Smart Design Policies

2025, Volume 2, Number 1, pages 1–18

Original scientific paper

Augmented Reality as a Design Tool in Enhancing Community Engagement: A Case Study of Souq Al Muharraq

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ARTICLE INFO:

Article History:
Received: 23 March 2025
Revised: 5 July 2025
Accepted: 15 July 2025
Available online: 20 July 2025

Keywords:
Augmented Reality,
Community Engagement,
Urban Development,
Souq Al Muharraq,
Technology Integration.

ABSTRACT

This research explores the potential of Augmented Reality (AR) as a participatory design approach to the revitalization of the historic market space, the Souq Al Muharraq in Bahrain. The research is positioned at the intersection of digital innovation and heritage preservation, investigating how AR can be used to improve the field of inclusive architecture and urban design, intersecting a range of knowledge levels between communities and professional planning. The mixed method approach made use of spatial observations, twelve semi-structured interviews, and three participatory workshops with eighteen stakeholders (locals, shopkeepers, and visitors). Printed overlays and annotated maps as analog AR simulations were deployed to receive feedback by users who had varied levels of digital literacy. Results indicate that AR-assisted approaches boosted spatial literacy and brought out culturally informed insights and allowed co-creation inclusively, especially among digitally excluded populations. The paper proposes a Smart Design Engagement Model that can bridge the gap between professional planning and lived experience of heritage sites. In the context of advancing research in participatory urbanism and smart governance of heritage, this paper is able to illustrate how low-barrier AR interfaces can be used as decision-making tools and in cultural-sensitive settings.

SMART DESIGN POLICIES (2025), ***2***(1), 1–18.
https://doi.org/10.38027/smart.v2n1-1

www.smartdpj.com

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How to cite this article: (APA Style)
SAlDoy, M., & Allani, N. (2025). Augmented reality as a design tool in enhancing community engagement: A case study of Souq Al Muharraq. *Smart Design Policies, 2*(1), 1–18. https://doi.org/10.25034/smart-v2n1-1

1. Introduction

1.1 Background and Context

Achieving a harmonious balance between modernization and cultural preservation within urban heritage districts has become a pressing challenge in the Gulf region. This challenge is reflected in areas, such as the the old city of Muharraq, where infrastructural investments tend to clash with the social and cultural spatial fabric of old neighbourhoods. The Souq Al Muharraq, one of the oldest markets on the island with a major tourist attraction in the UNESCO world heritage Pearling Path site, has recently undergone redevelopment in order to align with modern advancements in terms of visuals and touristic standards. Such measures involved rerouting pedestrian routes, street furniture, planters, and facade restorations. Despite these changes, conventional mobility patterns have been displaced, necessary parking facilities have been eliminated, and the daily spatial activities of locals,

store owners, and visitors have been undermined (Jallal, 2025) (Municipality, 2025) (Frank Othengrafen, 2023).

Regardless of the intended benefits, the implementation of these changes was conducted with no community participation, displaying a notable gap of communication between planners and everyday users. As a result of neglecting to include community feedback within the design process, the redevelopment project was openly condemned. Headlines in the Bahraini press highlighted the many urban issues through interviews with locals and shopkeepers. Lack of accessibility, in terms of pedestrianism and parking spaces, resulted in lack of footfall in shops and a reduction of 45% in sales (Jallal, 2025) (Municipality, 2025). These backlashes represent concerns regarding the result redevelopment projects, where they tend to focus more on tourist-friendly aesthetics rather than functionality and cultural sustainability within a heritage marketplace.

These inconsistencies are reflected in academic sources regarding participatory urbanism. According to scholars, urban regeneration in heritage spaces should not be only based on aestheticism but rather its preservation on a social foundation and inclusiveness of various (Ursina Christina Boos, 2023) (Timna Denwood, 2021) (Champion, 2022). Design legitimacy and public confidence in regions of strong place identities, embedded within the memory and ceremony of place, such as the Gulf, are also negatively affected by silencing local design feedback (Champion, 2022) (Max Allen, 2011). Moreover, in places like Muharraq, where the mechanism of participation is either institutionally fragile or symbolic in nature, these omissions reflect constitutional challenges to governance (R. Sabitha, 2024) (Wilcox, 1994).

This study explores the possibility of using Augmented Reality (AR) as a participatory design tool that can be used to democratize space visualization and public feedback. AR provides an opportunity to interface with digital overlays placed on existing physical landscapes and to empower non-experts to practice and critique architecture and urban-based interventions within the spatial realm they experience in everyday life. While AR has found applications in education, tourism, and heritage curation, its potential in participatory planning within historic environments remains unexplored (Celine Zhao Ying Yin, 2021) (Ursina Christina Boos, 2023). The study is a contribution to the growing discussion of AR tools in multiple site-based and workshop interactions on Souq Al Muharraq. This will examine the effectiveness in garnering spatial literacy, producing actionable feedback, and enabling effective communication between local citizens and architecture / urban professionals.

Complimented by both theoretical knowledge and empirical field research, the study endeavours to frame AR as a strategic participatory co-design tool to fill epistemic barriers, re-centre local knowledge, and creating inclusive heritage planning in Gulf regions.

1.2 Problem Statement and Research Gap

The recent redevelopment of Souq Al Muharraq as a site of heritage interest has not incorporated meaningful community input. This analysis has uncovered fundamental deficiencies in the urban planning framework. The municipal-led interventions, which worked towards paving, visual coherence, and commercial upgrades, failed to serve the everyday needs of the community. Reported cases of broken circulation, reduced vehicle accessibility, inefficient amenities, and the absence of restrained civic dialogue indicate an encompassing shortfall of participation in the redevelopment (Jallal, 2025) (Municipality, 2025).

This discrepancy reflects the broader academic spectrum of the sidelining of local knowledge within the heritage planning. Community engagement in the Bahrain has been found to be tokenistic (Jallal, 2025) though scholars point out that it has been instrumental in forming culturally resilient cities (Champion, 2022). Although digital implements have enhanced participatory urban design internationally within the professional fields, its integration in the Gulf heritage region with everyday users is limited due to the entrenched socio-spatial conventions (Răzvan Gabriel Boboc, 2022) (Ursina Christina Boos, 2023).

The potential to facilitate the reduction of this gap lies in the co-design tool, AR, and the visualization of planning proposals in the field of architecture and urban design projects. Despite its increased popularity in education and tourism (Celine Zhao Ying Yin, 2021) (Lin Y. W.-S., 2024), there is a scarcity of research testing its participatory capacity in heritage redevelopment, especially within a digitally marginalized community (Lin Y. W.-S., 2024). The study addresses the research gap with the following research question: "How can AR be utilized in participatory heritage planning to bridge the gap between professional perspectives and community experience?" Souq Al Muharraq, as a case study, will aid to employ empirical evidence and a transferable framework of inclusive digital engagement within Bahrain and the overall Gulf region.

1.3 Research Objectives

The aim of the study is to explore how one can conceptualize and assess AR as a means of engaging in participatory design within the context of heritage-based urban redevelopment, Souq Al Muharraq in Bahrain. As opposed to creating an AR application, the research investigates printed overlay filters and co-design participatory methods that replicate the spatial affordances of AR by providing community members with an immersive, yet accessible, interaction with architectural and urban planning interventions.

Accordingly, the research is guided by the following objectives:

- To critically assess the limitations of conventional participatory methods used in the recent redevelopment of Souq Al Muharraq, particularly regarding the exclusionary effects on local stakeholders and non-expert users.
- To implement AR-inspired participatory methods, such as printed overlays, annotated spatial diagrams, workshop-based simulations and video demonstrations; to comprehend the mediate local input on spatial planning decisions without requiring digital fluency.
- To evaluate the potential of AR as a conceptual framework to enhancing spatial comprehension, fostering community engagement, and supporting culturally grounded design interventions in heritage settings.

To achieve these objectives, this study will provide an interdisciplinary insight into the literature by focusing on participatory urbanism, immersive spatial tools, and smart heritage governance. These suggestions will provide methods of engagement in a similar context, offering scalable and low-barrier approaches.

1.4 Contribution and Structure of the Paper

This study is part of the developing literature on participatory heritage urbanism. It will offer a case analysis of Souq Al Muharraq and how AR has the potential to promote a community-led approach within a culturally sensitive redevelopment. Based on the ladder of participation by (Wilcox, 1994), adapted to flexible and inclusive practices by the scholars (Marcus Foth, 2023), the study presents a model of AR-mediated engagement that would fill existing gaps between expert-driven design and locally and culturally lived experiences.

Recent literature has focused on the role of digital tools in participatory architecture and urban planning (Champion, 2022) (Marcus Foth, 2023) (Răzvan Gabriel Boboc, 2022) (Frank Othengrafen, 2023) (Lin Y. W.-S., 2024), particularly in less prominent Gulf contexts where formal engagement with civic everyday use has been limited. The paper displays how spatial storytelling, visual feedback, and transgenerational discussions can be enabled through semi-structured field interviews, community workshops, and analog AR simulations in the regeneration of inclusive heritage planning.

The research paper is structured as follows: Section 2 delves into a literature review of the theoretical framework, including participatory urbanism and heritage, inclusivity in cultural settings, smart heritage policies and governance. Section 3 outlines the design of the study, including the field tools and sampling methods. Section 4 presents the results of community consultations and spatial observations. Section 5 discusses the implications of policy and participatory governance. Finally, Section 6 concludes with the presentation of future directions.

2. Literature Review

2.1 Theoretical Framework: Participation and Heritage Urbanism

The participatory process model, like the ladder of participation formulated by (Wilcox, 1994), continues to play a fundamental role in the comprehension and transformation of community engagement contribution to shifting the gears between passive and active participation processes. This ladder can be particularly beneficial in heritage planning by distinguishing between consultation as a superficial exercise and community action. Modern theorists state, in culturally sensitive settings, active involvement requires more than merely informing or consulting as a means of fostering shared decision-making and co-design (Champion, 2022) (Răzvan Gabriel Boboc, 2022). This is especially relevant in heritage districts where community identity and the form of the urban environment are intricately connected.

2.2 AR in Participatory Urbanism and Heritage

The use of AR has become a participatory medium that contributes to spatial literacy and aids in establishing engagement with non-expert users. AR, in urban planning, encompasses the ability communities add virtual objects to physical spaces and can deduce the proposed changes prior to the implementation (Max Allen, 2011) (Ursina Christina Boos, 2023). AR facilitates heritage site preservation by providing immersive layers that integrate history interpretation with present-day spatial planning (Shan Jiang, 2023) (Celine Zhao Ying Yin, 2021). The studies, however, report the necessity of adaptations concerning accessibility, especially with digitally marginalized groups, like the elderly, low-income communities, or non-native speakers. (Marcus Foth, 2023) (Lindlbauer, 2024).

2.3 Inclusivity and Cultural Responsiveness in Digital Design

Successful participatory digital tools are dependent on how well they correspond to local cultural values and practices. An array of research findings has shown the necessity of tailoring AR platforms to follow local discourses, languages, and symbolic spatial practices (Răzvan Gabriel Boboc, 2022) (Champion, 2022). An example of how AR can be used to democratize design is a participatory platform, designed to enhance walkability in neighbourhoods or urban storytelling, where underrepresented voices are amplified (Shan Jiang, 2023) (Baran, 2023). Gamification and analog-digital hybrid models have also been shown to be effective in inviting play among the generations, thus promoting cross-generational urban dialogue (Shin, 2025).

2.4 Smart Heritage Policies and Governance Tools

The integration of AR into urban policy practice has become a significant area of research. Scholars argue that participatory tools, like AR, should not be seen as mere technological enhancements but as governance mechanisms that can foster transparency, accountability, and iterative planning (Ursina Christina Boos, 2023) (Wilcox, 1994). Incorporating AR into official policy cycles is one method to institutionalize feedback and designate the populace influences in architecture and urban design choices. Such integration can enhance heritage spaces, as a part of smart city approaches, by reinventing relationships and creating co-management policies rather than having fixed conservation zones.

2.5 Summary: Positioning the Methodological Framework

The literature identifies a knowledgable gap within participatory design, digital inclusivity, and heritage governance. Although AR technologies showed promise in enhancing spatial awareness and civic discourse, their successful implementation depends on cultural story awareness, diversity of users, and internal preparedness. In heritage settings, such as Souq Al Muharraq, which has a rich history of memory and spatial nature, participatory mechanisms need to compensate for the technological innovation through community authenticity. Section 3 continues these reflections, describing a contextualized methodological approach that assesses how participatory urbanism can

be simultaneously inclusive and transformative on a layered historical site by combining interviews, workshops, and AR simulations.

3. Materials and Methods

3.1 Study Design and Setting

This research focus on applying a mixed-method case study design to analyze the commercial, heritage space. Souq Al Muharraq, consisting of 317 meters cultural heritage neighborhood that lies adjacent to the UNESCO Pearling Path in Bahrain. The study examines the application of AR participatory aspects in heritage redevelopment, especially in areas of cultural and spatial memory convergence. Souq Al Muharraq, an eclectic blend of commerce, religious historic buildings, and vernacular architecture, has recently experienced disruption due to modern redevelopment.

Municipal interventions have undermined the everyday user circulation and spatial legibility. These modifications did not include community feedback and engagement, mirroring the critiques in literature of design-driven regeneration dislodged to daily usage (Răzvan Gabriel Boboc, 2022) (Champion, 2022) (Timna Denwood, 2021). Social resentment has also been documented; local users and shopkeepers have acknowledged that they have experienced logistical and cultural estrangement (Jallal, 2025) (Municipality, 2025). Consequently, it will be disseminated to the participants of this study to acknowledge their experience with this novel redevelopment of the souq.

The study was conducted through one-site observational analysis, utilizing pedestrian tracking, congestion mapping, and site photography, complemented by materials on 12 interviews and 3 participatory workshops. Participants of the study interacted with analogy AR content, including printed overlays and marked maps. This approach was showcased in the literature as accessible to keep in mind users with low digital environment and literacy (Ursina Christina Boos, 2023) (Timna Denwood, 2021). Souq Al Muharraq offered a setting to discuss the potential of AR in cultural-based participatory planning centered around consumer knowledge and inclusion (Kain, 2022).

Table 1: Summary of Study Setting Components.

Component	Description
Study Area	317-meter corridor within Souq Al Muharraq, adjacent to the UNESCO-listed Pearling Path. The corridor serves as a traditional commercial spine.
Key Urban Disruptions	Recent street renovation introduced large concrete planters, caused loss of parking access, reconfigured traffic signage, and created bottlenecks.
Observational Tools	Thermal mapping for pedestrian clustering; manual tracking of circulation patterns and congestion nodes; photographic documentation.
Community Engagement	Twelve semi-structured interviews with residents and shopkeepers; three participatory workshops including eighteen participants of varying age groups and familiarity with the Souq.
AR Simulation Materials	Printed AR overlays to simulate digital interventions; map annotations; narrative feedback sheets; scenario-based spatial prompts; UrbanAR video demonstration of AR potential.
Objectives of Engagement	Identify barriers and spatial pain points; gather culturally embedded narratives; evaluate user understanding and design feedback using AR-informed simulations.

Figure 1. Souq Al Muharraq in the redevelopment process by the Muharraq Municipality that took 2-3 years with no access to shops.

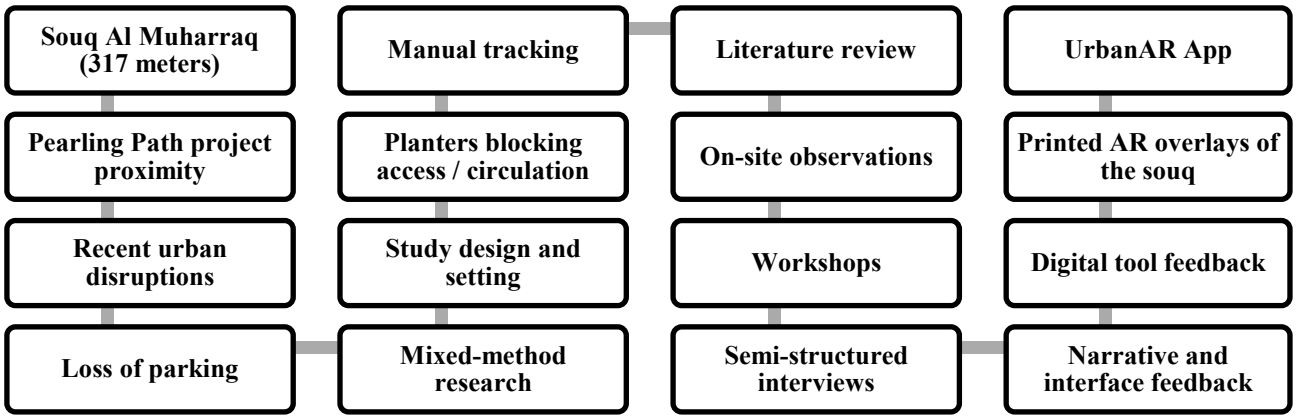

Figure 2. Mind map of study design and setting elements

3.2 Stakeholder Groups and Sampling Strategy

The sample involved sampling of thirty participants, who were highly involved with Souq Al Muharraq, to gather a wide array of socio-spatial views. These users were divided into three groups: locals, shopkeepers, and tourists. Each group represented a distinct perspective on accessibility, spatial use, and cultural significance (as seen in Tables 2 and 3). The data was gathered in the form of twelve semi-structured interviews and three participatory workshops among eighteen participants. Participants included locals aging from 18 to 47 years, rating from low to high-digital fluency. This will aid in analyzing their acceptance of implementing such technology and measuring their capabilities in utilizing the design tool to its fullest extent. Their inputs centered on the spatial discomfort related to redevelopment and familiarity with culture, enabled with visual and tactile devices to include annotated maps and AR overlays (Răzvan Gabriel Boboc, 2022) (Champion, 2022) (Lin Y. W.-S., 2024).

Despite the work schedule and availability constraints, shopkeepers (primarily male, aged 45 to 60 and older) were only able to participate in interviews. Their comments regarding commercial disruptions, accessibility issues, and planning mistrust were consistent with those of their counterparts in the literature and journalism of the era (Jallal, 2025) (Frank Othengrafen, 2023).

Tourists, ranging from 18 to 33 years old, proved to be tech-fluent by utilizing workshop materials, prioritized clarity in displays, orientation, cultural histories, and lend credence to the applicability of AR in heritage tourist settings (Celine Zhao Ying Yin, 2021) (Shan Jiang, 2023).

The sampling strategy sought to be generational, occupational, and technological diverse; by providing a multi-dimensional level of insight the redevelopment of heritage sites can be participatory.

Table 2: Interview Participant Overview (twelve participants in total)

Category	Participants (M/F)	Estimated Age Range	Technological Familiarity	Key Insights	Cultural Observations
Locals	4/2	28–47	Moderate	Showed urban discomforts, prioritized accessibility, and seating	Keen sense of place identity and cultural continuity
Visitors	2/1	30–33	High	Emphasized clarity in orientation and interest in AR storytelling tools	Viewed the souq as a historic tourism asset
Shopkeepers	3/0	45–60+	Low to Moderate	Stressed parking issues, visual disruption from planters, and signage placement	Highlighted disruption to traditional retail rhythms; showed mistrust in prior consultations
Total	9/3	28–60+	Variable	Nuanced spatial grievances across user types	Rich vernacular knowledge of heritage

Table 3: Workshop Participant Overview (eighteen participants in total).

Category	Participants (M/F)	Age Range	Engagement Type	Tech Familiarity	Feedback on AR Simulation	Behavioral Observations
Locals	2/13	18–45	Hands-on workshop with printed overlays and design tasks	Moderate to High	Demonstrated strong comprehension of spatial interventions, enthusiastic use of overlays	Actively proposed enhancements like seating, shading, and cultural wayfinding
Visitors	0/3	18–30	Scenario-based workshop using annotated maps	High	Focused on visual storytelling, digital heritage tagging, and navigational improvements	Engaged reflectively with space through memory and aesthetic preferences
Shopkeepers	0	—	—	—	—	Not present in workshop phase
Total	2/16	18–45	Participatory Design Workshop	Moderate to High	Participants evolved from passive observers to active co-designers through AR simulations	Expressed spatial insights with confidence once expressive tools were accessible

3.3 Participatory Workshops with Local Community

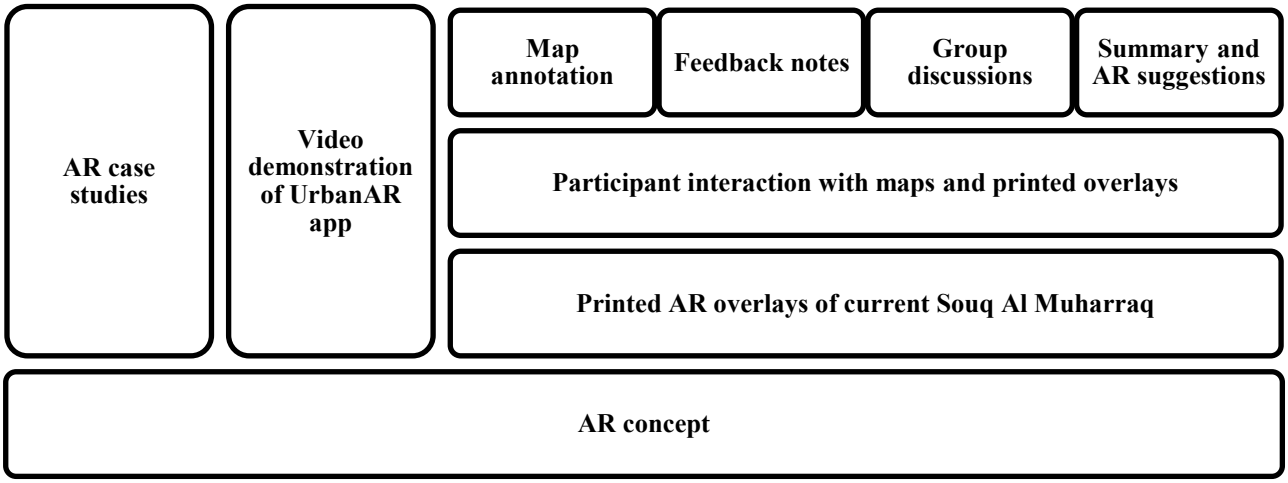

Figure 3. Participatory workshop structural process.

The research has utilized participatory workshop-based methodology to examine AR as a community engagement tool in heritage planning. Sessions, as displayed in Figure 3, took the form of introductory context-setting and collaborative spatial input, in accordance with participatory design models-based iterations (Răzvan Gabriel Boboc, 2022) (Timna Denwood, 2021).

The workshops then covered visual case studies of available AR applications in culturally similar environments to suit different digital literacy rates (Lin Y. W.-S., 2024). Then, participants interacted with print AR overlays of the re-developed Souq Al Muharraq, which included pathways, signage, and seating, that represented the tactile objects of spatial exploration within the AR design tool (Champion, 2022) (Frank Othengrafen, 2023).

Participants were then divided into sub-groups, using arrows, icons, notes annotated base maps, to highlight problems and suggest improvements. The map annotation and feedback notes are analogy tools that allowed non-expert users to exchange spatial knowledge without technical experience (R. Sabitha, 2024) (Marcus Foth, 2023).
The ending prompts encouraged reflection on the experiential intentions of the souq, prompting further design questions that explored themes such as accessibility, comfort, identity, and commerce.

3.4 Data Collection and Analysis Techniques

The data derived in a stratified manner to reflect the experiential, spatial, and textual aspects of the redevelopment in Souq Al Muharraq. This aligns with recent appeals to multimodal and inclusive techniques in participatory heritage planning, where spatial memory and cultural value hold pivotal roles (Răzvan Gabriel Boboc, 2022) (Champion, 2022). The strategies were triangulated, including semi-structured interviews, participatory workshops, on-site observation, and AR simulation tools, in order to corresponded to hybrid methodological frameworks (Lin Y. W.-S., 2024) (Champion, 2022). Twelve Arabic and English interviews with locals, shopkeepers, and visitors were conducted based on accessibility, cultural continuity, and spatial technology use. This highlights the studies on narrative-oriented information in the heritage domain (Max Allen, 2011). The AR overlays annotated base maps, and feedback tools, combined with eighteen participants who took part in participatory workshops, have immersed themselves in the lived experience of design interventions within the architecture and urban design field (Ariel Noyman, 2019) (Baran, 2023).
The workshops bridged the gap regarding digital literacy by proposing accessible AR solutions, like the UrbanAR app, alongside printed materials facilitating intergenerational engagement (J.A. Nagelhout (Arjo), 2021) (Ursina Christina Boos, 2023) (Frank Othengrafen, 2023). Spatial observation methods were complemented by thermal tracking and hand-mapping of pedestrians within the 317-meter corridor. This aligns with approaches presented in smart urbanism and behavioral design research (Frank Othengrafen, 2023) (Timna Denwood, 2021).
To enhance the analysis of multiple dimensions in the subsequent sections, the tables of participant types, data forms (visual, spatial, verbal data), and guiding themes (mobility, heritage attachment, and wayfinding clarity) were cross-referenced in a research grid.

Table 4: Data Collection and Analysis Summary

Method	Description	Tools/Formats Used	Purpose
Interviews	Semi-structured conversations with key stakeholders (residents, shopkeepers, visitors)	Audio recordings, handwritten notes	Capture qualitative insights on spatial perception and AR comprehension
Participatory Workshops	Interactive sessions using printed AR overlays and scenario-based prompts	Annotated photographs, printed maps, sticky notes, markers	Co-generate design feedback and community-driven interventions
Observational Mapping	On-site tracking of pedestrian and vehicular movement	Manual sketches, thermal maps, heat clustering tools	Understand real-time circulation, congregation, and disruption patterns
AR Tool Simulations	Analog presentation of AR content via printed overlays and case-study examples	Projection visuals, video demonstrations of the UrbanAR app, printed layers	Evaluate public comprehension of spatial augmentation and interactive feedback
Thematic Coding	Post-session analysis of transcripts, notes, and visuals	Manual coding, digital categorization (Excel, NVivo-style tagging)	Identify key themes such as memory, usability, and navigability
Comparative Feedback Matrix	Cross-referencing between interview and workshop data	Tabulated participant insights	Synthesize variations in design preferences by stakeholder type

4. Results

4.1 Site Observations

Figure 4. Traffic congestion and informal parking patterns in Souq Al Muharraq.
This collage of six original photographs was taken and annotated by the author using Procreate. The red markings indicate circulation obstructions, informal vehicle stops, and visual clutter that disrupt pedestrian flow. The images document the real-time spatial challenges caused by recent urban redevelopment and lack of structured mobility planning in the heritage district.

On-site observations of Souq Al Muharraq were taken within different time frames of weekdays and weekends to document major spatial and experiential disruption. It was confirmed by photographic record and mapping of thermal path to analyze the corridor circulation and user interaction. The previously smooth 317-meter marketplace now faces disruption due to concrete planters, change in circulation patterns, and limited parking spaces (Jallal, 2025) (Municipality, 2025).

The thermal mapping activity aligns with recent studies in urban pedestrian flows, which have demonstrated the clustering of heat and movement patterns that can be used to uncover informal pathways and bottlenecks (Marcus Foth, 2023) (Timna Denwood, 2021). Planters, which serve as aesthetic additions, unexpectedly blocked drop-off areas and crossings during rush hour, causing ad-hoc detours similar to those in Kadikoy district, Istanbul, where façade modifications significantly altered pedestrian behavior (Ursina Christina Boos, 2023) (Frank Othengrafen, 2023).

The significant reduction in parking spaces, leading to double parking and limited access to shops, mirrors trends in other pedestrian-heavy heritage districts in other cities, as pedestrian circulation and commercial dynamics are closely linked to infrastructure layout (Ursina Christina Boos, 2023) (Frank Othengrafen, 2023). Shopkeepers acknowledged that lower parking resulted in decreased footfall by 45% of their everyday sales and income. Many shops have resulted in being closed down as a result of limited accessibility to their space and loss in revenue (Jallal, 2025).

Other renewal initiatives, such as patterned markings and inadequate lighting, also compromised visual legibility and wayfinding. This aligns with arguments that urban improvement interventions frequently neglect the importance of designing spaces that allow users to orient themselves with relative ease (Lin Y. W.-S., 2024). This strengthens the literature in proposing combined regeneration planning that focuses on heritage aesthetics, flow of circulation, and inclusive mobility (Lin Y. W.-S., 2024) (Ursina Christina Boos, 2023).

Concisely, these observations create a case of reinforcing redevelopment frameworks with a focus on pedestrian legibility, visual coherence, and flexible spatial zoning. Thus, subscribing to the thesis of (Ursina Christina Boos, 2023) on the power of AR enhanced participatory design to visualize and solve the physical issues of the urban environment.

Figure 5. Circulation diagram of Souq Al Muharraq, highlighting the urban challenges shown through site observation, interviews, and workshops. Created by the author using Procreate, based on original fieldwork and site documentation. Base map adapted from [Google Earth].

4.2 Interview Insights

To capture diverse perspectives on the redevelopment of the Souq Al Muharraq, twelve semi-structured interviews were conducted with six residents, three shopkeepers, and three visitors. These interviews were based on their regular usage and cultural spatial familiarity within the redeveloped area (Răzvan Gabriel Boboc, 2022).

Residents expressed concerns regarding the disruption caused by the unexpected obstruction of planters, which necessitated the rerouting of paths into mobility that poses significant challenges for older users. Since the removal of parking and modifications in circulation, shopkeepers complained about decreased storefront visibility and footfall by 45% of their revenue income. This aligns with the literature on the exposed vulnerability of heritage-based retail (Champion, 2022) (Ursina Christina Boos, 2023).

Visitors referenced regional examples of digital navigation from their own country (UAE) through informal techniques on social media platforms, stating their way of acceptance and interest in AR-based tools. The participants of younger generations were showcased digital interfaces and older generations video demonstrations, justifying the importance of adapting to age (Marcus Foth, 2023) (Ursina Christina Boos, 2023).

The interviews led to discussions on exclusion and space transformation, guided by the enhancement of AR demonstrations in workshops, based on local context and aspirations.

4.3 Workshop-Based Insights on Community Engagement

4.3.1 Workshop 1: Online Participation and Health-Tech Integration

The first participatory workshop was held online with six participants of Bahrain and Kuwait. There field of expertise ranged from cybersecurity, public health, and architecture. The online medium enhanced the reach across diverse regions, with the notion on participatory democracy extending beyond geographic borders through online platforms (Kain, 2022) (Baran, 2023). Nonetheless, it also had its limitations, such as audio interruptions and a lack of spatial interaction.

Aside from these limitations, the meeting proved the cross-sectoral applicability of AR in urban planning. Participants in the public health sector pointed out the impact of air quality, pollution clustering, and lack of walkability on the well-being of the community. This is consistent with the plea to incorporate health indicators into spatial planning (Răzvan Gabriel Boboc, 2022). Cybersecurity and engineering participants were concerned with infrastructure stability of AR and data ethics, which are in relevance to the smart cities' governance (Chan M. A., Critical success factors (CSFs) for sustainable affordable housing, 2019) (Lin Y. W.-S., 2024).

Group mapping and simulation allowed participants to visualize the presence of areas with walkable zones, health-sensitive areas, and interactive journeying tools. These practices placed AR as a medium that can bridge disciplinary and civic agendas, especially in locations with limited physical space (Mario Wolf, 2024) (Baran, 2023).

Comprehensively, the session proved how immersive participatory approaches have the potential to support inclusive, multi-sectoral participatory co-design (Champion, 2022) (Lindlbauer, 2024).

4.3.2 Workshop 2: Visual Communication and Spatial Comfort

The second, and first face-to-face participatory, workshop engaged five professionals in architecture, medicine, marketing, and linguistics. The session was conducted in a semi-private cafe, where printed images and photo-overlay of Souq Al Muharraq were displayed to ensure people explored them tactilely. This method corresponds with the literature that also highlights visual stimuli as an effective participatory design tool along with the enhancement required based on interviews and online platform assessments (Champion, 2022) (Răzvan Gabriel Boboc, 2022).

Participants also reacted intuitively to aesthetic coherence, environmental comfort, circulation logic, etc. Coordinated façades, shaded seating, and public water fountains were among the proposed measures, breathing the tactics of bioclimatic heritage planning (Chan M. A., 2021).

Although the cafe environment did bring additional distractions to a limited extent, it also ensured open communication and collaborative thinking in terms of co-design. This is consistent with evidence to face-to-face workshops being more immersive and grounded learning experiences to do with spatial contexts (Ursina Christina Boos, 2023) (Wilcox, 1994).

The design recommendations focused on spatial equitability and urban inclusiveness, including a parking facility at the basement level, gender-sensitized terminals, and an exclusive cycling path. These suggestions are consistent with literature that situates participatory planning as the primary means of promoting equity in spatial decision-making (Lin Y. W.-S., 2024) (Răzvan Gabriel Boboc, 2022).

The session reconfirmed the relevance of analog AR tools in working up contextual design inclinations and open discourse among the participants.

4.3.3 Workshop 3: Civic Empowerment and Design Prototyping

The last participatory workshop engaged seven individuals covering engineering, security, literature, and government sector. To expand on the previous sessions, this workshop followed a more structural goal-oriented co-design approach. Conceptual and spatial engagement were high, showing the focus on the significance of scaffolding and easy-to-use tools in participatory sessions (Marcus Foth, 2023) (Champion, 2022).

Printed photographic overlays of Souq Al Muharraq were used for the brainstorming session and to capture the essence of AR within the urban planning. The participants suggested design opportunities like family rest areas, shaded seating areas, play area for children, and ATMs by the retail stations for visitor use. This hybrid model of analogue practice encouraged participation within various technological literacies (Lin Y. W.-S., 2024) (Răzvan Gabriel Boboc, 2022).

Stacking annotations enabled participants to simulate alternative layouts directly on printed visuals that supported the promise of the low-tech tangible AR techniques (Baran, 2023). The navigation and accessibility were the primary themes discussed to focus on inclusive heritage urbanism (Kain, 2022).

A government official, from the Ministry of Interior in Bahrain, expressed the hope that AR has to offer democratising spatial governance. He emphasized the importance of developing clear data protocols within certain urban policies in order to effectively apply such technology. The session showcased how co-design can significantly benefit, even without the expertise within the field, can provide effective tools in advancing claims of participatory writing of urban futures (Lin Y. W.-S., 2024) (Celine Zhao Ying Yin, 2021).

Figure 6. Overlay images of Souq Al Muharraq; annotated by the participants in the workshops to mimic VR as a co-design tool by the community participants to create design solutions fit to their needs with a heritage site.

4.4 Thematic Synthesis

4.4.1 Spatial Accessibility and Comfort

The spatial comfort and physical accessibility were prioritized in every engagement format. Some of the main complaints cited by users included blocked routes due to excessively large planters, limited parking spaces, the absence of shaded rest areas, and uneven paving. Such obstacles negatively impacted the locals (primarily the older generation), shopkeepers, and users with mobility restrictions; due to the inequalities built into modernized urban redevelopment by the Muharraq municipality (Ursina Christina Boos, 2023) (Lin Y. W.-S., 2024) (Municipality, 2025). Through spatial analysis, eighty-two retail stores along the main path were identified with only twenty-one parking spaces within the immediate vicinity. This imbalance highlights a notable difference between business densities and access by road, which has played a part in creating traffic congestion and low retail traffic. They coincide with the wider bodies of urban design knowledge supporting mobility justice and microclimatic comfort within hot, compact cities (Frank Othengrafen, 2023) (Shan Jiang, 2023).

4.4.2 Cultural and Memory Integration

The respondents were concerned with the intangible history of Souq Al Muharraq, which refers to memories, rituals, and local stories, that are spatially defined yet are often unacknowledged in redevelopment modifications. Tourists and long-term locals expressed concern that generic improvements to design were undermining symbolic ties to the history of the souq. The community members responded by suggesting that AR could be utilized to overlay storytelling, memory pathways, and signs using conventional names or roles. It reflects the conclusion of scholars, like (Champion, 2022) (Shan Jiang, 2023) and the importance of digital heritage interpretation to ground place identity alongside technology-enhanced experiences.

4.4.3 Visual and Functional Coherence

Another prevailing issue highlighted through the thematic synthesis of the souq was the visual inconsistency. Respondents criticized the visual pollutions of signages, inconsistent facades, and

substandard circulation rationale with the redevelopment process. These were issues of legibility that got in the way of cohesive aesthetics for the souq. Proposed recommendations comprised of the coordination of storefront treatments, streamlining directional signage, and minimizing spatial clutter. The comments support the ideals of urban design based on visual rhythm, intuitive wayfinding, and built-in placemaking (Timna Denwood, 2021) (Oliver Lock, 2019). AR was considered a possible intervener to model and visualize these uniting acts without urban and cultural disruption

4.4.4 Digital Inclusivity and Safety

Although most of the participants actively interacted with the AR-enhanced tools, some of them were worried about the risks associated with digital access, data privacy, and technological overreach. Older participants and shopkeepers found it difficult to utilize the digital interface of AR, whereas younger users, like cybersecurity experts, have expressed concerns regarding consent and data security in reference to ethics of surveillance. Such issues parallel wider apprehensions in the civic-tech literature regarding algorithmic bias, dangers of surveillance, and digital exclusion (Kain, 2022) (Lindlbauer, 2024). Workshop tasks were supported by low-tech simulations (e.g., printed overlays and physical marking) to provide equal access to the workshops, which is also proposed by (Ursina Christina Boos, 2023) and (Mario Wolf, 2024) in the context of multi-generational approaches.

5. Discussion and Policy-Level Implications

5.1 Regulatory and Institutional Frameworks

The fieldwork at Souq Al Muharraq resulted in an observed gap between planning authorities and the community. With national promises in heritage revitalization, the interventions of planters and traffic restructuring were carried out without community engagement of the space. This disconnection resulted in a prominent level of frustration and matches with a more general critique of technocratic planning, based on models that elude the experience (Ursina Christina Boos, 2023) (Timna Denwood, 2021).

In response, community participation requires to be formalized as a planning control condition in heritage planning. This includes participatory auditing with co-design tools, such as AR, prior to approval of redevelopment plans. The digital outlets, augmented by analog, must be developed to absorb, visualize, and respond to feedback across project stages (Ursina Christina Boos, 2023) (Răzvan Gabriel Boboc, 2022) (R. Sabitha, 2024).

The municipalities ought to put in place interdisciplinary review panels, comprised of locals, planners, and AR technologists, to co-review design proposals. This would result in community insights becoming a part of urban policy workflows. The funding, or development, of projects should be contingent upon public reporting feedback.

Codification of participation and the use of immersive technologies can transform the current modern approach to heritage governance. This transforms the process to an inclusive, participatory, co-creative approach that connects the practice of design to the smart and equitable urbanism idea (Champion, 2022) (Frank Othengrafen, 2023).

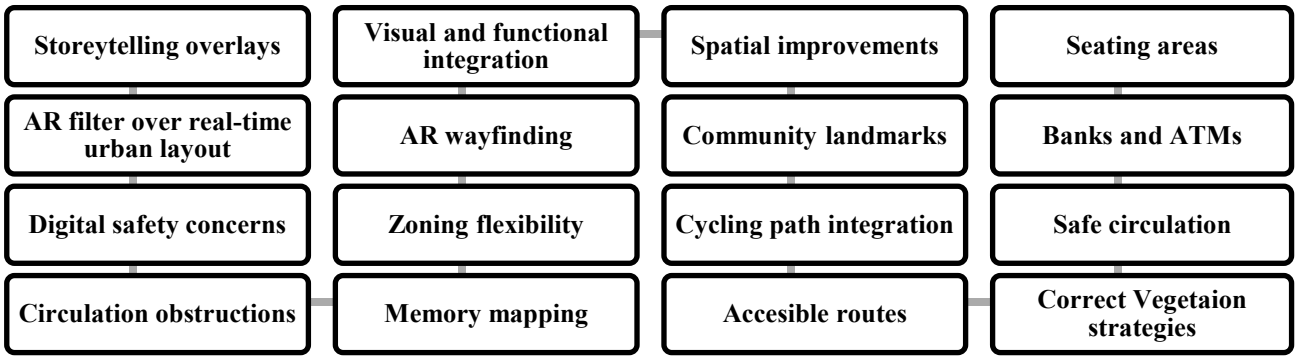

Figure 7. Mind map of common phrases from interview and workshop results.

5.2 Community Insight as Policy Capital

The activities of Souq Al Muharraq show that locals, shopkeepers, and tourists have significant spatial knowledge that is usually lacking in planning. Their feedback, up to and including circulation issues and cultural continuity, shows that communities are not helpless users. They exist as spatial knowledge producers due their experience within the space (Marcus Foth, 2023) (Ursina Christina Boos, 2023).

Workshops displayed that non-professionals can still suggest detailed design solutions, given access to accessible tools of annotated overlays. This defies conventional scales of knowledge and strengthens the literature in considering lived experience as a fundamental aspect of heritage planning (Champion, 2022) (Shan Jiang, 2023).

Various user groups offered different insights. The older shopkeepers prioritized cultural thresholds, the young were concerned about accessibility, and visitors reported on experiential friction. They collectively generate a more detailed working knowledge base than a single professional point of view (Timna Denwood, 2021) (Frank Othengrafen, 2023).

In converting this insight into actionable policies, municipalities must view community feedback as an asset to their planning process by designing perspectives with iterative feedback loops at the core. Community feedback must be reinforced with AR simulations and mobile toolkits (Ariel Noyman, 2019) (Mario Wolf, 2024). Making such practices as a routine could change the discourse of urban design as a specialized process into a collaborative civic activity.

5.3 Augmented Reality as a Design Governance Tool

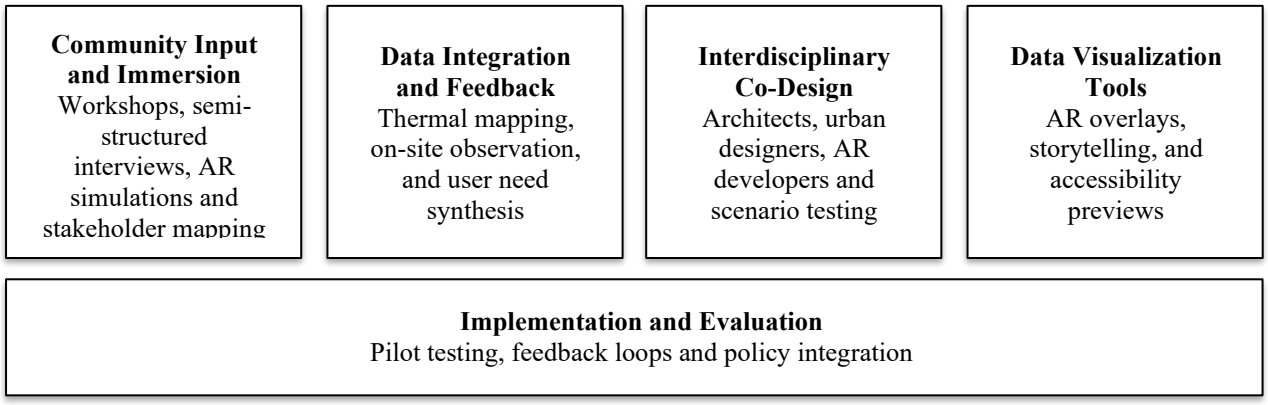

Figure 8. The diagram illustrates a five-step process for integrating community participation into heritage site regeneration using Smart Design Engagement Model principles. Beginning with immersive community input and progressing through data synthesis, interdisciplinary co-design, digital visualization via AR, and iterative implementation. This process bridges gaps between professional designers and lived experiences, ensuring responsive and inclusive urban interventions.

In contexts of heritage sensitivity, such as the traditional marketplace of Souq Al Muharraq, urban politics are usually characterized by tensions between institutional knowledge and lived memory. This study demonstrates that AR, in addition to being a visualization tool, has the potential of being a strategic component of participatory governance.

In the workshops, participants worked with printed AR layers, that allowed them to mimic the experience, through changing the location of planters or suggesting additional parking spaces. These tools enabled non-professionals to harness spatial thinking with ease, confirming the importance of AR in reducing the technical barriers within engagement (Mario Wolf, 2024) (Răzvan Gabriel Boboc, 2022).

Three important governance processes were identified based on the application of AR: (1) temporality responsiveness, which allows iterative feedback about community; (2) geospatial accuracy,

connecting input with areas; and (3) transparency, which allows users to observe and participate in the planning process (Ursina Christina Boos, 2023) (Oliver Lock, 2019). These capabilities will increase confidence and be consistent with inclusive smart city practices.

This has been formalized into the Smart Design Engagement Model (see Figure 8), a five-step circle of co-design, simulation, and feedback to integrate professional planning standards with realities upon the community. This model has the promise of transforming heritage planning as a modern administrative process into a collaborative urban transformation process. The process can be worked within municipal processes through policy directives, AR literacy programs, or as free-to-use platforms.

5.4 Smart Heritage Policy Innovations

The interventions in Souq Al Muharraq show that the incorporation of AR into heritage redevelopment can transform heritage components into, not only a preservation project, but also a course of policy innovation. AR filled a gap that existed between formal urbanism and community input by bringing planning concepts to participatory formats. It correlates with the pleas to recast urban planning as a co-designed and iterative process instead of a top-down system (Celine Zhao Ying Yin, 2021) (Champion, 2022) (Michael Atafo Adabre, 2020) (Marcus Foth, 2023).

In order to harness this potential, AR must be institutionalized as a regular tool in planning as opposed to a one-time engagement method. The use of AR in consultation phases of heritage projects can be incorporated at a municipal level, introducing feedback mechanisms to allow participatory action (Ursina Christina Boos, 2023).

The inclusion aspect cannot be neglected. Results of the workshop revealed that young participants were more inclined to use digital tools, but older users were more predisposed to using printed overviews and guided materials supporting the multi-format adoption opportunity (Ursina Christina Boos, 2023). Literacy levels should also be considered in participatory technologies to make them inclusive among many generations.

Moreover, policy should also concern data governance. AR overlays must include content about culture written by members of the community, entailing ethical stewardship and sovereignty of its culture (Kain, 2022). The result of the participatory sessions, including annotated maps and visual proposals, should be stored in ‘Urban Design Insight Repositories’ to assist in future interventions, benchmarking, and institutional knowledge (Baran, 2023).

Finally, the use of AR in heritage planning not only visualizes, but it also provides a route towards a more collective, collaborative, and reactive smart city governance.

6. Conclusion

This paper explored the potential of AR and its utilization as a participatory tool in heritage-related redevelopment within an urban setting. The mixed-method approach to conducting this research involved spatial observations, interviews, and participatory workshops. This has shown the potential of AR-supported engagement and how it promotes a better comprehension of urban space, empowers underrepresented users, and allows for a more inclusive co-design within historically sensitive spaces. The results confirm the original hypotheses, to which AR can serve as a civic interface to address the experiential gap between urban professionals and communities’ members. The analog simulations of AR not only captured the design deficits that modern planning might have missed, but also engaged the spatial intelligence of shopkeepers, locals, and tourists, especially those with minimal digital fluency. These observations confirm the theoretical assumption of locally adapted digital tools and how it promotes socially sustainable urban transformation.

The paper adds to the existing literature on participatory urbanism and smart heritage governance, by presenting an empirically informed, conceptualized model, i.e., Smart Design Engagement Model that combines immersive technology with community authored knowledge. Albeit promising, the study has its limitations, such as the lack of longitudinal follow-up data, and the inability to gather quantitative analytics into usage. Further research may be conducted to study the generalisability of

AR-based per engagement in various urban backgrounds and evaluate the long-term behaviour and policy implications. This paper eventually promotes the concept of institutionalizing participatory technologies as a norm in heritage and smart design policies to create inclusive, culturally relatable, and intelligent urban conditions.

Acknowledgements
The authors would like to acknowledge the University of Bahrain for providing institutional and academic support that enabled the completion of this research. Thanks, are also extended to the faculty members whose guidance and constructive feedback contributed to the study's development. The authors are particularly grateful to the locals, shopkeepers, visitors, and municipal representatives who participated in interviews and workshops; their insights and time were instrumental in shaping the study's findings. Appreciation is also due to the local community and stakeholders involved in the participatory design activities at Souq Al Muharraq.

Funding
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflicts of Interest
No conflicts of interest were reported by the authors.

Data Availability Statement
The data supporting the findings of this study are available from the corresponding author upon reasonable request. Workshop materials and anonymized interview data are archived in a secure institutional repository and may be shared with appropriate permissions.

Institutional Review Board Statement
Ethical approval for this study was obtained from the Research Ethics Committee at the University of Bahrain. All participants provided informed consent prior to their involvement in the study.

CRediT author statement:
Conceptualization: M.A.; Data curation: M.A.; Formal analysis: M.A.; Investigation: M.A.; Methodology: M.A.; Supervision: N.A.; Validation: N.A.; Visualization: M.A.; Writing (Original Draft): M.A.; Writing – review & editing: M.A., N.A. All authors have read and agreed to the published version of the manuscript.

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