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Preferences for a lake landscape: Effects of building height and lake width

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ABSTRACT

Cities with lakes must balance the relationship between development and preservation of the natural landscape. Tall buildings are important in urban development, while landscape destruction and visual pollution caused by tall buildings have attracted more attention. Many qualitative or quantitative restrictions for building height have been designated along lakefronts. However, it is unclear whether the public accepts these restricted heights. This study aimed to assess the effects of building height and lake width on public preferences for lake landscapes. Two experiments were designed with two common lake scenarios. Three levels of building height crossed with three levels of lake width were presented in nine synthetic lake landscapes in each experiment, which were assessed by 50 participants using a psychological evaluation tool, namely the Affect Grid. The results showed that when lake width was within the Close View range with only trees on the other side of the lake, a lake landscape with the heights of buildings' visible part moderately less than average height of the trees contour was preferred over rigidly restricting that all buildings be barely visible. For lake landscapes with mountains in the background, it was found that a lake-wide threshold existed between 0.6 km and 1.8 km. Using this threshold, the Medium View range could be reclassified so that a lake width within this range might correspond to a particular type of building height restriction. These findings provide a reference for urban planners and suggest that lakes can be categorized on the basis of lake width and, in this category, building height can be restricted more appropriately.

1. Introduction

From a cultural perspective, lakes and lake landscapes are vital for urban civilization and human living environments. They exemplify excellent aesthetic value derived from beautiful sceneries and historic sites, and as such, can serve as resources for tourism and environmental education (ILEC, 2007). In recent decades, increasing human activities have resulted in severe damage to lake landscapes, as well as to visual amenity perceived by the public. One cause of such damage is the excessive heights and monotonousness of tall buildings.

The erection of high-rise buildings appears inevitable for urban development (Tavernor, 2007). However, the visual impact of tall buildings could perhaps be weakened by adjusting the building heights to integrate with the surroundings in harmonized ways. In this light, one of the research questions is how high would the general public consider too high for tall buildings to fit in with a lake's surroundings. In addition, as an important indicator of a lake, distance (i.e. lake width) is also taken into account, and that brings up another research question: due to the effect of distance, whether stricter building height control should be enforced for lakes, which have smaller widths, in order to obtain a greater visual preference.

1.1. Visual impact assessment

According to Tang and Wang (2007), and the The Landscape Institute (2013), visual impact is due to development caused by human activities. One of the main manifestations of human activities in the landscape may be the emergence and increasing number of man-made elements in urban and rural landscapes. Preference of natural and man-made elements has thus become a major concern in visual impact assessment in recent decades. The emphasis of these studies was to simply compare the beauty and ugliness of natural and man-made landscapes in their beginning states (e.g., Hull and Reveli, 1989; Ulrich, 1981; Wong and Domroes, 2005), and then to decompose landscapes into various elements in order to assess the impact of individual or specific elements on preferences (e.g., Arriaza et al., 2004; Bulut and Yilmaz, 2008; Filova et al., 2014; Misgav, 2000; Yao et al., 2012).

During the process, several elements stood out. Natural elements

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such as vegetation and water were more preferred (Gobster et al., 2007; Kaplan et al., 2006; Ulrich, 1981), and positive man-made elements that harmonized with nature increased the visual appeal of the landscape (Bulut and Yilmaz, 2009; Bulut and Yilmaz, 2008; Yao et al., 2012). The increase of man-made elements is inevitable from a social and economic point of view (De Vries et al., 2012). Therefore, scholars gradually turned their attention to improving the integration of man-made landscapes into the surrounding environment. Several studies have examined the visual impact of renewable energy facilities (centred on wind turbines) on surrounding residents' preferences (Bishop and Miller, 2007; Kokologos et al., 2014; Rodrigues et al., 2010; Tsoutsos et al., 2009). Other studies have attempted to select reasonable locations for new man-made structures in order to minimize the negative impact on the rural environment (Hernández et al., 2004; Rogge et al., 2008). This study also attempted to analyze the possible visual impact of tall buildings on lakesides from the perspective of aesthetic integration.

1.2. Visual impact of tall buildings

As a representative of man-made elements, tall buildings offer a "way out" for the development of modern cities, in which population growth and future needs force the more efficient exploitation of limited land (Reddy, 1996; Frenkel, 2007; Tavernor, 2007). It is believed that tall buildings will play a crucial role in the spatial and visual sustainability of urban areas (Tavernor, 2007). However, the environmental impact of tall buildings has received equally high criticism. Tall buildings often become the subject of public complaints as a result of visual intrusion of historical sites, reflection of sunlight by huge glass curtain walls, shadowing of shaded streets, increasing the urban heat island effect, etc. (Lim and Heath, 1994; Short, 2007; Tavernor and Gassner, 2010). Among these, visual quality which is the most important feature that directly affects public preferences (Bulut and Yilmaz, 2009) of tall buildings attracts a great deal of attention from researchers. The fundamental issues are determining where tall buildings should be located and how they should be designed or restricted.

Until now, a number of studies have tried to analyze and quantify the visual properties of tall buildings. These studies can be classified into two categories: one is related to the physical features of tall buildings themselves, while the other addresses the buildings' relationship with the surrounding environment.

Given the diversity of physical features of tall buildings, different researchers have investigated based on different features. Several studies focus on the visual complexity of tall buildings resulting from silhouette complexity and facade articulation (Heath et al., 2000), while others focus on the impact from setting building attributes, such as height, width, depth, and setback (Stamps et al., 2005). Samavatekbatan et al. (2016) assessed the effectiveness of height, top, and color on the visual preference of tall buildings and determined that height contributed most to visual appearance.

When discussing the relationship between tall buildings and their surroundings, tall buildings tend to be viewed as a group in the skyline. These studies are mainly concerned with the balance between the skyline forms and public preferences. Some studies test the effects of various attributes of tall buildings, such as slenderness ratio and spacing, on preferences (Lim and Heath, 1994). Other studies observe the changes of preferences by regulating the height of buildings and the permutations and combinations of buildings, such as adjusting the continuity of natural landscapes and the number of visual corridors (Zacharias, 1999), or adjusting the fractal dimension of tall buildings to fit with the fractal dimension of a mountainous backdrop (Stamps, 2002).

Based on a review of the empirical literature described above, building height is found to be a highly important factor among the numerous visual properties of tall buildings. Hence, building height was chosen as one of the variables in this study.

1.3. Impact of tall buildings on lake landscapes

Following Arriaza et al. (2004), Krause (2001), and the The Landscape Institute (2013), the term "landscape" derives from the natural environment and the human sociocultural environment, as well as the interaction of both, which can be perceived by people in daily life. Therefore, "lake landscape" refers to landscapes with views of lakes, including the lakes, the adjacent natural or built environment, and the relationships between them. In this study, "lake landscape" is narrowly defined as those lake landscapes across the lake that can be viewed from one side of the lake. Also, the term "lake" used here refers to urban lakes that are located within or adjoined to the city area.

Urban lakes are more directly subjected to interactions of anthropogenic activities and natural processes than other lakes that are surrounded by mountain forests or farmland. The interactive impact of humans and nature increases the fragility of urban lakes, however, boosts their value. Apart from having the same functions as other lakes, urban lakes also provide public open spaces for citizens. Urban lakes and lakefronts often materialize the unique character of a city. However, in the literature, numerous studies focus on the ecological issues of urban lakes (e.g., Dudgeon et al., 2006; Qin et al., 2007), while to the best of our knowledge, landscape destruction and visual pollution caused by tall buildings have attracted little attention. According to the small amount of current research, the negative impact of tall buildings was found second only to off-shore drilling platforms and wind farms when investigating public preferences of large waterfronts (De Vries et al., 2008). Therefore, to address the destruction of lake landscapes by tall buildings, a relevant and specific study is needed.

Nevertheless, building height control surrounding a lake is beset with difficulties. The lake landscape is irregular and freeform, which makes building height restriction more difficult as compared to other historic sites, such as ancient buildings, traditional streets, and traditional settlements. Therefore, although urban design guidelines or plans have been enforced in many cities, the majority uses vague language to control tall buildings surrounding lakes. According to a study by Lin et al. (2016), qualitative and subjective descriptions are widely used for lake landscape preservation in Japan, such as "compatible with neighboring environment," "does not give a sense of pressure," or "does not appear directly in the range of vision." Such ambiguous descriptions on aesthetic controls are likely to cause extensive controversy and reduce the effectiveness of regulation in practice (Stamps, 1997). Currently, the degree of elevation angle or the ratio of the horizontal distance from a viewpoint to a visual object to the height of the visual object is usually used to evaluate human psychological or aesthetic feelings (Ashihara, 1981; Ladd, 1987; Shinohara, 2003). This theory is effective when planning the scale of a square, the height of buildings on either side of a street, or when designing the best viewing distance to enjoy the sight of an individual building, statue, etc. However, this method seems ineffective to control the height of buildings surrounding a lake because of the scale of a lake, which usually does not completely fall within the field of view, and the visual object, which is dominated by the irregular natural landscape, such as large areas of lake water, trees, and mountains. It is thus imperative to explore and customize an effective way to control the height of buildings surrounding lakes.

1.4. Distance and visual perception

Distance has a significant impact on visual scale (size) (Bell, 2004; García et al., 2006). Depending on the distance of the observer, the number and size of landscapes that can be seen will change on both the horizontal and vertical dimensions (Bell, 2004), and as a result, people's appreciation and perception of the landscape will change too. Some studies have taken distance into account as an important factor on public perceptions. García et al. (2006) demonstrated the relationship between observation distance and textures (created by the building material), as well as highlighted a decisive influence of distance on the