Visual Impression of urban waterways in shrinking cities: Case study of Matsue canal network around the castle

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Visual Impression of urban waterways in shrinking cities: Case study of Matsue canal network around the castle

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Abstract. Matsue City in Japan, known as the "City of Water," has historically celebrated its urban waterways for their scenic beauty. However, due to factors like rapid urbanization, an aging population, and recent isolation challenges, these waterways have lost their prominence. This research aims to understand the visual impression of Matsue City's waterways and their connection to the city. Our approach involves a mixed data collection method. We mapped physical elements along the waterways, categorized them, and analysed the results. We also captured photos of the sceneries, examining their composition using photo segmentation. Additionally, a photographic questionnaire was conducted with respondents familiar with these areas, cross-referencing their responses with interviews that included renderings of the sceneries. The outcomes reveal insights into the visual appeal of urban waterways and their impact on inhabitants. By identifying elements that resonate and understanding shortcomings in the current landscape, our research contributes to revitalization efforts. The findings emphasize the potential of Matsue City's historical waterways for sustainable development strategies, highlighting the importance of preserving and enhancing these natural assets for the benefit of residents and the city's overall development.

1. Introduction

Traditional waterway sightseeing has always been integrated with scenic spots in urban areas, forming a regional identity with distinctive characteristics. Beyond their historical roles in water transport and border security, canals contribute significantly to cities' unique urban character. As cities evolve, the relationship between canals and urban areas moves toward a harmonious and reciprocal behavioural pattern. While cities like Amsterdam, Venice, or Bangkok showcase how planning and management of urban canals enhance the imageability of cityscapes, in Japan, cities with rich river networks focus on improving water quality as an effective measure to promote urban water tourism and regional development [1]. Also, nowadays, urban waterways regeneration projects, evolving into tourist destinations beyond their ecological functions, play a crucial role in shrinking cities' revitalization as subject to the positive or negative perceptions of tourists and residents. Previous research explores how the visual attractiveness of urban waterways contributes to residents' well-being [2] and examines the impact of landscape aesthetics on tourism experiences and the revitalization potential of the region [3]. The assessment of visual aesthetics is influenced by preferences and perceptions, with physical features like environmental cleanliness, cityscape and waterscape composition, and vegetation coverage as indicators of correlation between public perception scores and specific segmentation elements [4].

On the other hand, regarding shrinking cities, suburban areas facing a population decline, particularly those with strategically located wasteland, try to implement urban revitalization policies from their regional natural environment. These policies aim to create climate-resilient and recreational urban

spaces that reflect a common theme in post-pandemic urban research, urging a shift in public policies towards more human-centred space development [5]. However, despite the increasing attention on human perception in the urban environment, particularly emphasizing residents' values in shaping the cities' impression, most research is typically approached from a tourism perspective in popular cities [6], while research based on residents' impressions is relatively lacking, as so for the case of cities' urban waterways. Hence, this study aims to fill this gap by exploring residents' perceptions of attractiveness as a specific aspect of regional government promotion to revitalize suburban shrinking cities.

The study target is the famous historical and cultural city of Matsue, a long-standing name of the City of Water since the Edo period in Japan. Matsue has been renowned in Japanese literature for its picturesque water scenery surrounded by the mountains and sea integrated into the beautiful natural environment of its historic castle and the canal network connected to the castle moat. In terms of development, despite being a prefectural capital city, Matsue is struggling with the outflow of the young generation to the metropolitan cities. The area is trying to promote industry and economy through a regional network of compact core cities while protecting its refined heritage landscape preserved from the Edo period. However, judging from the current on-water sightseeing section, the perceptions of the water landscape are generally limited to serving tourism. The remaining section of the network consists of ordinary scenery that lacks identity and attractiveness. Also, due to rapid urbanization, an ageing population and recent pandemic isolation, regional governments encourage the implementation of technology to promote the city scenery through Virtual Reality despite the fear that technology could affect the visual impression of the ancient castle scenery preserved since the old time. Hence, the research seeks to clarify the characteristics of urban waterways and their connection with Matsue City through residents' opinions. The results aim to grasp the visual impression of urban waterways contributing to the revitalization efforts of the historical town and highlight its potential as an integral component of city development strategies for urban revitalization.

2. Framework for visual attractiveness in shrinking city

While the global population continue growing, Japan is facing demographic challenges characterized by a rapid decline in population due to decreasing birth rates and an ageing society. The outward migration of young people to metropolitan areas has continued since the beginning of the rapid economic development. Under this pressure, governance tries to foster population growth, improve urban space formation, and enhance people's quality of life to achieve sustainable development through wiser utilization of social infrastructures. A concrete approach promoted by the Ministry of Land, Infrastructure, Transport and Tourism's policy on developing a compact and livable community is to adopt a Compact City structure. This structure, which Matsue City is defined as the Multipolar Network Type [7], is expected to bring about positive impacts such as healthier and more comfortable lives, enhanced financial and environmental sustainability of cities, and foundational support for the local economy. This structure continued to evolve into regional public systems development and restructuring while taking advantage of digital technology as of 2023 [8]. The concept typically involves a high-density development of neighborhood patterns and establishing linked urban areas through public transportation with convenient access to workplaces and local services. However, despite economic support from both national and local governments, the Compact City concept, aimed at improving service delivery efficiency, has not led to increased compactness in residential patterns, as observed in the case of Matsue (Figure 1 [9]). This situation is explained by the research of Kajita [10], which investigated whether Matsue's prefectural capitals, typically characterized by administrative and consumer-focused attributes, demonstrate a "dam function" to shed light on changes in the city's socio-economic structure. The research highlights the transformation in Matsue's industrial landscape, characterized by the contraction of construction and manufacturing sectors and a simultaneous expansion of the medical and welfare industry with various emerging challenges within the city, providing insights into the diverse issues of its changing dynamics. Another vision demonstrated by Yoshida using a future urban structure model [11], incorporating a wide-area urbanized area linkage where Matsue is estimated to experience a rapid population decline. This phenomenon urges the city to form a hub with a concentration of high-level urban functions while taking advantage of the excellent

natural scenery, the unique historical and cultural assets of the region, and tourist resources, aiming to realize an international city of culture and tourism that values water, greenery, history, and education.

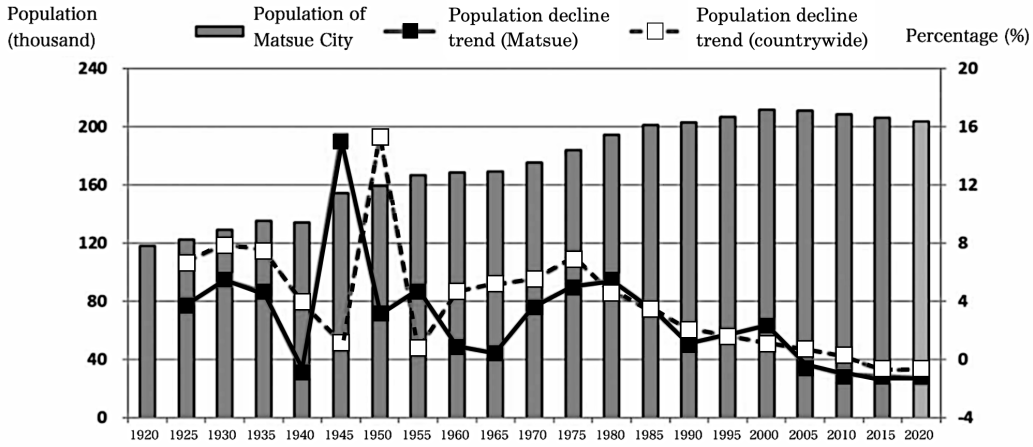

Figure 1. Matsue population (1920-2020) per registered residents.

Therefore, to tackle the issues of shrinking cities, Matsue is focusing on leveraging its unique attributes and engaging in urban development to sustain its vibrancy by maintaining an appeal that attracts people and businesses, promoting growth and emphasizing urban strengths. Belong to 138 major Japanese cities, Matsue city was rated by several criteria in the ongoing study of the "Japan Power Cities–Profiling Urban Attractiveness", an initiative of the Mori Memorial Foundation, Institute for Urban Strategies [12]. The study aims to perform comparative analyses using quantitative and qualitative data to understand city characteristics, strengths, and attractiveness. From 2018 to 2023, Matsue ranked among the top 40% of cities with high ratings in terms of Cultural Interaction, Livability/Daily Life and among the top 10 cities in terms of Environment. The composition of the population also switches from a mix of family-senior-tourist toward more diverse with a high immigration of single employees (JPC 2023 report). Finally, based on the City Perception Survey of the same year report, where the population was asked to decide which image keywords link to their perception of the city, the highest rating is “Water”, with 7% frequency among approximately 300 residents, and image recognition is “Matsue Castle”, with 16.2% frequency among close to 900 non-residents [13]. These characteristics solidify the visual perception of Matsue city that links with its castle and water network, addressing the underlying mechanism of residents' and non-residents' visual impressions.

Concerning the literature review on the visual impression of urban waterways, an urban water network such as a river, moat and canal within an urban context can be studied as a public space, defined as an open area including an unobstructed view of the sky, the cityscape, and the waterscape. In urban landscape perception literature, the presence of water has been identified as significant in human preference [14], particularly in collective memories associated with urban settings [15], with various studies indicating the cognitive and emotional benefits of interacting with water [16]. Firstly, rivers and canals are city landmarks, contributing to the image of its identity and playing a crucial role in the perception of its uniqueness. Secondly, collective memories, social traditions, architecture, and historical monuments can also influence the appeal and aesthetics of urban canals. The waterscape evokes events and social histories that connect the past and present, contributing to a sense of community identity [17]. Thirdly, human activities fostering relationships with waterways increase the potential for diversity, enhancing the experience at points of contact with water, which can be bustling with activities or peaceful with natural scenery, depending on individual preferences. Whether crossing water on a bridge, moving along the water by soft transportation modes, or navigating the stream, access to the water body promotes closer contact with nature, enhancing waterfront attractiveness.

Concerning the visual perception of an urban waterscape, a branch of research on spatial cognition involves the investigation of intricate stimuli from physical elements in the urban waterscape scene to depict the relationship between their spatial arrangement and personal factors. The empirical approach to addressing environmental studies of urban open spaces considers a robust relationship between the

built environment and the aesthetic dimension of urban space. A theory such as Lynch considers essential characteristics of urban forms, including paths, edges, nodes, districts, and landmarks, that contribute to defining the quality of the city image [18]. Meanwhile, Cullen looks for the definition of townscape [19], which involves the arrangement of urban settings adorning the environment to identify the physical form of a city based on the emotional levels of each observer, with the place interpreted by the observer's experiences in a specific location delimited within existing boundaries. In this interpretation, the concept of content encompasses the physical appearance of elements in terms of colour, texture, character, style, scale, and uniqueness. Urban designers like Russell evaluate the cityscape based on identity, structure, and meaning, representing psychological constructs related to subjective assessments of feelings about the environment [20]. Nasar investigates how people interpret an environment in terms of psychological and affective appraisal [21].

Inspired by the above literature, this study examines urban waterways in Matsue to understand the visual impression of the waterscape through images. The research begins with a review of Matsue's landscape preservation policies through a regional development study, focusing on the innovative approach to shrinking cities. Subsequently, fieldwork involving photography is conducted to identify the characteristics of urban waterways. Their impact on the visual experience of residents and travellers, such as preferences and opinions, is gathered through questionnaires. Finally, a comparison is made between actual photos and virtual representations, providing insights into the evaluations of digital imaging of the city and water network. The findings contribute to a better understanding of the visual impressions of Matsue's urban waterways, with implications for refining its virtual model.

3. Methodology

Concerning data collection, the study was conducted in four steps. Firstly, focusing on the Matsue castle and its moat connecting with urban canals and rivers, we mapped buildings and physical elements along urban waterways accessible by street. Through mapping, we collect 146 photos of scenery from the urban waterways. Secondly, we utilized the image segmentation method to extract spatial composition (such as sky, townscape, waterscape, and vegetation) from the collected photos to explore the visual characteristics of the waterways. From the analysis, we narrowed down to 108 photos - 36 sets - representing three patterns of waterscape based on the ratio of dominant elements (pattern 1 with only one dominant, pattern 2 with two dominants and pattern 3 with equal distribution among elements). Thirdly, targeting respondents familiar with these sceneries of Matsue, we conducted a questionnaire with 32 people, both residents and non-residents of Matsue, to depict their visual preferences. The questionnaire was done online in March 2023 for Japanese and English speakers. Finally, by building a virtual model of Matsue City around the castle moat, we prepared a set of computer-generated images and conducted an online interview in December 2023. In the interview, we asked 7 participants to compare actual photos with the rendered photos obtained from the virtual model. Figure 2 summarizes the photo collection method and experiment details through different steps.

Concerning the database for photo collection, this research conducts a mixed method of data collection from two models of urban waterways. The first model was built from fieldwork photography and mapping as a base for questionnaires conducted with respondents who can be residents or travellers familiar with the Matsue water scenery. This mixed method was proven effective in visual impressions investigation of urban space [22]. The second model was built from the mapping data of fieldwork as a virtual model of Matsue urban waterways around the castle. This virtual model belongs to the initiative to digitalize the city's points of attraction for tourism promotion. From the model, we generated rendering based on the location and representation of the actual photo collected from fieldwork to use as a base for the visual appraisal interview. This method was initiated in research to collect mass ratings of the visual attractiveness of urban waterways [23].

Concerning the structure of questionnaires, a set of reasons has been proposed containing four choices of reasons and a free optional description. These choices are inspired by the model of aesthetic response to the built environment defined by Nasar [24]. The first choice concerns the waterscape and urban surroundings, encompassing spatial quality, accessibility, and infrastructures. The second relates to the attachment or psychological connections to a specific environment or historical memories. A third dimension is associated with people's relationship with the space, including aspects like relaxation,

peace, and its effect on positive moods and feelings. And the last reasons concern the photo aesthetics, such as layout composition, colours, etc.

Finally, concerning the interview, the selected participants are from the previous questionnaire, with criteria having an architecture background, either being students, graduates, or practitioners. This selection is based on the cultural evaluation of visual cognition in the photographs [25], which showed a similarity in the respondents of the architecture field compared to the general one. The interview also employs the vocabulary of visual attractiveness and technical terms in virtual simulation and modelling. For the interview procedure, the participants first hear the explanation about the virtual environment of Matsue City, visualize it and experience a walk-in inside the model. After that, the respondents were given three sets of two photos, containing one captured on-site and a rendered one. Participants are requested to describe their impression by comparing the two photos, identify elements of similarities and differences and explain the reason. Their speech is recorded for further transcript.

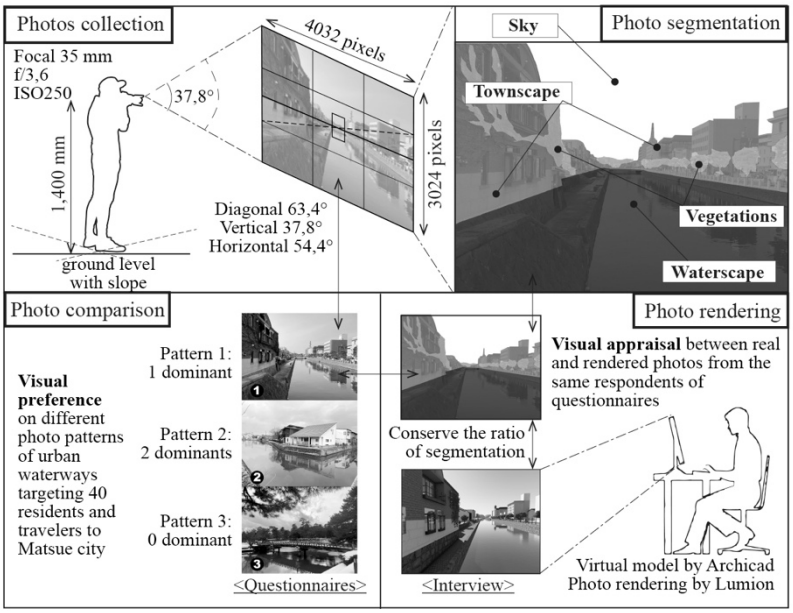

Figure 2. Settings for photo collection and experiment.

4. Results and discussions

4.1. Matsue City Landscape Conservation Law and Revitalization Basic Plan.

During and after the period of rapid economic growth in Japan, an increased interest in environmental and landscape conservation led by citizens started in Japan. In various regions, citizen movements advocating for bottom-up policies based on consensus building among residents have emerged. There is a growing recognition of the importance of everyday landscapes, defined as "living townscapes" [26]. In the case of Matsue, the city started preserving its unique landscape in the late 1960s, emphasizing its distinction as an undamaged city with remnants of a rare castle town in Japan. With Japan's fifth largest lake, Lake Naka-Umi, and the seventh largest lake, Lake Shinji, to the east and west sides of the city, as well as the Sea of Japan to the north, Matsue is bordered by three bodies of water. Nowadays, with the moats around the castle remaining unchanged, Matsue is a national historical, cultural and tourist destination of Japanese domestic travel. Concerned about the threat of modernization to these historic sites, the Matsue City Traditional Beauty Preservation Ordinance was enacted in 1973. Additional laws, such as the Matsue City Urban Landscape Ordinance in 1994, were enacted to maintain and conserve the unique landscape around the urban canal. In 2005, Matsue City became a landscape administration organization in compliance with the Landscape Law. The 2007 Matsue City Landscape Plan provided comprehensive guidelines, including priority areas with specific landscape standards, and the 2019

Matsue City Central Urban Revitalization Basic Plan was enacted to define areas to promote development, taking into consideration the rich natural landscape and waterfront (Figure 3).

Figure 3. Area of Matsue City Landscape Conservation Law and Revitalization Basic Plan.

4.2. Visual distribution

On-water touring is one of the quintessential views of an Edo period of a former feudal stronghold, a charming castle town belonging to twelve remaining original castles in Japan. A modest urban canal passes through the city, connects the castle moat with the residential area, and heads toward the Ohashi River through the pedestrian zone near Kyobashi River, delimiting the tourist area and forming a landscape pattern dictated by water networks. In the Edo period, Matsue was famous for its beautiful and picturesque scenery, and the world-famous photographer Shoji Ueda took inspiration from his collection of life scenes over the waterscape [27]. Considering the area of the urban canal and buildings designated in the landscape conservation law, we select all the locations accessible by pedestrians to conduct a photographic survey. According to Matsue city landscape conservation law, aside from the area connected to Lake Shinji, nine areas were defined as priorities for landscape design and conservation criteria during revitalization development [28]. Also, the surveyed zones are packed with landmark buildings such as historical and administration buildings, schools and conference halls, and natural conservation areas such as parks, green spaces, etc. (Figure 4).

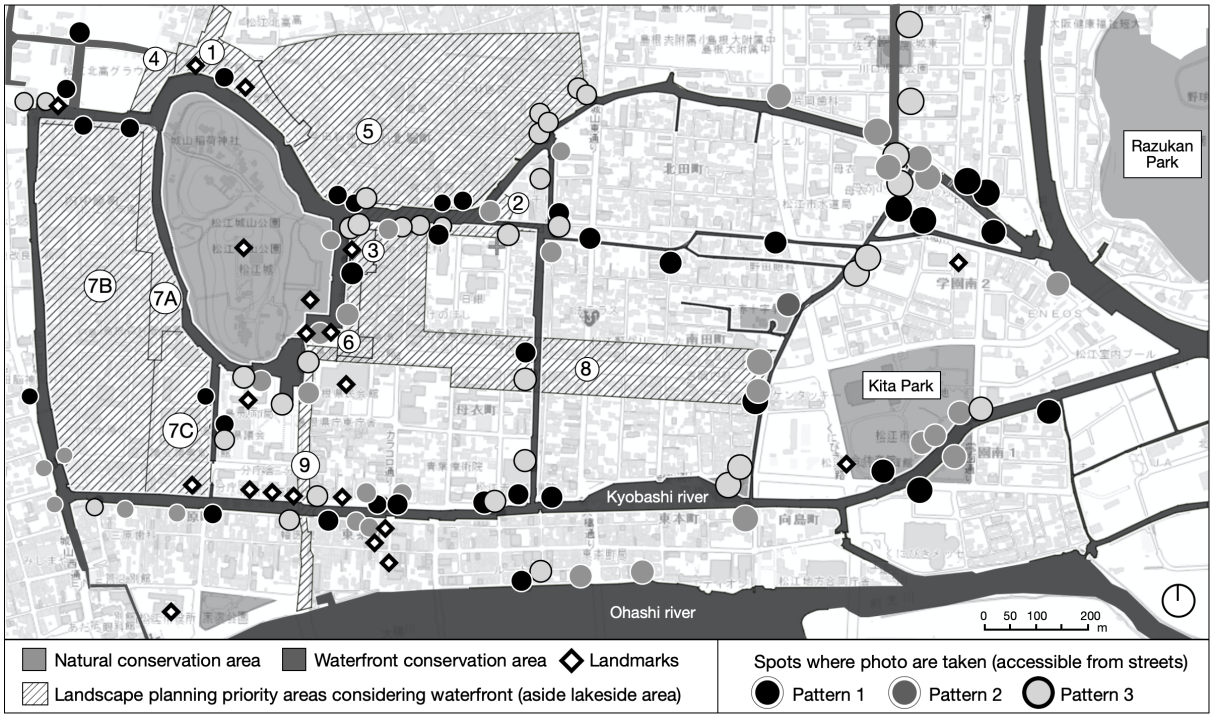

Figure 4. Locations of photos collection accessible from the streets.

At first glance, it can be seen variable distribution of visual patterns around the canal networks with all patterns. A concentration of patterns is found near the group of landmarks with the highest concentration of Pattern 1, with only 1 dominant element, especially close to the priority areas or natural conservation areas. This phenomenon is explained by the prevailing dominance of the landmark building within the visual field, so the visual perception is influenced by its presence. The phenomenon was mentioned in previous research on urban visual attractiveness, and the findings were used for tourism waterfront landscape promotion, especially for the area close to the castle town or the pedestrian area of Kyobashi River. On the other hand, Pattern 2, which has two dominant elements, seems more dispersed on the site with no distinct concentration except for the area near Kita Park. This part of the canals is part of a residential area along the backstreets where pupils and students from nearby schools and university campuses often commute. Pattern 3, with no dominant element, is found in groups, especially near the junction of the urban canal. This result could be understood by the open view of bridges over the water, offering a view over the city, which has a sense of harmony within the photo frame. Aside from the designated priority area where there is a high concentration of amenities for tourism, these patterns are also present in more scarce groups, a bit far away from the tourist zone, which represents a non-homogenous continuity of visual attractiveness along the urban canal, which is the daily visual perception of Matsue residents.

4.3. Visual preference on Matsue urban water networks.

Regarding the 32 participants for the questionnaires, 18 are foreigners living in Matsue or have travelled to Matsue, and 14 are Japanese residents of Matsue. From these participants, gender is 42% male versus 58% female, with the age range distributed nearly equal between those under 30 and between 30-60 years old. Their exposure to the water environment is equally distributed, as shown more than 50% of them report seeing a water scenery daily while the rest see it a few times a week or at least once a week. Concerning interest in the topic of water environment, around 65% were interested in more than one topic, with the highest interests among them being “scenery of daily life around waterways” and “life close to nature”, with 60% choices. Concerning the preference for visual attractiveness, the three patterns show a close distribution with Pattern 1 (one dominant) at 30% of choices, Pattern 2 (two dominants) at 32% of choices and Pattern 3 (no dominant) at 38% of choices. However, concerning the number of clicks performed during the selection of preferred photos, participants seem to prefer multiple choices rather than only one.

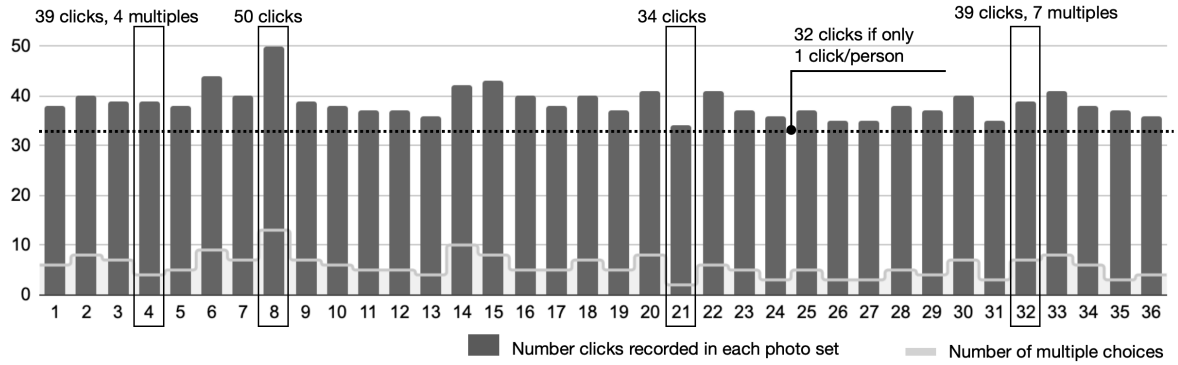

Figure 5. Multiple choices on visual preferences of urban waterways.

As shown in Figure 5, all the sets have at least more than one person with multiple choices, with the highest click at 50 (set No. 8) and the lowest at 34 (set No.21). The quantity of multiple choices also differs with people choosing two photos or three photos as preferences. Furthermore, by analysing the reasons for their choices in all photo set, the highest quantity associated with “good feeling” (36% among all choices), the next two are “having an appealing element” or “the photo itself looks nice” with 27% and 25% respectively, the choices associate with “remind me of something similar” stand at the lowest with 12%. This distribution is clearly shown in the set with the highest and lowest ratings (Figure 6). Also, this distribution is the same between Japanese and English speakers.

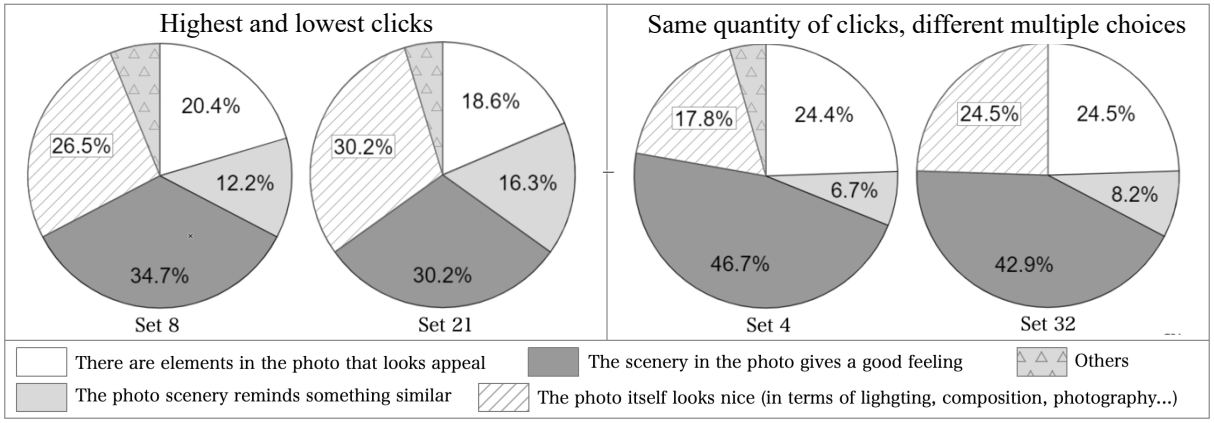

Figure 6. Distribution of reason for photo selection in relevant sample set.

4.4. Visual evaluation of virtual model of Matsue urban waterways.

For the interview, the respondents consist of three undergraduate students, two graduates with working experience and two practitioners who worked for more than ten years. This selection is based on the differences in terms of experience and familiarity with the virtual environment despite belonging to the same field of architecture. Their comments on the comparison between the real scene and the rendered scene are summarized in Table 1. As general remarks, the pattern with only one dominant poses a challenge in rendering for practitioner and their evaluation compared to the photo. For students and graduates, the rendered photos in Patterns 1 and 2 are judged better in color and cleanness. The rendering of Pattern 3 (non-dominant element) is considered closer to the scene in the photo, even though this photo pattern was not chosen as the most preferred pattern during the questionnaire.

Table 1. Verbal description during comparison process.

Set of patterns	Interviewee	Remarks and discussions
Pattern 1 (1 dominant) 	Students	Preference for the rendered one is more colourful and livelier, with more activities in the virtual image.
	Graduated	They see both photos are similar as they depict the space with waterscape, vegetation, and the surrounding buildings. Some details and colours are mismatched, but it doesn't affect the ability to reflect reality.
	Practitioners	They prefer the photos as the rendered ones lack quality in detail, colours, light, etc. These remarks come from the high portion of one dominant in the photo, which is easy to recognise during the comparison process. Also, there are several critics regarding the technical issues of rendered images that do not reflect the feeling of the old town.
Pattern 2 (2 dominants) 	Students	The difference in terms of lighting between the photo and the rendered picture affects how the viewer imagines the space. While one finds it lacking the vibe of the activities on waterways, another says it's ok if they can see the object reflecting the activities (boats, water, boat station, etc.)
	Graduated	Clear preference for the rendered photo as it depicts well the boat station and could add to the imagination of the old town.
	Practitioners	Despite a gap in details compared to the photo, the rendered picture depicts well the water scenery. Having several elements that compose the scene makes the visual focus less criticised the overall quality of the render.

Pattern 3 (no dominant) 	Students	They find both photos have the same elements and atmosphere and present a clear imagination of space.
	Graduated	They find the photo and render are similar in terms of the experience of walking around the city. There is a preference for the rendered picture as it looks cleaner.
	Practitioners	Find both photos depict the scenery in the same atmosphere while the contrast colour in render works better to give the feeling of the space. This pattern 3, with no dominant element, simplifies the focus on details, making the difference between the two photos less obvious. In terms of waterscape, the reflection is not well delivered.

5. Conclusion

In summary, this study explores the correlation between urban waterways, visual appeal, and residents' perceptions in Matsue City, a historical and cultural city struggling with population decline and urban revitalization. The study highlights the significance of Matsue's visual identity, emphasizing water-related elements and the historical castle, as reflected in the city's high rankings in cultural interaction, liveability, and environment. Some results shed light on the city's efforts to address shrinking populations and an ageing demographic through tourism planning around waterways, although not fully meeting residents' expectations. In terms of visual distribution, there is a well-distributed visual appeal around the touristic zone and landmark, extending to the residential area, albeit not homogeneously. This result indicates Matsue's commitment to landscape conservation laws but reveals gaps in planning for other zones. The visual preference survey shows the high attractiveness of Matsue's urban waterways among residents and travellers, with diverse reasons for photo selection. Insights into the multifaceted aspects influencing visual preferences are observed across Japanese and foreign perspectives. Finally, incorporating both actual photos and renderings allows for a comprehensive evaluation of the virtual representation of Matsue's urban waterways. Participants express preferences based on factors such as lively scenery depicting activities and concerns regarding the preservation of the atmosphere of the old town. Notably, photo segmentation with no dominance is perceived as less contentious in the virtual model, a notable finding for the digitalization of the Matsue virtual model.

However, it is crucial to acknowledge certain limitations in the study, such as the small sample size and the focus on the touristic zone, potentially limiting the generalizability of findings. The technological quality of the virtual model may influence participant perceptions, suggesting a need for further exploration in future research, such as using eye-tracking and VR goggles. Future studies may consider incorporating deep learning to accommodate a larger sample size and capture diverse opinions to enhance data collection and analysis methods. In a broader context, this research contributes to understanding visual aesthetics in shrinking cities, providing insights for policymakers, urban planners, and residents. Recognizing diverse preferences for urban canals allows Matsue City to tailor the different approaches to the revitalization strategies aligning with community values and fostering a sustainable urban future.

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