windcatcher* operates according to the condition of the *wind* and *sun radiation* in the region. In ancient times and in traditional *buildings* in *arid and dry regions*, the *windcatcher* functioned like the modern *air conditioning system*. A *windcatcher* is like a chimney whose end is in the underground and the top is set over a specific height on the roof and is built at the entrance of the *house* over *underground water reservoirs* or *ponds* built inside the *house*. The *dry and warm air* passes over a *pond* with a *fountain* and gets *cool* and *wet* through *evaporation*. The *windcatcher's material* plays another role. Due to the high fluctuation of *temperature* differences between day and night in this *climate* and nighttime coldness, a *windcatcher* which is made with *mud-brick* gets *cool* by *radiation* and *convection*.
ID_Post 4	The ancient *city* of *wind catchers*, Yazd, located in central Iran, is one of the great *adobe cities* of the world. Poking high above many of the *buildings*, the tower-scaled *windcatchers* in Iran are designed to *cool* the inside of *homes* by directing the *air* down and inside the *homes*. There are usually small *ponds* of *water* below the *windcatchers* to further help them act as *air conditioners*, as Yazd is one of the *driest cities* in Iran.

5.2. Comparative Analysis

Among the 20 most frequent attributes in each data source, there are seven common attributes addressed by all the stakeholders, namely city, house, building, water, air, garden, window, and roof. Nevertheless, the stakeholders associated different values with these attributes.

Figure 7 highlights the relation between values and these most frequent attributes concerning windcatchers in Yazd. Various stakeholders not only convey a great diversity of values to windcatchers but also illustrate the relation between these values and specific attributes. The case study confirms that cultural significance is defined by a combination of tangible and intangible attributes and values and that its cultural significance is better understood when perceived as an ecosystem. For example, some tangible and intangible attributes (e.g., climate character of Yazd, garden, water, openings) work together with windcatchers to ventilate the air in a building to create a microclimate, to passively provide thermal comfort for the users, and also to protect the building from earthquakes (ecological and economic values of windcatchers). As such, preserving only windcatchers rather than the ecosystem as a whole could endanger the relevant values.

Academic experts highlight fewer attributes, mainly related to certain values, namely economic, ecological, and scientific. Nevertheless, policymakers and users refer to a broader range of values and attributes. As such, while some attributes and values were already conveyed by all stakeholders, the other values and attributes mentioned by only one or two groups of stakeholders are more complementary than contradictory. For example, only users frequently refer to special buildings with unique windcatchers, namely the Aghazadeh and Dowlat-Abad buildings. Together with the policymakers, users highlight the landscape of the historic city of Yazd, created by the urban ensemble punctuated by landmarks such as windcatchers, turquoise domes, and minarets. Lastly, the significance of decoration and decorative materials (e.g., plaster and tile) and their social values are referenced by policy documents.

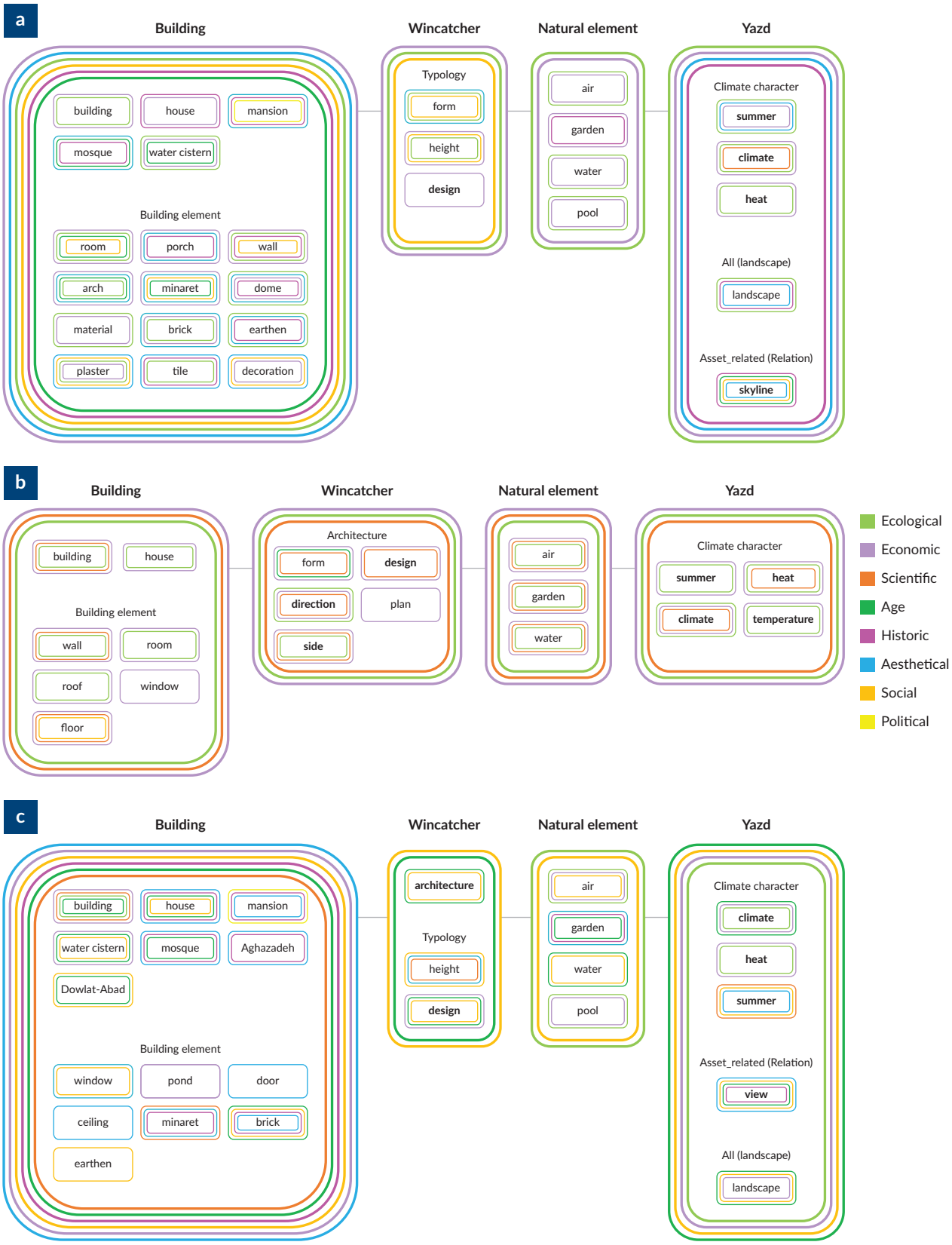

Figure 7. The relation between values and the most frequent attributes concerning the windcatchers in Yazd, with data from (a) policy documents, (b) literature, and (c) social media. Notes: Colorful lines show the values as illustrated in the legend; tangible: normal font style; intangible: bold font style.

6. Discussion

Inclusive heritage planning is crucial for accommodating the diverse cultural significance conveyed by various actors to built heritage. Understanding and acknowledging these values, similarities, and differences is essential to foster inclusive discussions and decision-making. However, the sheer volume of data generated by these actors makes manual analysis time-consuming and impractical. To address this challenge, digital humanities and technologies such as AI offer promising solutions by streamlining the analysis process and potentially uncovering new insights.

This work introduces an innovative methodology for heritage planning that provides deeper insights into the perceptions of policymakers, experts, and users on the heritage values of windcatchers in Yazd, Iran, using social media data, academic literature, and policy documents. AI was applied to analyze the data sources—policy documents, literature, and social media posts—and facilitate the exploration of similarities and differences among the actors. The findings highlight the existence of both similarities and differences, shedding light on the various aspects of values they prioritize. This empirical foundation provides a more robust basis for inclusive discussions and facilitates the inclusive nature of the heritage planning process.

This research challenges the notion that users have little interest in windcatchers, revealing that many users hold positive values toward them. While a small number of posts expressed negative values related to their practicality in modern life, there is a consensus on the positive cultural and social values associated with windcatchers. However, further research is needed to explore if there are additional negative values held by residents. The different perspectives on windcatchers' significance among stakeholders can lead to conflicts over the future of built heritage. Taking into account both positive and negative values can contribute to a more inclusive and democratic approach to heritage governance and planning. Decision-makers and experts need to consider negative values as a complement to the official heritage discourse, representing diversity and multiculturalism and addressing heritage controversies and various interests. This comprehensive understanding can guide heritage managers in their efforts to conserve the cultural significance of windcatchers effectively.

We acknowledge the role that social media can play in empowering the users' community. Social media helps to materialize and foster public engagement, especially when the community is active. This research confirms the potential role that social media can play in broadening the current understanding of the cultural significance of built heritage and in allowing greater inclusiveness in heritage planning. Besides, AI makes it possible to automatically analyze stakeholders' perspectives with great speed and minimum cost.

While this study demonstrates AI's potential to enhance the recognition and planning of cultural heritage, it is important to address several challenges. AI may struggle with contextual understanding, potentially missing nuances in the history and culture of heritage sites that human experts can capture. Furthermore, biases in training data can lead to skewed representations of cultural aspects. Additionally, the complexity of AI algorithms can hinder transparency and accountability, making it difficult to explain decision-making processes to policymakers and potentially eroding trust in the technology. Addressing these challenges is essential for maximizing AI's effectiveness in heritage planning. Besides, AI relying on available data sources including social media data may not fully represent all stakeholder perspectives or demographic information. The methodology's limitations include a focus on official policy documents, academic literature, and social media, potentially overlooking other policymaker, expert, and user groups.

Additionally, the findings from this study, which are based on the analysis of windcatchers in Yazd, Iran, offer valuable insights into the diverse cultural values and perspectives of users, experts, and policymakers. However, to enhance the applicability of these results, future research should focus on a more detailed examination of how these findings can be generalized and applied to other cultural heritage contexts. This involves evaluating how the methodology used here can be adapted to different geographical locations, cultural settings, and heritage types. By extending the analysis to other case studies and comparing results across various contexts, researchers can assess the broader relevance and adaptability of the proposed approach. Such exploration will contribute to a deeper understanding of how stakeholder perspectives can be integrated into heritage planning processes on a global scale, ensuring that the methodologies developed are robust and versatile for diverse heritage scenarios.

7. Conclusion

This research confirmed the assumed benefit of analyzing and comparing various available data, illustrating different stakeholders' perspectives on heritage properties with the support of AI models, to identify and interpret heritage cultural significance (values and attributes). It confirmed the relations between diverse cultural significance (attributes and values) conveyed to the windcatchers of Yazd. The research illustrated the importance of considering an ecosystem and the relations multiple between attributes and values, rather than just the relation of one attribute/value with other attributes/values, researched in isolation. This approach avoids neglecting attributes, tangible and intangible, that are highly related to each other, even when stakeholders omit their relation and highlight only some of the attributes and values of the ecosystem. An innovative aspect of this work consists of the methodology developed, which can be applied to other case studies and different scales in heritage planning studies. Such methodologies using AI and available data sources (e.g., social media) can provide necessary information for heritage managers to enhance legislative frameworks.

Although international organizations such as UNESCO recommend greater public participation, the implementation of participation remains critical. Future studies could illustrate how heritage planning is growing in inclusiveness by using AI and available data sources (e.g., social media). Besides, it is important to investigate the exchange of heritage knowledge (cultural significance conveyed by different stakeholders) between policymakers, academic experts, and users in an inclusive heritage planning system, which can lead to a shared understanding of the cultural significance of heritage and, when needed, help reach consensus among different stakeholders.

Conflict of Interests

The authors declare no conflict of interests.

Data Availability

The data are available at https://data.4tu.nl/datasets/5e55cf64-7912-4b07-8b8e-c2afb067c3e7/2

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