The Role of Product Design in the Development of Desert Air Conditioners Pilgrims' Camps

Safaa Ibrahim Abd EL-Fattah Hanafy *
Professor, Product design department, Design and Art College, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.
Sihanfy@pnu.edu.sa
https://orcid.org/0000-0002-4944-1806

Fatimah Hussain Ali Hamdi, Ph. D
Department of Product Design, College of Design and Art, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.
Fhhamdi@pnu.edu.sa
http://orcid.org/ 0000-0002-2500-1232

Manar Mahmoud Mouhialdeen Aazam
Product design department, Design and Art College, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.
441003368@pnu.edu.sa
https://orcid.org/0000-0002-4988-6530

Abstract: This interdisciplinary study delves into the cultural and philosophical dimensions surrounding the mitigation of high humidity levels in traditional desert air conditioning systems used during the Hajj pilgrimage in Mecca. Through a questionnaire survey involving 56 Hajj pilgrims, operational challenges of conventional air conditioning systems are scrutinized, guiding principles for desert air conditioning design are discerned, and proposed remedies are evaluated. Findings reveal diverse perspectives crucial for developing culturally attuned solutions. The imperative of integrating cultural values and philosophical tenets into the design discourse is underscored. Results highlight the transformative potential of melding culture and philosophy into environmental design, advocating for strategies that honor cultural sensibilities and promote sustainability. The study engages 36 experts in industrial design, product design, air conditioning engineering, and technology, providing invaluable insights into the cultural and philosophical facets of desert air conditioning solutions, illuminating pathways for future innovation and cultural stewardship in environmental design.
Keywords: Hajj pilgrimage, Mecca, Desert Air Conditioning, Cultural Significance, Environmental Conditions, Innovative Solutions.

1. INTRODUCTION

Embarking on the spiritual journey of Hajj, the cornerstone of the Islamic faith, entails more than just the pilgrimage; it is a profound odyssey

resonating with devotion, unity, and profound cultural significance. As devout Muslims converge in Mecca during the auspicious time of the Hijri year, they partake in sacred rites and rituals commanded by God, including the circumambulation of the Kaaba and the moving gathering at Arafat (Saeed et al., 2023). Serving the pilgrims who journey to the Kingdom of Saudi Arabia to perform the Hajj rituals is not merely a duty, but a sacred obligation deeply intertwined with the cultural fabric of the nation (Showail, 2022). Thus, the Saudi government established the Ministry of Hajj and Umrah, recognizing the immense cultural and philosophical importance of Hajj and Umrah (Haase et al., 2016). With Saudi Arabia being the sole region designated by God Almighty to house the Sacred House in the Holy City of Mecca, where Muslims perform the rituals of Hajj and Umrah, these ceremonies hold profound cultural and philosophical significance. Moreover, Hajj and Umrah serve as vital sources of economic income for Saudi Arabia. Therefore, the Ministry of Hajj and Umrah strives to facilitate Hajj and Umrah trips and ensure comfort for pilgrims and Umrah pilgrims. However, the climatic conditions prevailing in the holy sites, especially during the Hajj season, pose significant challenges. In the arid region of Mecca, where temperatures rise and humidity levels reach unprecedented heights, traditional desert air conditioning systems face severe tests (Ibrahim et al., 2012). Despite the deployment of nearly 50,000 units, the persistent humidity hampers their performance, reducing cooling efficiency and endangering pilgrims' safety (Haase et al., 2016). The combination of scorching temperatures and stifling humidity not only undermines pilgrims' comfort but also jeopardizes their health, particularly that of the elderly and vulnerable. With rituals performed under the harsh sun, the risk of heat-related illnesses escalates, necessitating meticulous attention to temperature regulation and ventilation strategies rooted in cultural wisdom and philosophical principles (Khan et al., 2017). Hence, the core of the research puzzle lies in devising innovative solutions to mitigate the impact of high humidity on desert air conditioning inside and outside pilgrim camps. By harnessing the power of design methodologies, the aim is to usher in a new era of environmental adaptability, where the discomfort and health risks associated with excess heat and humidity are mitigated, all while honoring the rich cultural and philosophical dimensions of the Hajj experience.

1.1. Research Questions

1.1.1. Main Research Question

What is the impact of cultural and philosophical factors on the design,

infrastructure, and communal dynamics within Hajj camps?

1.1.2. Subsidiary Research Questions

(1). How do cultural beliefs and practices influence the spatial layout and architectural features of Hajj camps?

(2). What role do philosophical principles, such as sustainability and ethical considerations, play in shaping the infrastructure and operational policies of Hajj camps?

(3). How do pilgrims from diverse cultural backgrounds perceive and interact with the cultural symbols and amenities within Hajj camps?

(4). To what extent do cultural norms and philosophical perspectives impact the social cohesion and communal interactions among pilgrims residing in different segments of Hajj camps?

(5). Are there significant differences in the utilization of amenities and engagement with communal spaces among pilgrims based on their cultural backgrounds and philosophical outlooks?

(6). How do cultural heritage preservation efforts intersect with philosophical reflections on modernization and technological advancements within Hajj camps?

(7). How do cultural narratives and philosophical frameworks influence pilgrims' perceptions of Hajj camps as sacred spaces and sites of spiritual transformation?

(8). What are the potential implications of cultural and philosophical considerations for the future planning and management of Hajj camps, particularly in the context of increasing pilgrimage numbers and changing environmental conditions?

1.1.3. Exploratory Questions

(1). How do pilgrims from different cultural backgrounds describe their experiences of living in Hajj camps during the pilgrimage journey?

(2). What are the attitudes and beliefs of pilgrims regarding the integration of cultural traditions and philosophical values into the design and infrastructure of Hajj camps?

1.1.4. Comparative Questions

(1). How does the incorporation of cultural and philosophical elements into the design and management of Hajj camps in Saudi Arabia compare to similar pilgrimage sites in other countries?

(2). What are the differences in the organizational structures and

communal dynamics of Hajj camps with varying degrees of emphasis on cultural and philosophical considerations?

1.1.5. Longitudinal Questions

(1). How have cultural practices and philosophical perspectives within Hajj camps evolved over successive pilgrimage seasons?

(2). What are the long-term effects of cultural and philosophical interventions on the overall experience and well-being of pilgrims residing in Hajj camps?

1.2. Problem Statement

The research problem revolves around the cultural and philosophical implications of high humidity levels on traditional desert air conditioning systems utilized during the Hajj pilgrimage in Mecca. Despite the deployment of significant resources, including approximately 50,000 units, these systems face operational inefficiencies due to the unique climatic conditions prevalent in the region, characterized by soaring temperatures and exceptionally high humidity levels during the Hajj season. This not only undermines the physical comfort of pilgrims but also challenges the cultural and philosophical underpinnings of the pilgrimage experience itself. Therefore, the research seeks to address this pressing issue by exploring innovative solutions to enhance the performance and effectiveness of desert air conditioning systems, ensuring optimal conditions for pilgrims undertaking their sacred journey, while also respecting the cultural and philosophical significance of the Hajj rites.

1.3. Research Aim

-The aim of this research is to explore the cultural and philosophical dimensions of high humidity levels on traditional desert air conditioning systems utilized during the Hajj pilgrimage in Mecca, and to develop innovative solutions that respect and enhance the cultural and philosophical significance of the pilgrimage experience.

1.4 Research Objectives

(1). Investigate the cultural and philosophical underpinnings of the Hajj pilgrimage and its rituals, with a specific focus on the impact of environmental conditions, including humidity levels, on pilgrims' well-being and spiritual experience.

(2). Examine the operational challenges faced by traditional desert air

conditioning systems in Mecca, particularly during the Hajj season, and analyze their implications for pilgrims' comfort and safety.

(3). Identify cultural and philosophical principles that should inform the design and implementation of desert air conditioning solutions in Mecca, taking into account the sacred nature of the pilgrimage and the values it embodies.

(4). Develop innovative strategies and technologies to enhance the performance and effectiveness of desert air conditioning systems in Mecca, with a view to mitigating the impact of high humidity levels on pilgrims while respecting and honoring cultural and philosophical considerations.

(5). Evaluate the feasibility and practicality of proposed solutions through field testing and stakeholder consultation, ensuring alignment with cultural sensitivities and philosophical values inherent in the Hajj pilgrimage.

By achieving these objectives, this research aims to contribute to a deeper understanding of the cultural and philosophical dimensions of the Hajj pilgrimage and to provide practical solutions that enhance the pilgrimage experience while respecting its sacred traditions and values.

2. LITERATURE REVIEW

2.1. Hajj, Climate Change, and Cultural Implications

Undertaking the sacred pilgrimage of Hajj entails not only a spiritual journey but also a deeply ingrained cultural tradition within the Islamic faith (Khan & Alghafari, 2018). However, contemporary challenges such as climate change have cast a shadow over this revered ritual, particularly in regions like the Kingdom of Saudi Arabia (Aljeddani, 2023). Research conducted by scholars from the Massachusetts Institute of Technology has sounded the alarm regarding rising temperatures and humidity levels, posing severe risks to pilgrims during the Hajj rituals (Yezli et al., 2023). The intersection of climate change and cultural practices becomes evident as pilgrims face prolonged exposure to extreme heat (Abonomi et al., 2022), a stark departure from the historical context of the pilgrimage. Furthermore, the cyclical nature of the Hijri calendar adds a philosophical dimension to this issue (Mohamed, 1996), with the shifting seasons altering the climatic conditions experienced during Hajj (Kang et al., 2019). The projected exacerbation of these challenges underscores the urgency for preventive measures rooted in both cultural sensitivity and environmental stewardship (Schmidt, 2023). By acknowledging the cultural significance of

Hajj and its intrinsic connection to the natural environment, stakeholders can formulate strategies to ensure the safety and well-being of pilgrims while preserving this revered tradition for future generations (Abonomi et al., 2022).

2.2. Impact of High Temperatures on Pilgrims

The cultural significance of Hajj is intimately intertwined with the physical and emotional well-being of pilgrims, making the adverse effects of high temperatures particularly concerning. In Mecca, where temperatures soar between 40°C to 47°C during the summer months, pilgrims face a myriad of health risks exacerbated by these extreme conditions (Saeed et al., 2021). Elderly pilgrims, comprising a significant percentage of participants, are especially vulnerable to thermal injuries, dehydration (Alshumrani et al., 2020), sunstroke, and cardiovascular incidents. This confluence of climatic challenges and cultural practices underscores the need for innovative solutions that prioritize pilgrim safety while respecting the traditions and philosophies underpinning the Hajj pilgrimage (Deris et al., 2009).

2.3. Ventilation Strategies and Philosophical Reflections

2.3.1. Desert Adaptation

The implementation of desert air conditioning systems reflects a pragmatic response to the climatic challenges faced during Hajj (Schmidt, 2023). However, the persistence of discomfort among pilgrims despite these interventions prompts philosophical reflections on the balance between technological advancements and cultural authenticity (Morsy et al., 2021). The quest for comfort amid the harsh desert environment raises questions about the intersection of modernity and tradition, highlighting the need for solutions that harmonize with cultural values and philosophies (Saif et al., 2021).

2.3.2. Spray Fans

The deployment of mist fans and water mist columns embodies a holistic approach to ventilation, blending technological innovation with cultural adaptation. These systems not only alleviate physical discomfort but also evoke the spiritual symbolism of water (Amer et al., 2015), a recurring motif in Islamic rituals. By integrating nature-inspired solutions with cultural symbolism, stakeholders can create environments that resonate with pilgrims on a deeper, philosophical level, enriching their Hajj experience

while addressing practical concerns.

2.4. Cultural Diversity in Hajj Camps

Hajj camps serve as temporary refuges for millions of pilgrims who embark on a sacred journey to Mecca, reflecting the convergence of cultural identities and spiritual aspirations (Jay et al., 2021). The division of the camps into distinct categories reflects Saudi Arabia's commitment to hosting pilgrims from diverse backgrounds while adhering to the principles of hospitality rooted in Islamic culture (Akinwale & AboAlsamh, 2023). From the towering towers of Mina to the meticulously designed tents and traditional hospitality of the undeveloped tents, each part offers pilgrims a unique cultural experience (Abalkhail & Al Amri, 2022). The architectural marvel of Mena Towers, with its towering presence and modern amenities (Paché, 2023), symbolizes the Kingdom's vision for the future while honoring the region's rich cultural heritage. On the contrary, undeveloped tents evoke a feeling of simplicity and communal living and strengthen bonds of solidarity among pilgrims regardless of their social and economic backgrounds. By embracing cultural diversity within Hajj camps, Saudi Arabia reaffirms its role as a custodian of Islamic traditions while promoting inclusivity and unity among pilgrims from around the world (Jay et al., 2021).

2.5. Philosophical Reflections on Tent Design and Comfort

The development of tent infrastructure within Hajj camps goes beyond mere function and embodies profound philosophical reflections on human comfort and environmental preservation (Daher et al., 2015). The careful design and construction of the tents developed using advanced materials such as flame-resistant telephone underscores the Kingdom's commitment to ensuring the safety and well-being (Abalkhail & Al Amri, 2022) of pilgrims without compromising cultural values. Equipped with the latest amenities including air conditioning units and private bathrooms, these tents provide pilgrims with a haven of comfort amid the rigors of Hajj(General Authority for Statistics, 2023). Moreover, the focus on sustainability and energy conservation reflects a philosophical ethos rooted in the Islamic principle of caliphate on earth. By embracing modern technologies while respecting traditional wisdom, pilgrimage camps serve as examples of the harmonious coexistence of human needs and environmental responsibilities (Kanan, 2021). This philosophical foundation extends to maintenance guidelines for air conditioning systems,

which prioritize efficiency and safety in accordance with the ethical requirements stipulated in Islamic jurisprudence (Paché, 2023). Through these philosophical reflections, Hajj camps emerge not only as logistical marvels, but also as embodiments of timeless principles that resonate with pilgrims on a spiritual level (Showail, 2022).

2.6. Desert Air Conditioning Systems: Function and Cultural Implications

Desert air conditioning systems represent a prevalent cooling solution in arid regions (Amer et al., 2015), where the dry and hot climate demands effective temperature control to ensure comfort and well-being (Yezli et al., 2019), aligning closely with cultural preferences for environmental adaptation. Operating on the principle of evaporative cooling, these systems cool the air by evaporating water (Saif et al., 2021), thereby reducing temperatures. Evaporative cooling, akin to a natural phenomenon observed when any liquid evaporates in a dry atmosphere, serves as a cultural metaphor for adaptation to harsh environmental conditions, reflecting philosophies of resilience and resourcefulness, Table 1.

Table 1: Pros and Cons of Desert Air Conditioning Systems.

Aspect	Advantages	Disadvantages
Economic Efficiency	Cost-effective compared to traditional systems	Requires a substantial amount of water for operation
Energy Consumption	Low electricity consumption, especially in arid areas	Increases water usage, leading to environmental concerns
Installation and Portability	Simple installation and portability	High humidity levels may have adverse effects on health
Air Quality Improvement	Emits fresh air, acts as an air filter	Ongoing maintenance and part replacement are essential

Table 1 provides a comparative analysis of the pros and cons associated with evaporative air conditioning systems. Advantages include economic efficiency due to cost effectiveness compared to conventional systems, lower energy consumption, especially in arid areas, simple installation, portability, improved air quality by emitting fresh air and acting as an air filter. However, these benefits are offset by some disadvantages such as the greater need for water for operation, increased water use resulting in environmental concerns, the potentially harmful effects of high humidity levels on health, and the necessity of constant maintenance and replacement of parts. This table provides a comprehensive overview of the key factors to consider when evaluating evaporative air conditioning systems, aiding decision-making processes in selecting the appropriate

cooling solutions for specific environments.

2.6.1. Cultural Considerations in Functionality and Usage

Unlike traditional air conditioners relying on refrigerants and compressors (Moussa, 2019), the desert air conditioner comprises only an indoor unit with no external body, embodying cultural values of simplicity and minimalism. Its primary function is to convert hot, dry air into cool, moist air by transforming liquid water into water vapor. Culturally, the emphasis on connecting to a constant water source underscores the importance of resource management and sustainability in desert environments, reflecting philosophical beliefs in harmony with nature, figure 1.

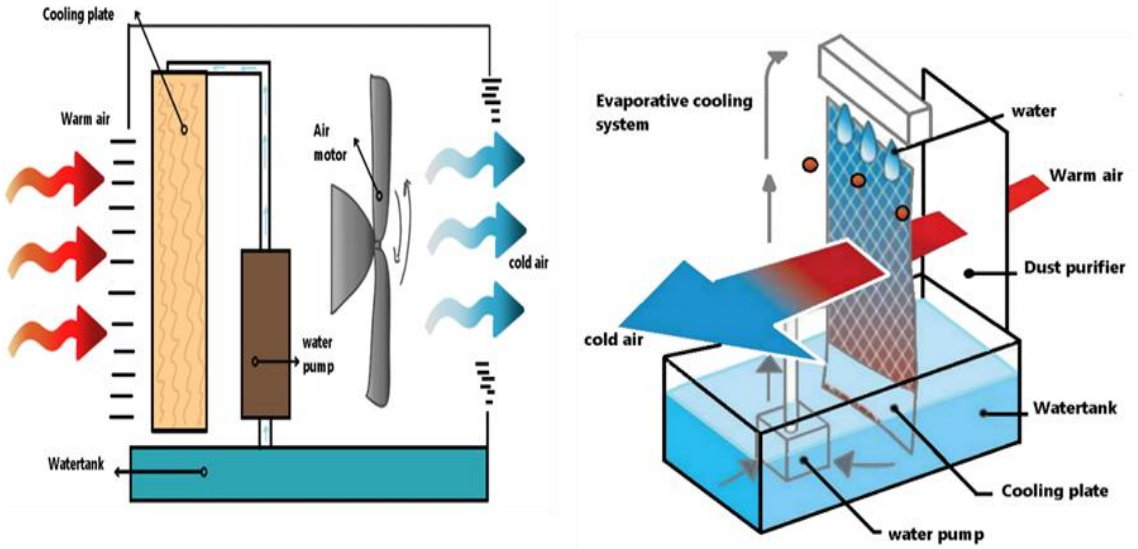

Figure 1: Operational Mechanism of Desert Air Conditioner (Caption: "Detailed View Illustrating the Internal Components and Operational Mechanism of the Desert Air Conditioner.")

3. RESEARCH METHODOLOGY

3.1. Literature Review

Conduct a comprehensive review of existing literature to explore the cultural and philosophical dimensions that influence pilgrims' well-being resulting from air conditioning systems during the Hajj season within pilgrim camps. This included analyzing relevant articles, reports and scientific texts to understand the impact of desert air conditioning challenges on pilgrims from diverse cultural backgrounds.

3.2. Survey Design

A carefully structured questionnaire was developed using Google Drive to

collect data on pilgrims' experiences and challenges related to air conditioning during Hajj. The questionnaire was carefully designed to address cultural sensitivities and philosophical perspectives, ensuring it resonated with a diverse group of participants. A total of 56 people participated in the survey.

3.3. Selection of Participants

A diverse sample of participants was carefully selected, representing different nationalities, ages, and genders, all of whom had previously performed the Hajj. The questionnaire was distributed to ensure representation of diverse cultural backgrounds and philosophical beliefs, and to facilitate a comprehensive understanding of the cultural nuances and sensitivity surrounding the issue of high humidity resulting from the use of desert air conditioners during Hajj.

3.4. Data Collection

Administer the questionnaire to selected participants, focusing on capturing their perceptions, experiences and preferences regarding air conditioning systems in Hajj camps. Data collection was conducted with careful consideration of cultural norms and philosophical considerations, ensuring that responses authentically reflected the views of participants.

3.5. Ideation and Visualization

The ideation phase began to develop initial sketches and design concepts aimed at addressing identified challenges while maintaining cultural norms and philosophical principles. This creative process involved brainstorming and visualizing potential solutions to evaluate their feasibility and alignment with cultural and philosophical values.

3.6. Expert Consultation

Participation in consultations with experts in engineering, design and air conditioning technology, involving both professional practitioners and academics. Expert opinions were sought to ensure the cultural appropriateness and philosophical coherence of the proposed solutions. These consultations, which took place through dialogue and brainstorming sessions, aimed to discuss the feasibility of implementing and manufacturing the proposed ideas.

3.7. Concept Evaluation

A comprehensive questionnaire was developed to evaluate the feasibility

and effectiveness of the best designs, with particular emphasis on their ability to reduce the humidity emitted by evaporative air conditioners. The evaluation, which involved 36 experts in industrial design, product engineering and air conditioning technology, ensured a careful assessment to meet technical requirements and cultural expectations.

3.8. Ethical Considerations

Adherence to ethical guidelines throughout the research process, prioritizing respect for cultural beliefs, privacy, and autonomy of participants. Transparency was maintained in data collection and analysis to support the integrity of the research and ensure the well-being and comfort of pilgrims from diverse cultural backgrounds. By following this carefully structured methodology, the study aimed to develop culturally sensitive and philosophically aligned solutions to enhance the effectiveness and sustainability of air conditioning systems during the Hajj season, ultimately contributing to the well-being and comfort of pilgrims from diverse cultural backgrounds.

4. DATA ANALYSIS

4.1. Data Analysis with a Cultural and Philosophical Perspective

The analysis of the questionnaire data provides valuable insights not only into the technical challenges faced by pilgrims in Hajj camps but also into the cultural and philosophical dimensions of their experiences.

4.2. Gender Distribution

The balanced distribution of genders among respondents reflects the inclusive nature of the Hajj pilgrimage, where individuals from diverse backgrounds come together in pursuit of spiritual fulfillment. This balance signifies a cultural ethos of equality and shared participation in the sacred journey.

4.3. Age Distribution

The diverse age groups represented among respondents highlight the intergenerational aspect of the Hajj pilgrimage, where individuals of varying life stages converge to fulfill a common religious obligation. This diversity speaks to the enduring cultural significance of the Hajj as a transformative experience that transcends age barriers.

Table 2: Gender and Age Distribution of Respondents

		Gender			
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Male	29	51.8	51.8	51.8
	Female	27	48.2	48.2	100.0
	Total	56	100.0	100.0	
			Age		
Valid	18 under	1	1.8	1.8	1.8
	18-24	4	7.1	7.1	8.9
	25-34	8	14.3	14.3	23.2
	35-44	6	10.7	10.7	33.9
	45-54	15	26.8	26.8	60.7
	55-64	11	19.6	19.6	80.4
	65 or Older	11	19.6	19.6	100.0
	Total	56	100.0	100.0	

Caption: "Data Presenting the Gender and Age Distribution of Respondents, Providing Insights into the Demographic Composition of the Sample Population."

4.4. Participation in Hajj

The varying degrees of Hajj participation among respondents reflect the pilgrimage's universal appeal and the deeply ingrained cultural importance of undertaking this spiritual journey. Whether it is the first time or the fifth, each Hajj experience carries profound personal and communal significance, reflecting the philosophical ideals of spiritual growth and communal solidarity.

4.5. Comfort Level with Technology

The participants' comfort level with technology underscores the evolving cultural landscape of pilgrimage experiences. While traditional rituals and practices remain central to the Hajj, the integration of modern technologies, such as air conditioning systems, reflects the adaptive nature of pilgrimage culture in response to changing environmental conditions and technological advancements.

4.6. Encountered Problems with Air Conditioning Systems

The challenges faced by pilgrims with air conditioning systems highlight the intersection of environmental factors with cultural and religious practices. High humidity levels and inadequate cooling not only affect physical comfort but also impact the spiritual experience of the pilgrimage, as pilgrims strive for inner peace and tranquility amidst challenging conditions.

Table 3: Participants' Experiences and Air Conditioning Issues During Hajj

		Frequency	Percent	Valid Percent
Have you ever Participated in Hajj?	Yes	56	100.0	100.0
How many times does Hajj Take Place?	First time	31	55.4	55.4
	2-5 times	16	28.6	28.6
	More than 5 times	9	16.1	16.1
	Total	56	100.0	100.0
How would you Describe your Comfort Level when using Technology?	Very comfortable	11	19.6	19.6
	comfortable	31	55.4	55.4
	Neutral	4	7.1	7.1
	Uncomfortable	10	17.9	17.9
	Total	56	100.0	100.0
Have you Encountered any Problems or Challenges with Air Conditioning systems in Hajj areas?	Yes	38	67.9	67.9
	No	18	32.1	32.1
	Total	56	100.0	100.0
What type of Air Conditioning System did you have Problems with?	Desert coolers	54	96.4	96.4
	Other	2	3.6	3.6
	Total	56	100.0	100.0
What Specific Problems did you Encounter with Air Conditioning Systems during Hajj?	0	1	1.8	1.8
	Inadequate cooling	14	25.0	25.0
	High humidity levels	30	53.6	53.6
	Air conditioning malfunction	11	19.6	19.6
	Total	56	100.0	100.0

Caption: "Summary of Participants' Experiences during Hajj, their Comfort with Technology, Encountered Air Conditioning Problems, and Specific Issues Faced."

This table provides a summary of participants' experiences during Hajj, their comfort levels with technology, encountered air conditioning problems, and specific issues faced. The data source indicates that the information was compiled from survey responses provided by participants, ensuring transparency regarding the origin of the data.

4.7. Proposal Analysis

The innovative proposals aimed at tackling air conditioning challenges are intricately linked with the cultural fabric of continuous improvement and adaptation observed during the Hajj season. They epitomize a philosophical commitment to care and sustainability, underlining the imperative of harmonizing modern technology with traditional values to enrich the Hajj experience for future generations.

4.7.1. First Design

The design concept of the outdoor air conditioning unit is meticulously crafted to serve as a strategic solution for ventilating and cooling unshaded areas and adjacent regions near campsites. By harnessing solar energy to minimize electricity consumption, the unit incorporates mist outlets to facilitate temperature reduction. Conceptual drawings were developed outlining the form of an outdoor air conditioning unit targeting open spaces, Figure 2.

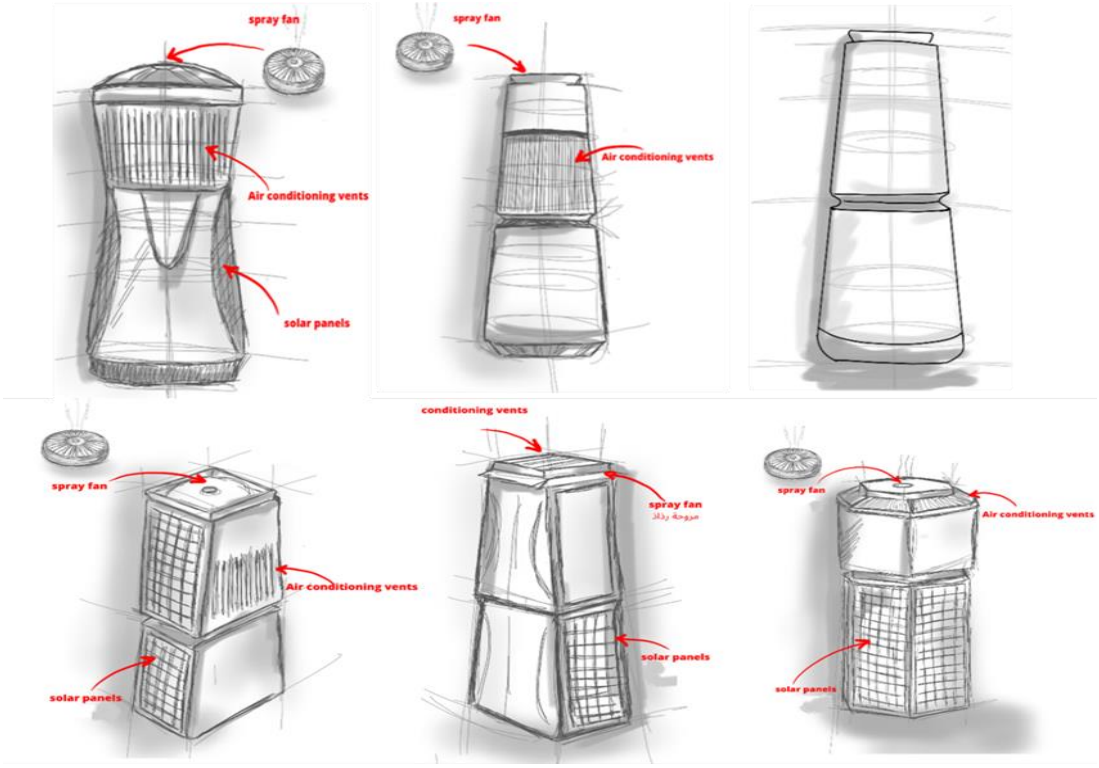

Figure 2: Conceptual Renderings of Solar-Powered Outdoor Air Conditioning Unit. Caption: "Conceptual Renderings Illustrating the Basic Concept of an Outdoor Air Conditioning Unit Designed to Utilize Solar Energy as a Sustainable Source of Power. The Unit Incorporates a Mechanism to Convert Moisture into Water, Subsequently Powering the Desert Air Conditioner to Effectively Lower Humidity Levels."

(1) Operating Mechanism: The unit operates by generating electrical energy through the conversion of light energy into electrical power using solar panels. Leveraging Makkah's abundant solar resources, particularly during the scorching summer months when temperatures exceed 45 degrees Celsius, solar panels have been intricately integrated into the design to mitigate the high energy demand associated with traditional air conditioning units, which are often susceptible to hazards such as fires due to prolonged, uninterrupted operation. Moreover, the inclusion of a battery

storage system ensures optimal energy utilization. The proposal offers versatility, accommodating two types of evaporative air conditioners:

(A). Air Conditioners with Freon System: This system operates similarly to traditional air conditioners utilizing Freon technology, albeit with a significant emphasis on energy reduction and the utilization of alternative energy sources, such as solar power. It consumes relatively higher energy levels.

(B). Desert Air Conditioner: This system operates by utilizing water for cooling, with an added humidification feature to minimize moisture output compared to standard evaporative air conditioners. Drawing inspiration from water-saving technology implemented in NEOM City, Saudi Arabia, which converts humid air into usable water, this proposal aims to reduce water consumption while decreasing humidity levels in Mecca. Collaboration with specialists in refrigeration and air conditioning engineering culminated in confirming the feasibility of the proposal. It has been demonstrated that outdoor cooling can be effectively deployed in unshaded areas, provided a sufficient number of units are installed and the temperature differential is maintained, as evidenced by the climate-controlled Qatar Street in Doha. The most viable proposals, deemed the easiest to implement, were selected following expert evaluation, Figure 3.

Figure 3: Final Design of Existing Air Conditioning System after Brainstorming Sessions. Caption: "The Final Design Resulting from Collaborative Brainstorming Sessions between Designers and Experts in Air Conditioning and Refrigeration Engineering. This Design Represents the Culmination of Scientific Analysis and Practical Considerations Aimed at Achieving Optimal Efficiency."

This commentary succinctly captures the essence of Figure 3, highlights its importance as the end result of collaborative efforts and emphasizes its

focus on achieving optimal efficiency through scientific analysis and practical considerations.

4.7.2. Second Design

In the development of the second design, researchers aimed to create a versatile solution applicable both inside and outside camps. A key innovation in this design is its dual functionality, capable of operating as either a fan or an air conditioner, depending on specific requirements. This multifaceted approach aligns with the overarching objective of minimizing energy consumption while mitigating the elevated humidity levels associated with continuous use of evaporative air conditioners. This holistic concept is visually depicted in Figure 4.

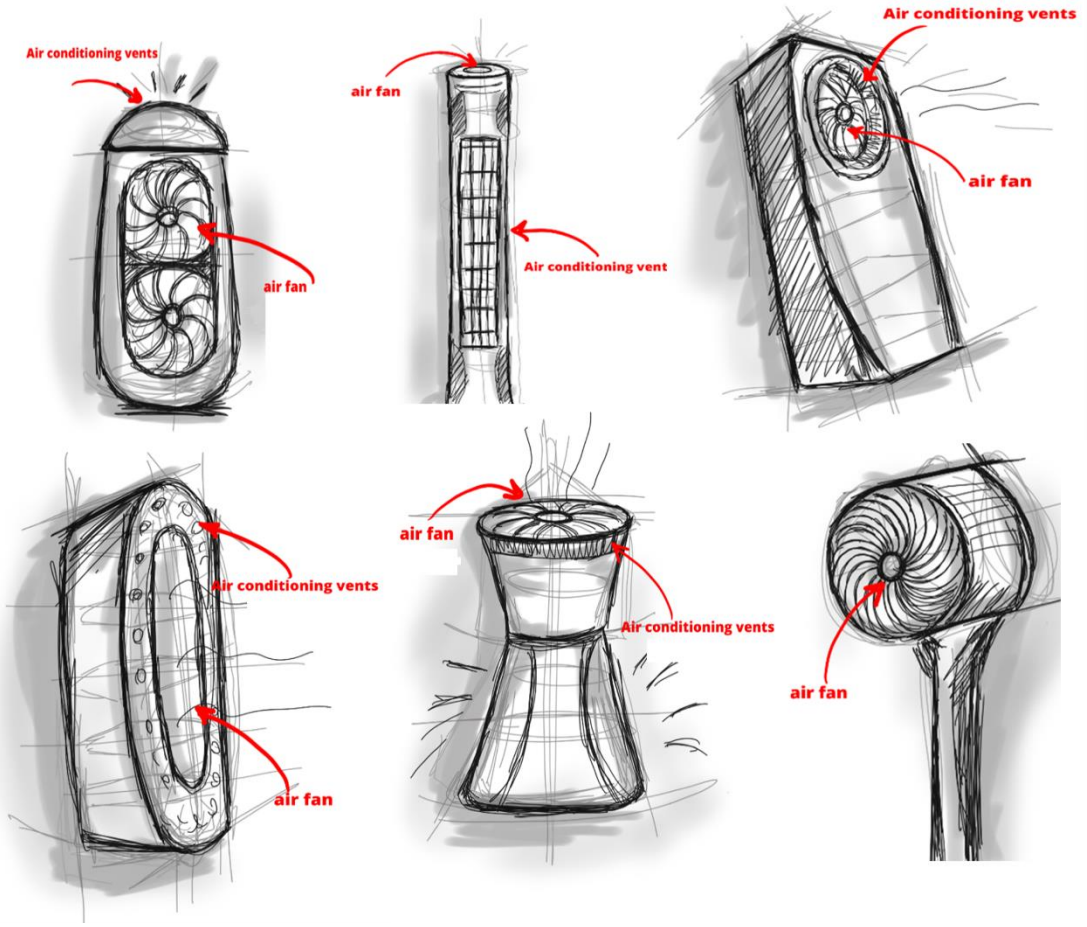

Figure 4: Conceptual Renderings of Versatile Air Conditioning Units. Caption: "Conceptual Renderings Illustrating the Design of Versatile Air Conditioning Units Capable of Operating as both an Air Conditioner and a Fan. These Adaptable Units are Designed for Indoor and Outdoor use, Providing Flexibility to Meet Diverse Environmental Conditions Encountered, including Camping Scenarios."

(1). Operating Mechanism: (A). Air Fan Mode: This mode operates with

reduced energy consumption compared to conventional air conditioners. Utilizing the fan alone aids in humidity reduction, a critical aspect given the pronounced increase in humidity resulting from prolonged use of desert air conditioners.

(B). Air Conditioning Mode: While this mode necessitates higher energy consumption, it delivers cool and refreshing air, significantly lowering ambient temperatures. However, alternating between fan and air conditioning modes effectively mitigates electrical energy usage and reduces humidity levels within and around the camp areas.

(C). Integration of Solar Technology: Solar panels can be seamlessly integrated into the design to diminish electricity consumption, strategically positioned throughout the product. Additionally, incorporation of a battery module enables efficient energy storage.

(D). Feasibility of Implementation: The integration of dual cooling functionality within a single product offers adaptability, with one of the two units regulating temperature as needed. This enables customizable cooling or ventilation tailored to regional climate conditions. These designs underwent rigorous evaluation by a panel of academic experts and professional practitioners specializing in design and adaptation engineering during collaborative brainstorming sessions. A design was ultimately selected based on its perceived effectiveness in implementation and anticipated operational efficiency, as depicted in Figure 5.

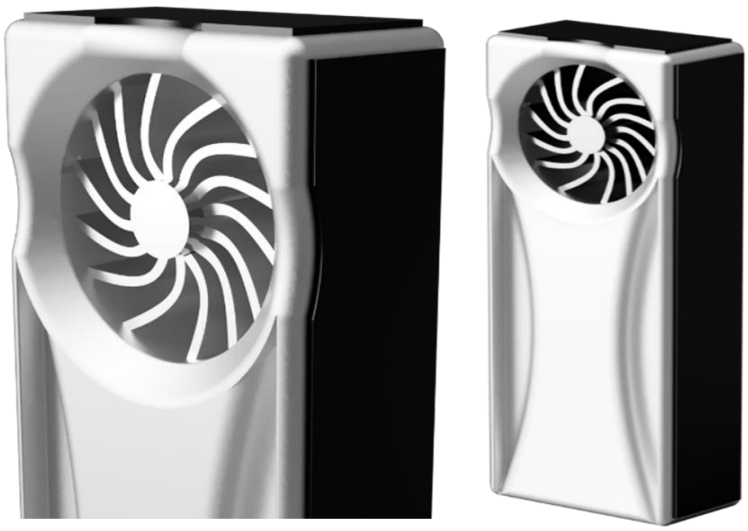

Figure 5: Final Design Combining Air Fan and Air Conditioner.
Caption: "Illustration Depicting the Final Design Resulting from Study, Analysis, and Efforts to reduce electricity Loads by Integrating the Functions of an Air Fan and an Air Conditioner."

4.7.3. Third Design

In this proposed design, researchers focused on further reducing

humidity by introducing a novel air conditioning approach. This method involves extracting moisture from the atmosphere and converting it into usable water, aligning with our cultural dedication to environmental stewardship and sustainability. The resulting water can be utilized, and the unit is adaptable for both indoor and outdoor use, featuring a tank equipped with a drainage tube for effortless water removal, Figure 6.

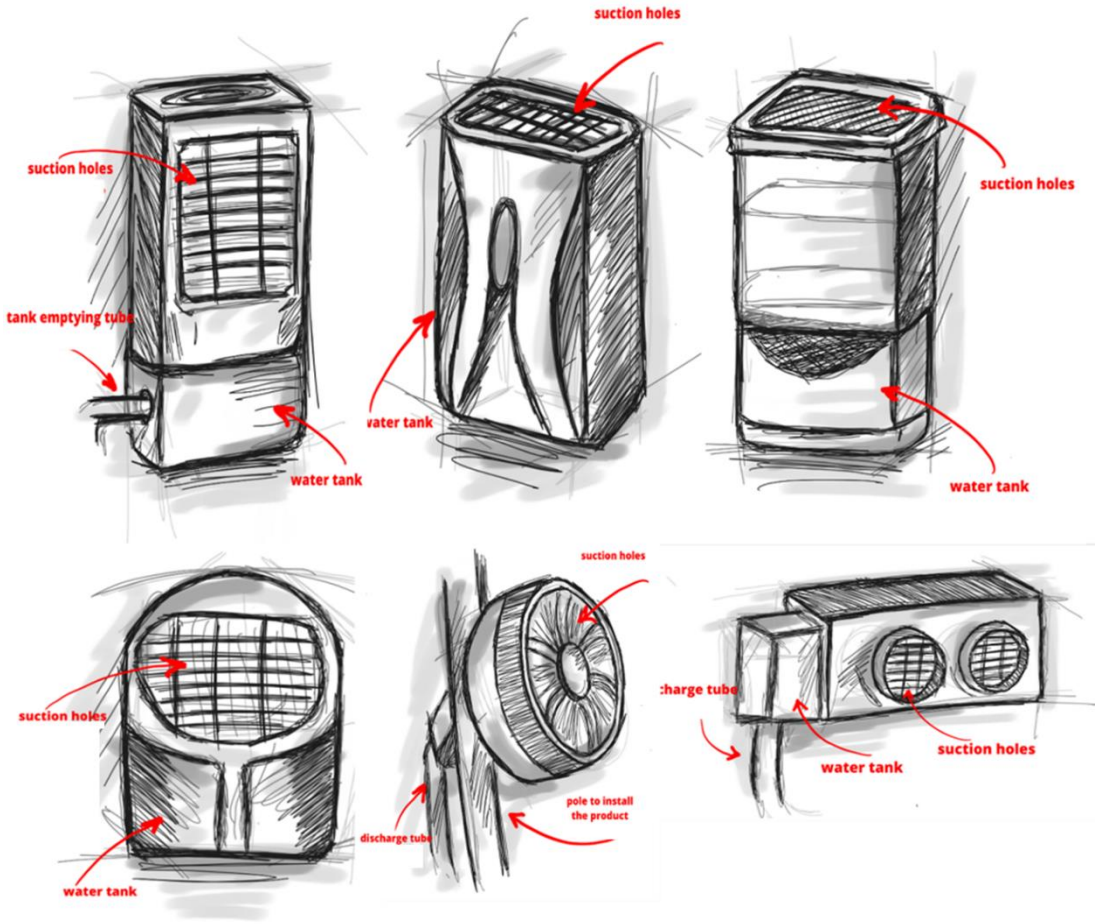

Figure 6: Conceptual Illustrations of Moisture-Extracting Air Conditioning Units. Caption: "Conceptual Illustrations Showcasing Innovative Air Conditioning Units Designed to Extract Moisture from the Air and Convert it into Water. These Units, Suitable for both Outdoor and Indoor use, Incorporate Advanced Technology based on the Peltier Effect."

(1). Operating Mechanism: (A). Moisture Extraction Technology: Utilizing the Peltier effect, which involves a potential difference applied to a thermocouple, causing a temperature difference between its junctions, the third design extracts moisture from the air and converts it into water within the unit. This process effectively reduces humidity levels by approximately 20% outdoors and up to 40% indoors, reflecting our commitment to creating comfortable environments while conserving resources.

(B). Air Purification: The unit incorporates an integrated air filtration system that not only removes impurities and dust from the air but also enhances the purity of the extracted water.

(C). Water Tank Drainage System: Featuring a storage chamber for collected water, the unit facilitates automatic drainage through a connected tube, streamlining the unpacking process, particularly in open environments. This design element underscores our dedication to user-friendly and efficient solutions, Figure 7.

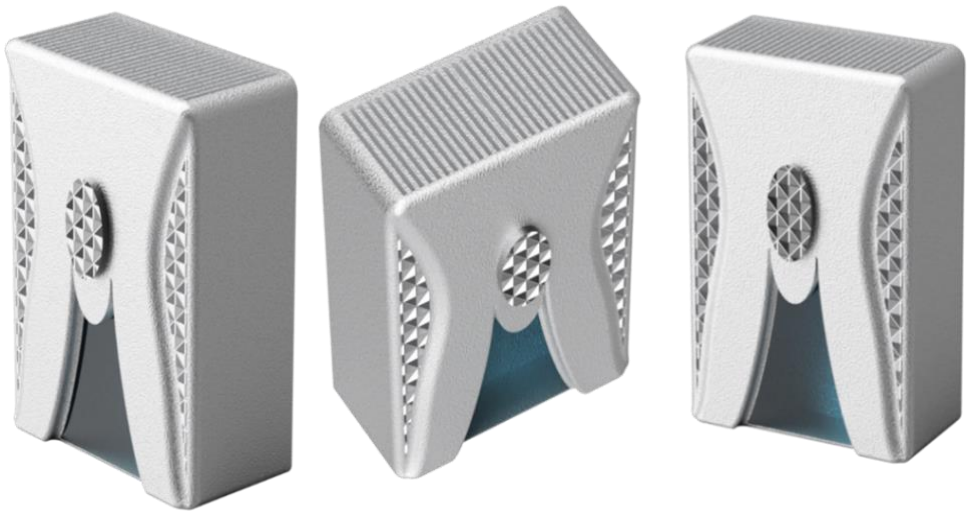

Figure 7: Displays the Ultimate Design Outcome Derived from Collaborative Brainstorming Sessions Involving Designers and Experts in Air Conditioning, including Specialists in Refrigeration Engineering. This Design Represents the Culmination of Collective Efforts, Particularly for the Third Design, which Focuses on the Innovative Conversion of Moisture into Water.

In conclusion, the analysis not only sheds light on technical challenges but also offers insights into the cultural and philosophical dimensions of the Hajj pilgrimage, highlighting the dynamic interplay between tradition, innovation, and spiritual fulfillment.

5. RESULTS

Following the completion of the three design concepts, researchers meticulously crafted a comprehensive questionnaire, meticulously detailing each concept's intricacies, including design visuals, operational mechanisms, and potential contributions. This questionnaire was disseminated to domain experts, with careful deliberation to exclude the brainstorming team, ensuring the integrity and transparency of the results. Figure 8.

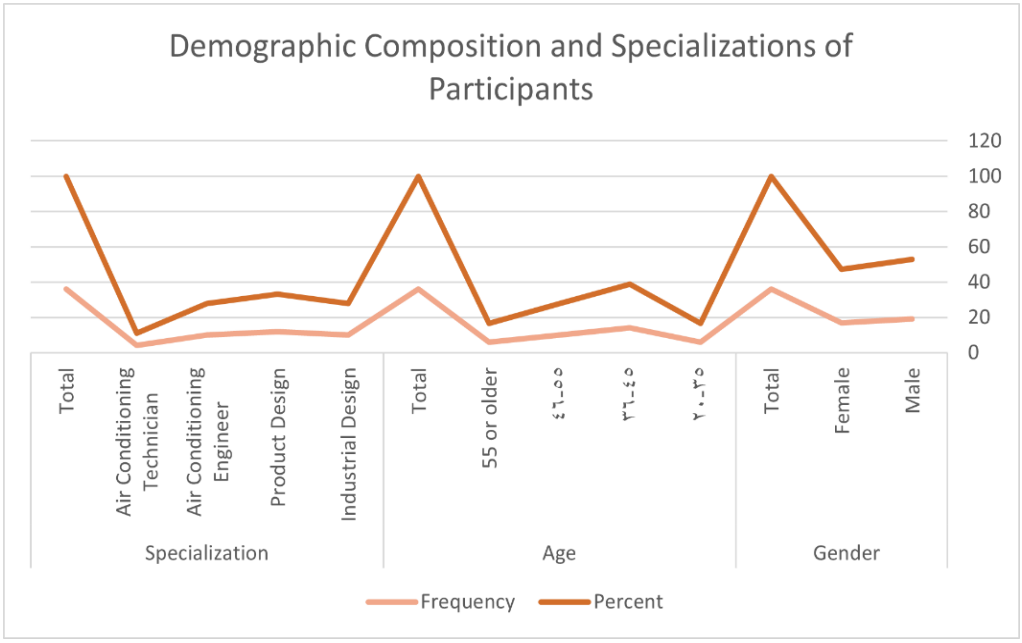

Figure 8: Demographic Composition and Specializations of Participants
Caption: "Bar Chart Depicting the Demographic Composition and Specializations of Participants based on Gender, Age, and Specialization."

(1). Gender: A balanced representation was observed among respondents, with 52.8% male and 47.2% female participants, indicating a diverse perspective.

(2). Age: Participants spanned various age groups, with 16.7% aged 20-35, 38.9% aged 36-45, 27.8% aged 46-55, and 16.7% aged 55 or older, highlighting a diverse range of experiences and viewpoints.

(3). Specialization: The expertise of respondents varied, with 27.8% specializing in Industrial Design, 33.3% in Product Design, 27.8% as Air Conditioning Engineers, and 11.1% as Air Conditioning Technicians, underscoring a multidisciplinary approach to the evaluation process.

(4). Analysis of Evaluation: Table No. 4

1. Design 1: - 86.1% of participants affirmed that Design 1 effectively reduced humidity levels, showcasing its practical efficacy. - 88.9% of participants anticipated that Design 1's operating method would adapt well to desert conditions, demonstrating its adaptability. - The majority of participants (52.8%) rated Design 1 as "highly innovative," reflecting its creative and pioneering attributes.

2. Design 2: - Likewise, 88.9% of participants perceived Design 2 as successful in reducing humidity levels effectively. - An equal percentage (88.9%) expected Design 2 to adapt suitably to desert environments. - Participant ratings for innovation varied, with 44.4% considering it "very innovative," 36.1% "innovative," and 13.9% "somewhat innovative."

3. Design 3: - A significant majority (91.7%) of participants affirmed the

effectiveness of Design 3 in reducing humidity levels. - 86.1% of participants believed that Design 3's operating method would be sufficient for desert adaptation. - Design 3 garnered high praise for innovation, with 63.9% rating it as "very innovative," 27.8% as "innovative," and only a small percentage considering it "somewhat innovative" or "traditional."

Table 4: Summary of Expert Questionnaire Responses.

		Frequency	**Percent**
Do You Believe Design 1 is Successful in Reducing Humidity Levels Effectively?	Yes	31	86.1
	No	5	13.9
	Total	36	100.0
Do You Expect the Operating Method of Design 1 to be Sufficient to Adapt to the Desert?	Yes	32	88.9
	No	4	11.1
	Total	36	100.0
How Would You Rate the Innovativeness of Design 1 on a Scale of 1 to 5? (5 Being not Innovative at all, 5 Being Highly Innovative)	Very Innovative	19	52.8
	Innovative	10	27.8
	Somewhat Innovative	7	19.4
	Total	36	100.0
Do You Think Design 2 is Successful in Reducing Humidity Levels Effectively?	Yes	32	88.9
	No	4	11.1
	Total	36	100.0
Do You Expect the Design 2 Mode of Operation to be Sufficient to Adapt to the Desert?	Yes	32	88.9
	No	4	11.1
	Total	36	100.0
How Would You Rate the Innovativeness of Design 2 on a Scale of 1 to 5? (5 Being not at all Innovative, 1 Being very Innovative)	Very Innovative	16	44.4
	Innovative	13	36.1
	Somewhat Innovative	5	13.9
	Traditional	2	5.6
	Total	36	100.0
Do You Think Design 3 is Successful in Reducing Humidity Levels Effectively?	Yes	33	91.7
	No	3	8.3
	Total	36	100.0
Do You Expect the Design 3 Operating Method to be Sufficient to Adapt to the Desert?	Yes	31	86.1
	No	5	13.9
	Total	36	100.0
How Would You Rate the Innovation of the Design 3 on a Scale of 1 to 5? (5 Being not at all Innovative, 1 Being very Innovative)	Very Innovative	23	63.9
	Innovative	10	27.8
	Somewhat Innovative	2	5.6
	Traditional	1	2.8
	Total	36	100.0

Interpretation of Table 4 summarizes participants' evaluations of three designs regarding their effectiveness in reducing humidity, adaptability to desert conditions, and innovation.

Design 1: - Effectiveness: 86.1% believe that it reduces humidity effectively. - Adaptability:88.9% find that its operation is sufficient for desert conditions.

- Innovation: 52.8% rated it as very innovative, 27.8% as innovative, and 19.4% as somewhat innovative.

-Design 2: -Effectiveness:88.9% believe that it reduces humidity effectively. - Adaptability:88.9% find that its operation is sufficient for desert conditions. - Innovation:44.4% rated it as very innovative, 36.1% as innovative, and 13.9% as somewhat innovative.

-Design 3: - Effectiveness: 91.7% believe that it reduces humidity effectively. - Adaptability:86.1% find that its operation is sufficient for desert conditions. -Innovation: 63.9% rated it as very innovative, 27.8% as innovative, and 5.6% as somewhat innovative.

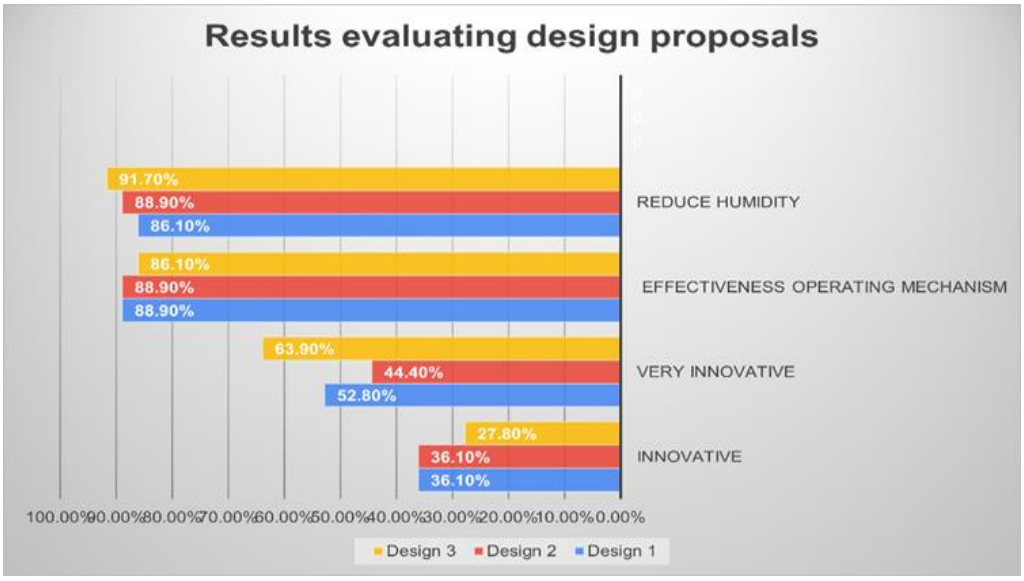

Figure 9: Comparative Evaluation of Design Proposals Caption: "Statistical Analysis Comparing the Innovation Levels of Three Design Proposals. Design 3 is Perceived as the Most Innovative and Effective, Followed by Design 2 and Design 1. The Majority of Participants find all Designs to be Suitable and Adaptable to Desert Conditions."

6. JUSTIFICATION OF RESEARCH OBJECTIVES

Investigate the cultural and philosophical underpinnings of the Hajj pilgrimage and its rituals, focusing on the impact of environmental conditions, including humidity levels, on pilgrims' well-being and spiritual

experience. - Justification: Understanding the cultural and philosophical aspects of Hajj is crucial for addressing environmental factors like humidity. This insight helps develop air conditioning solutions that respect both physical comfort and the spiritual significance of the pilgrimage.

Examine the operational challenges faced by traditional desert air conditioning systems in Mecca during the Hajj season and their implications for pilgrims' comfort and safety. - Justification: Identifying the specific issues with traditional air conditioning systems during Hajj can guide the development of more effective solutions. Considering these challenges through a cultural lens ensures the solutions enhance both comfort and the pilgrimage experience.

Identify cultural and philosophical principles to inform the design and implementation of desert air conditioning solutions in Mecca, considering the sacred nature of the pilgrimage. - Justification: Air conditioning solutions must align with the cultural and philosophical principles of Hajj. This alignment ensures the solutions respect the pilgrimage's sacred nature and the values of the pilgrims, enhancing both comfort and spiritual significance. Develop innovative strategies and technologies to improve the performance of desert air conditioning systems in Mecca, mitigating high humidity impacts while respecting cultural and philosophical considerations. - Justification: Innovation in air conditioning technology can improve system performance in Mecca. Integrating cultural and philosophical values into these innovations ensures they address technical challenges while enhancing the pilgrimage experience in a culturally sensitive manner. Evaluate the feasibility and practicality of proposed solutions through field testing and stakeholder consultation, ensuring alignment with cultural sensitivities and philosophical values of the Hajj pilgrimage. - Justification: Field testing and stakeholder feedback are crucial for assessing proposed air conditioning solutions. Incorporating cultural sensitivities and philosophical values ensures these solutions are accepted and adopted by the diverse cultural groups participating in Hajj.

7. DISCUSSIONS

The discussion of the findings from this study offers valuable insights into the intersection of technology, culture, and philosophy in the context of environmental interventions, particularly in settings of cultural significance such as the Hajj pilgrimage in Mecca. By analyzing the effectiveness of innovative design solutions and their alignment with

cultural values and philosophical principles, this study contributes to a deeper understanding of the complexities involved in addressing environmental challenges in culturally diverse contexts.

7.1. Implications for Future Research

The findings of this study have significant implications for future research endeavors in several key areas. Firstly, the study highlights the importance of exploring the cultural and philosophical dimensions of environmental interventions to develop solutions that are not only technically effective but also culturally sensitive. Future research could further investigate the nuanced relationship between cultural beliefs, environmental practices, and technological innovations, with a focus on developing holistic solutions that resonate with local communities. Moreover, longitudinal studies could be conducted to assess the long-term efficacy and acceptance of these solutions among pilgrims and local communities. Understanding how these interventions evolve over time and impact the socio-cultural fabric of the pilgrimage experience is essential for informing future design iterations and policy decisions.

7.2. Importance of Stakeholder Engagement

The active involvement of stakeholders played a pivotal role in evaluating the proposed designs and ensuring their alignment with cultural values and philosophical principles. Moving forward, continued collaboration and dialogue among stakeholders will be essential for the successful implementation of these solutions. By fostering a participatory approach that engages experts, designers, engineers, and end-users, researchers can create solutions that reflect the diverse perspectives and cultural sensitivities of the communities they serve.

7.3. Addressing Challenges and Limitations

Despite the promising results, it is important to acknowledge the challenges and limitations encountered during the evaluation process. Resource constraints, technological barriers, and cultural sensitivities may have influenced the design outcomes and require careful consideration in future endeavors. By transparently documenting these challenges and actively seeking solutions through interdisciplinary collaboration, researchers can enhance the robustness and applicability of future studies. This study highlights the interdisciplinary nature of design innovation and the importance of integrating cultural and philosophical perspectives into

environmental interventions. By embracing stakeholder engagement, addressing challenges, and fostering a culture of continuous improvement, future research endeavors can contribute to the development of sustainable solutions that honor cultural heritage while promoting environmental stewardship. Through ongoing collaboration and dialogue, researchers can strive to create a more inclusive and resilient future for all.

8. CONCLUSION

In conclusion, this study underscores the pivotal role of culture and philosophy in shaping technological innovations aimed at addressing environmental challenges, particularly in culturally significant settings like the Hajj pilgrimage in Mecca. By integrating cultural values and philosophical principles into the design process, researchers can develop solutions that not only meet technical requirements but also resonate with the deeply held beliefs and traditions of the communities they serve. The findings of this study emphasize the importance of interdisciplinary collaboration and stakeholder engagement in fostering a holistic approach to environmental interventions. By fostering a culture of inclusivity and diversity, researchers can leverage the collective wisdom and expertise of diverse stakeholders to co-create solutions that honor cultural heritage while promoting sustainability. Moving forward, it is imperative to continue exploring the intricate interplay between culture, philosophy, and technology in the development of environmental solutions. Longitudinal studies and ongoing dialogue with stakeholders will be essential for assessing the long-term impact of these interventions and ensuring their continued relevance and effectiveness in diverse cultural contexts. In essence, this study highlights the transformative potential of incorporating cultural and philosophical considerations into environmental design, paving the way for a more harmonious relationship between human communities and the natural world. Through collaborative efforts guided by a deep appreciation for cultural diversity and philosophical wisdom, researchers can strive to create a more sustainable and equitable future for generations to come.

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