THE ROLE OF WATER-BASED IMAGEABILITY IN CLIMATE ADAPTATION: PROMOTING UPSTREAM WATER RETENTION THROUGH WATER-BASED PLACE IDENTITY

RISING, HOPE HUI
Landscape Architecture Program, School of Design and Construction, Washington State University, PO Box 642220, Pullman, WA 99164-2220, hope.rising@wsu.edu

1 ABSTRACT

Many downstream areas have used urban design to implement controlled flooding for climate adaptation. It is more cost-effective, however, to mitigate downstream flooding through upstream water retention. To investigate the potential of water-based place attachment in encouraging upstream water retention, water-based place attachment was operationalized into water-based place identity and dependence. Cognitive mapping and photovoice recall questions were used to interview 60 participants sampled from eight water cities. These questions measured waterscape mappability and identifiability as contributors to water-based place identity. Water-based place dependence was derived from interview questions concerning waterscapes' capacities to help reduce stress and to facilitate spatial orientation. Water-based place attachment was measured by the extent to which participants would miss waterscapes if they were to leave the city. Mediation analyses showed that the significant relationship between watershed location and water-based place attachment became insignificant due to the mediating effects of aquaphilic urbanism. Aquaphilic urbanism was proposed as a higher-order construct of waterscapes' mappability, identifiability, stress-reducing effect, and potential to facilitate spatial orientation. When water-based place attachment was derived from water-based place identity, it significantly increased people's openness toward water-coherent urbanism. Openness toward water-coherent urbanism was measured by interview questions concerning public support for storing public stormwater runoff, infiltrating public stormwater runoff, water transportation, and waterways. The findings suggest that, while upstream areas are likely to have lower water densities, making waterscapes mappable and identifiable helps generate public support for upstream water retention, which in turn makes flood mitigation downstream more cost-effective.

1.1 Keywords

Climate adaptation, place attachment, imageability, water retention, waterscape, mappability, identifiability

2 INTRODUCTION

Cultural geographer Yi Fu Tuan (1974, p. 93) popularized topophilia as a term describing our “affective ties with the material environment.” Ogunseitan (2005) revealed that topophilia was significantly attributed to the restorative effects of water features, flowers, and spatial familiarity. Although non-water natural features—hills, mountains, rocks, trees, and forests—were included in the experiment, they did not have a significant effect on topophilia. This micro-study suggests that love of nature, which Wilson (1984) refers to as biophilia, may be largely attributed to aquaphilia, which I define as people’s love of water. Design may help evoke topophilia if water is integrated in a way that increases an environment’s spatial familiarity and restorative effect.

While no empirical study investigated how design affects water’s influence on place attachment, a macro-study discovered that a higher density of water amenity was significantly associated with a higher population growth in the presence of other favorable amenity-related and socioeconomic variables as controls (Deller, Tsai, Marcouiller, & English, 2001). The findings suggest that water-based place attachment may be stronger in downstream cities because their watershed locations tend to be related to higher water densities.

Although it is more cost-effective to mitigate downstream flooding by capturing runoff in upstream areas (Hartmann, 2010), most long-detention facilities have been proposed for downstream locations due to a more urgent need to provide emergency flood management in downstream areas. These projects increase the amount of water surface in downstream areas with high water densities already, contributing to population growth in the areas most susceptible to the impacts of climate change.

Place attachment mediates societal responses to climate adaptation and encourages pro-environmental behaviors (Vaske, & Kobrin, 2001). It is speculated that biophilia, or our instinctual affinity for nature, is a likely mechanism underlying greening behaviors (Kaplan, 1995; Kellert, 1995). Stedman and Ingalls (2013, p. 137) discovered that the intersection of biophilia and topophilia instigated “collective attempts to restore nature in places that serve as loci of attachment.” Water-based place attachment, i.e., the contribution of aquaphilia to topophilia, may help encourage water retention or “blue-greening” behaviors in upstream cities as loci of attachment.

This study substantiated water-based place attachment as a potential mechanism through which aquaphilic urbanism helps mainstream water-coherent urbanism in upstream cities to make them more attractive migration destinations. Water-coherent urbanism here refers to an urban design approach that promotes water retention. Aquaphilic urbanism alludes to a water-centric, place-making approach that evokes aquaphilia. This study qualified aquaphilic urbanism as a water-based sense of place that contributes to environmental identifiability and mappability, as well as stress reduction and spatial orientation.

3 BACKGROUND

3.1 Cognitive outcome from the aesthetic aspect of aquaphilic urbanism

Kaplan (1984) described sense of place as the extent the aesthetic aspect of a place influences its legibility as a cognitive map and make environmental features identifiable. He further defines a topophilic sense of place as what makes it easy to attach oneself to a novel place because the place seems familiar. Using identifiability as one of the measures for spatial familiarity, Ogunseitan’s (2005) micro-level study substantiated the influences of aesthetics on spatial familiarity as a significant contributor to topophilia. At the city-level, Lynch (1960) speculated that the aesthetic coherence of the urban environment tends to enhance people’s emotional bonding with a city by making it easy for people to form a coherent cognitive image of it. Lynch (1960) also postulated that water-centric cities, such as Venice and the Dutch polder cities, are imageable environments, and that polder cities tend to have a unifying structure connecting identifiable parts.

In an imageability study conducted with visitors and residents in three Dutch water cities, De Jonge (1962) observed greater detail in sketch maps drawn at closer proximity to bodies of water. Water-based elements may serve as higher-order spatial anchors that help organize spatial information (Golledge, 1992; Milgram & Jodelet, 1976). Spatial anchors are among the first features recalled from participants’ cognitive maps (Osmond, 1963). These spatial anchors help form a coherent image of the environment to facilitate wayfinding. Golledge (1992) stated that spatial anchors contribute to spatial familiarity, which he defines as the ability to identify and locate features, in addition to relating them to other features, in a cognitive map. This study adopted water-based mappability and identifiability as variables for measuring the cognitive outcome from the aesthetic aspect of aquaphilic urbanism. Mappability and identifiability seem to correspond to two components of imageability proposed by Lynch (1960): structure and identity. Structure is similar to the mappability-based legibility, and identity is akin to the identifiability of environmental features, as described in Kaplan's (1984) functional view of aesthetics.

3.2 Behavioral outcome from the functional aspect of aquaphilic urbanism

From the perspective of spatial behavior, Kaplan (1984) associates topophilic sense of place as the degree to which a place's physical configuration facilitates spatial orientation and provides psychological comfort. With stress reduction as a measure for restorative experience, psychological comfort contributes to topophilia (Ogunseitan, 2005). Using the environment to adjust the physiological self is a form of environmental self-regulation (Korpela, Hartig, Kaiser, & Fuhrer, 2001) that leads to topophilia (Korpela, 1989). Potentially, stress reduction may improve spatial performance, including orientation and navigation, because stress impairs spatial working memory and learning (Diamond, Fleshner, Ingersoll, & Rose, 1996). The behavioral outcome from the functional aspect of aquaphilic urbanism was thus measured by the degree to which water facilitates spatial orientation and stress reduction to aid spatial behavior.

3.3 Tripartite theory of place attachment

The tripartite theory of place attachment suggests that place attachment can be operationalized into place identity and place dependence (Scannell & Gifford, 2010). Jorgensen and Stedman (2001, 2006) validated the tripartite model by conceiving of place identity, place dependence, and place attachment as the cognitive, behavioral, and emotional dimensions of people's attitudes towards place (Figure 1).

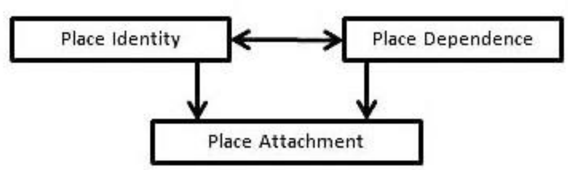

Figure 1. The tripartite model of attachment.

3.4 Tripartite theory of water-based place attachment

Water-based place dimensions were generated from the tripartite model of place attachment to investigate the effects of designing water into the public realm based on place-based attitudes. Using a wayfinding perspective, this research conceptualized water-based place identity, place dependence, and place attachment as people's cognitive, behavioral, and emotional attitudes toward aquaphilic urbanism due to their interactions with environmental features. As shown in Figure 2, this study characterized aquaphilic urbanism with water-based place identity and dependence as the cognitive and behavioral outcomes from its aesthetic and functional aspects. This study proposed to measure water-based place identity and dependence with the contributions of waterscapes to people's spatial cognition (through water-based mappability and identifiability) and spatial behavior (through water-based stress reduction and spatial orientation). Water-based place attachment was modeled as the emotional outcome from both the aesthetic and functional aspects of aquaphilic urbanism and the cause of people's openness toward water-coherent urbanism.

3.5 Aquaphilic urbanism as a higher-order construct

Two-way interactions have been found between place identity and place dependence as interrelated constructs (Jorgensen & Stedman, 2001, 2006). Figure 2 shows that aquaphilic urbanism is likely a higher-order construct of water-based place identity and dependence, with water-based place attachment as its outcome. However, Nicholls and Cazenave (2010) pointed out that the interaction is one-way, with place dependence influencing place identity. On the other hand, spatial cognition researchers found that the identifiability and imageability of a place lead to familiarity, influencing spatial behavior (Brunyé et al., 2009). The findings of this study suggest that the one-way influence originates from place identity toward place dependence instead. The direction of the interactions among these place-based dimensions will not be investigated within the scope of this paper. This paper is primarily concerned with how to design with water to evoke aquaphilia and how to mainstream water-coherent urbanism with aquaphilic urbanism.

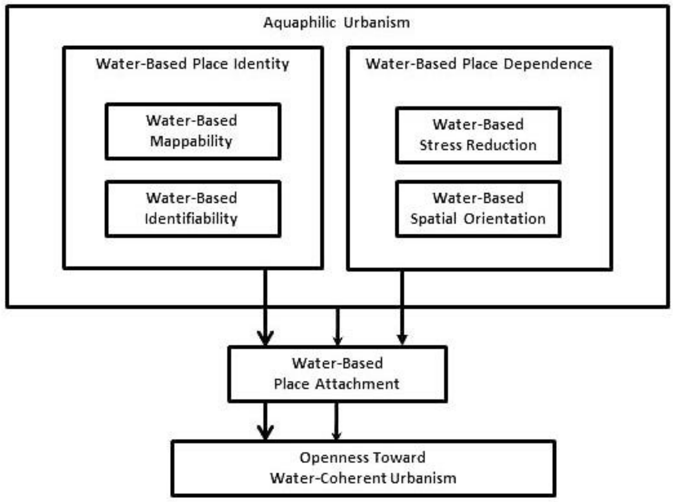

Figure 2. Interrelationships of constructs and variables.

4 STUDY OBJECTIVES AND HYPOTHESES

4.1 Water-based place attachment as a potential catalyst

One objective of this study was to identify possible catalysts for encouraging water retention in upstream cities. This research tested the extent to which water-based place attachment influences the relationships between the functional and aesthetic aspects of aquaphilic urbanism and people's openness toward water-coherent urbanism as a pro-environmental behavior.

4.2 Aquaphilic urbanism as a potential intervening factor

The other objective of this study is to identify the mechanism though which aquaphilic urbanism helps intervene in the positive feedback loop between watershed location (a low- or high-water city) and water-based place attachment. The first step was to test the significance of the relationship between watershed location and water-based place attachment. This test helped confirm whether the model had sufficient ecological validity to represent the self-perpetual migration trend towards downstream cities or cities with higher water densities. The second step was to test whether aquaphilic urbanism nullifies this significant relationship that captures the migration trend as a ground reality.

Mediation analysis is an appropriate method for testing these working hypotheses because it requires a significant linear relationship between an independent and a dependent variable. Additionally, the method is used for testing whether this significant relationship becomes insignificant with the addition of a mediator that can fully explain it (MacKinnon, Fairchild, & Fritz, 2007).

5 METHODS

5.1 Measuring water-based mappability with cognitive mapping recall protocol

Cognitive mapping was employed to measure water-based mappability because it had been used to investigate the extent that water spatially anchors people's cognitive maps (Rasmussen, 1931; Southworth, Cranz, Lindsay, & Morhayim, 2012). Certain socioeconomic and age groups had difficulty drawing accurate sketch maps of a large-scale environment, although they were able to navigate the environment (Clayton & Woodyard, 1981; Hart, 1981). Instead of acquiring sketch maps, a survey-administered, cognitive mapping protocol was used as a prompt to obtain the recall sequence of water-based features. These recall sequences determined the extent that these waterscapes were spatial anchors contributing to water-based mappability. The recall sequence was used to create a weighted measure to account for the gradient of spatial saliency it reflected.

5.2 Measuring water-based identifiability with photovoice recall protocol

To capture an eye-level perspective of spatial memory and supplement sketch maps and verbal interviews, Lynch used photograph recognition. The photographs were preselected by investigators and may not have been as ecologically or cognitively valid as those obtained from photovoice. Photovoice is an effective place-research method engaging participants to express their impressions of an environment by taking photographic images (Ruggeri, 2014; Wang & Burris, 1997). To increase the ecological validity of this study, photovoice was used to investigate water-based place identifiability. A photovoice recall protocol was employed because it was not possible for the interviewer to travel with all participants to take five pictures around the city. Furthermore, in the absence of an interviewer, participants might be inclined to take photographs of salient features they have easy access to. Only a few would travel to specific locations to capture the most memorable pictures of an entire city. During the photovoice recall protocol, participants were guided to recall five pictures and articulate the content of each recalled photograph. Then, they were asked to locate the observer's position and viewing angle on a city map. Like the cognitive mapping recall protocol, the recall sequence from the photovoice recall protocol was used to generate a weighted measure. This data coding scheme assumed that the scenes that emerged earlier had a higher level of saliency in spatial cognition.

5.3 Measuring water-based place attachment with emotional recall protocol

Emotional bonding with spatial features influences their saliency in cognitive maps (Brunyé et al., 2009). Water-based place attachment was measured by the weighted score generated from a recall question concerning people's emotional bond with waterscapes. Proximity-seeking is associated with emotional bonding with a locus of attachment (Douglas, Kearney, & Leatherman, 2000). The emotional recall protocol probed environmental features and locations evoking proximity-seeking.

5.4 Measuring water-based stress reduction with a structured question

A structured interview question was used to both measure water's contributions to stress regulation and determine people's ability to self-orient in a water-centric environment. Although physiological instruments can be used to provide an objective assessment of stress reduction, self-reporting measures using questionnaires are useful substitutes (Masood, Ahmed, Jongyong Choi, & Gutierrez-Osuna, 2012). This study intended to measure the aggregated effects of many place-based experiences within a city. This study did not employ physiological instruments for measuring stress because they were costly.

5.5 Measuring water-based spatial orientation with a structured question

Objective measurements of spatial abilities have been effectively predicted by inexpensive, self-report measures (Hegarty, Richardson, Montello, Lovelace, & Subbiah, 2002). Self-reports of sense of direction reflect spatial orientation ability (Kozlowski & Bryant, 1977). They are also more highly correlated with the measures of spatial knowledge acquired from direct environmental experience than with those from secondary sources, such as maps, videos, and virtual environments (Hegarty et al., 2002). In this study, a structured question on sense of direction was used to provide a self-reported measure for spatial orientation.

6 DATA COLLECTION

6.1 Selection of water cities

Many water cities have been considered comparable to Venice (MacLean, 2011; Raplee, 2010). I chose six as study sites based on their similarity in precipitation pattern and geographical proximity to minimize the cost of sampling. The six cities were Amsterdam and Giethoorn in the Netherlands, Ghent and Bruges in Belgium, and Berlin and Hamburg in Germany. Only Amsterdam and Hamburg are downstream cities with nearby harbors. The other four are upstream water cities. Rotterdam and Almere were added to the selection of study sites because they are two of the fastest-growing polder cities in the Netherlands with easily accessible harbors. The final list of study sites comprised four downstream water cities and four upstream water cities. This selection of water cities allowed for some level of variability in the amounts and types of water features. All eight water cities have canals. The four downstream water cities have a water density greater than 10% due to the presence of larger water bodies, such as harbors and lakes. The water density for the upstream cities is less than 10%. Water densities were calculated by dividing the total surface of water in each city by its total area. The eight cities were coded as 1 or 2 based on whether they have low or high water densities, creating the grouping variable of high- or low-water city.

6.2 Recruitment of field participants

A simple and obvious sampling frame for residents and tourists does not exist, as tourists enter and exit the cities constantly and typically do not have permanent local addresses. Instead, randomly sequenced sampling sites recruited participants, creating an approximation of a random sample derived from a theoretical sampling frame. This theoretical sampling frame assumes that it is possible to include all residents and tourists in all eight cities during the sampling time frame. A randomized order was used to sequence the eight cities. Each city's nine sampling sites always included major entry points (such as airports, intercity train stations, and bus stations), city halls, and tourist bureaus, as well as various hotels, cafés, ethnic stores, and universities. These sites were chosen to sample a representative mix of residents and visitors, high- and low-income populations, environmental design experts and non-experts, and immigrants and visitors from various countries of origin. Each sampling site was sampled for five hours, for a total of 45 hours for each water city. Spending equal time in each sampling site and city helps reduce sampling bias.

6.3 Expert interviews and reviews

To formulate four questions for measuring openness toward water-coherent urbanism, the investigator conducted two open-ended, expert interviews with a Landscape Architecture faculty member from a Dutch university and a Dutch consultant with an international non-profit organization specializing in Urban Planning and Design. Six faculty members in Landscape Architecture, Architecture, Urban Planning, and Sociology from an American university reviewed the four questions before they were deployed for field interviews. The first two items asked participants to provide ratings related to several possible urban design solutions for storing and infiltrating public stormwater runoff. The last two items prompted participants to rate the likelihood of urban design features to promote travel by water and waterways in the urban environment. The ratings were generated based on "very," "somewhat," and "not" as response categories equally spaced along a three-point Likert scale. These answers generated the score of 3, 2, or 1, respectively. Each measure was based on the average score of all response ratings. These questions are presented in Table 1.

Table 1. Interview items and coding for aquaphilic urbanism measures.

Variable: *openness toward storing runoffs*	
1. Flood-prone cities are considering the following ways to address flooding issues in the public spaces. How likely would you support storing 90% of the stormwater from public roads and properties during storms by…	
a. converting auto lanes to 1m deep canals with bike paths.	□ Very (3) □ Somewhat (2) □ Not (1)
b. deepening existing canals from 1m to 3m.	□ Very (3) □ Somewhat (2) □ Not (1)
c. lowering the grounds of plazas and playgrounds.	□ Very (3) □ Somewhat (2) □ Not (1)
d. retrofitting plazas to float on top of water.	□ Very (3) □ Somewhat (2) □ Not (1)
e. retrofitting underground parking for storage.	□ Very (3) □ Somewhat (2) □ Not (1)
f. building big underground pipes for storage.	□ Very (3) □ Somewhat (2) □ Not (1)
g. Please specify or explain why you did not support any of the above solutions: ________	
Variable: *openness toward infiltrating runoffs*	
2. How likely would you support returning 90% of the stormwater from public roads and properties after storms by…	
a. converting auto lanes to creeks with bike paths.	□ Very (3) □ Somewhat (2) □ Not (1)
b. converting parking lots into parks.	□ Very (3) □ Somewhat (2) □ Not (1)
c. converting plazas into parks.	□ Very (3) □ Somewhat (2) □ Not (1)
d. making roads porous.	□ Very (3) □ Somewhat (2) □ Not (1)
g. Please specify or explain why you did not support any of the above solutions: ________	

Variable: *openness toward water transportation*	
3. How likely would you travel by water more…	
a. if you had an amphibious car?	□ Very (3) □ Somewhat (2) □ Not (1)
b. if water were near your home?	□ Very (3) □ Somewhat (2) □ Not (1)
c. if water were near where you typically go?	□ Very (3) □ Somewhat (2) □ Not (1)
d. if you could take your bicycle along?	□ Very (3) □ Somewhat (2) □ Not (1)
e. if the water network were expanded?	□ Very (3) □ Somewhat (2) □ Not (1)
f. if water movement generated energy?	□ Very (3) □ Somewhat (2) □ Not (1)
g. if it improved water quality?	□ Very (3) □ Somewhat (2) □ Not (1)
h. if there were more security docking?	□ Very (3) □ Somewhat (2) □ Not (1)
i. if it improved your wellbeing?	□ Very (3) □ Somewhat (2) □ Not (1)
j. if flood evacuation were likely in your area?	□ Very (3) □ Somewhat (2) □ Not (1)
k. if there were no fuel cost?	□ Very (3) □ Somewhat (2) □ Not (1)
l. if it reduced climate change impacts?	□ Very (3) □ Somewhat (2) □ Not (1)
m. if it decreased sea level rise?	□ Very (3) □ Somewhat (2) □ Not (1)
n. if it reduced risks of flooding in your city?	□ Very (3) □ Somewhat (2) □ Not (1)
o. if it reduced risks of flooding in other cities?	□ Very (3) □ Somewhat (2) □ Not (1)
Variable: *openness toward canals and creeks*	
4. Would you like to see more canals or creeks…	
a. supported floating parks?	□ Very (3) □ Somewhat (2) □ Not (1)
b. supported floating greenhouses?	□ Very (3) □ Somewhat (2) □ Not (1)
c. generated renewable energy?	□ Very (3) □ Somewhat (2) □ Not (1)
d. supplied clean water?	□ Very (3) □ Somewhat (2) □ Not (1)
e. reduced floods?	□ Very (3) □ Somewhat (2) □ Not (1)
f. supported water transportation?	□ Very (3) □ Somewhat (2) □ Not (1)
g. improved water quality?	□ Very (3) □ Somewhat (2) □ Not (1)
h. supported floating bicycle paths?	□ Very (3) □ Somewhat (2) □ Not (1)
i. supported floating traffic lanes?	□ Very (3) □ Somewhat (2) □ Not (1)
j. supported boathouses	□ Very (3) □ Somewhat (2) □ Not (1)
k. reduced heat in urban areas?	□ Very (3) □ Somewhat (2) □ Not (1)
l. if it reduced climate change impacts	□ Very (3) □ Somewhat (2) □ Not (1)
m. if it decreased sea level rise?	□ Very (3) □ Somewhat (2) □ Not (1)
n. provided water during droughts	□ Very (3) □ Somewhat (2) □ Not (1)
o. supported vegetation?	□ Very (3) □ Somewhat (2) □ Not (1)
a. were necessary for distributing water?	□ Very (3) □ Somewhat (2) □ Not (1)
b. were necessary for distributing energy?	□ Very (3) □ Somewhat (2) □ Not (1)
c. were necessary for distributing food?	□ Very (3) □ Somewhat (2) □ Not (1)
d. supported wildlife?	□ Very (3) □ Somewhat (2) □ Not (1)
e. returned stormwater to the ground?	□ Very (3) □ Somewhat (2) □ Not (1)
f. supported floating parks?	□ Very (3) □ Somewhat (2) □ Not (1)
g. were more straight?	□ Very (3) □ Somewhat (2) □ Not (1)
h. were more meandering?	□ Very (3) □ Somewhat (2) □ Not (1)
i. needed energy to keep water in it?	□ Very (3) □ Somewhat (2) □ Not (1)

Assume response categories are equally-spaced points along a Likert scale to generate scores as shown above in parentheses. Use the average score across all responses to create a variable measure.

6.4 Field interviews

Sixty participants from sampling sites in all eight cities were recruited for semi-structured interviews. As shown in Table 2, during each interview the investigator conducted cognitive mapping (item 1), photovoice (item 2), and emotional recall protocols (item 3). Item 1 prompted the participant to identify the first five features to emerge from a two-dimensional, top-down cognitive map of the city. Item 2 probed the first five photograph-like, eye-level cognitive images to surface from his or her spatial memory of the city. Item 3 generated the five elements that would be most missed if the participant had to leave the city the next day. I used these three recall protocols to assess water-based mappability, identifiability, and place attachment. Two interview questions were used to measure water-based stress reduction (item 4) and water-based spatial orientation (item 5).

Table 2. Interview items and coding for aquaphilic urbanism measures.

Variables	Interview items for field participants
water-based mappability[a]	1. Cognitive mapping protocol: imagine you are drawing a map of the city. Please name or describe the five features or locations that come to mind first. Please do not consult a city map.
water-based identifiability[a]	2. Photovoice protocol: If you were to take 5 pictures of the city to describe it to someone who has never been there, what would you take pictures of?
water-based place attachment[a]	3. Non-visual protocol: What are the 5 things you would miss about the physical environment if you had to leave the city tomorrow?
water-based stress reduction[b]	4. How much do the bodies of water in the city help you relax when you are stressed? □ Very much (3) □ Somewhat (2) □ Not at all (1)
water-based spatial orientation[b]	5. How much do you use the bodies of water in the city to orient yourself? □ Very much (3) □ Somewhat (2) □ Not at all (1)

a. Code each answer 1 or 0 based on whether it contains a target waterscape, assign a weight from 5 to 1 to account for the sequence of recall, and use a weighted average to create variable measures.

b. Assume response categories are equally-spaced points along a Likert scale to generate scores as shown above in parentheses.

7 DATA ANALYSIS

7.1 Coding for aquaphilic urbanism measures

For items 1, 2, and 3 in Table 2, we assigned a base score of 1 or 0 to each response depending on whether it contained water. We applied a weight of 5 to the base score for the first answer, 4 for the second, and so forth, to account for the significance of each water-based feature's recall sequence. As shown in the following formula, we took a weighted average from the sum of all five weighted base scores:

Weighted average = (5 * *first answer base scor*e + 4 * *second answer base score* + 3 * *third answer base score* + 2 * *fourth answer base score* + 1 * *fifth answer base score*) / 5

This formula was used to derive the mappability, identifiability, and place attachment measures, respectively, for water-based features from the results of the cognitive mapping, photovoice, and emotional recall protocols in Table 2. For items 4 and 5 in Table 2, we used a three-point Likert scale to ordinate the score for water-based stress reduction and water-based spatial orientation.

7.2 Data reduction

Correlation analysis showed that several measures of aquaphilic urbanism and water-coherent urbanism were correlated. To reduce these measures to a smaller set of uncorrelated variables as components, we conducted an internal consistency reliability test (based on Cronbach's alpha) and a principal component analysis (PCA) using the-eigenvalue-greater-than-one rule (Kaiser, 1960; McGraw & Wong, 1996). The PCA was also used to provide content validity for the measures of water-based place identity and place dependence by verifying whether these measures were reducible into their respective component constructs. Components are linear combinations of variables based on weights (eigenvectors) developed by an analysis (Jolliffe, 2002). Principal components represent most of the information in the original set of variables. The first principal component extracted captures as much of the variability in the data as possible. Each succeeding component accounts for as much of the remaining variability as possible. We used a correlation matrix to perform the PCA because the units of measurement of the individual measures differed.

7.3 Composite score for aquaphilic urbanism

According to 0.6 as the threshold for Cronbach's alpha (Hume, Ball, & Salmon, 2006), the four measures for aquaphilic urbanism had an acceptable internal consistency reliability ($\alpha = 0.71 > 0.6$) and can thus be condensed into fewer variables. With promax rotation and the-eigenvalue-greater-than-one rule (Kaiser, 1960), we used the PCA to extract two principal components to explain approximately 2.44 and 1.08 of the variable worth, or 60.88% and 27.01% of the four measures' total variance, respectively. The loadings (simple correlations) between each of the four measures and either of these two components were either close to zero or much higher than the correlations between the same measures. Additionally, the residual correlations, or the differences between observed and reproduced correlations, were less than 0.3, indicating an absence of uncaptured strong correlations between residuals. Most residual correlations' absolute values were less than 0.05, while the residual correlation between water-based identifiability and water-based mappability was less than 0.3. These relatively small residuals showed that the variances in the measures were well-captured by the component scores. The PCA outcome suggests that water-based place dependence, as the first principal component, parsimoniously represents water-based stress reduction and water-based spatial orientation, while water-based place identity, as the second principal component, effectively denotes water-based mappability and identifiability. The results supported the use of a composite score for aquaphilia urbanism as a variable for mediation analyses. To generate the variable in SPSS, we used the two component scores in the covariance matrix to weight these two principal components as the independent variables of a linear regression.

7.4 Composite score for openness toward water-coherent urbanism

The four measures for openness toward water-coherent urbanism also underwent data reduction because they had an adequate internal consistency reliability ($\alpha=0.86>0.6$). With 1 as the eigenvalue threshold, PCA extracted one component, which accounted for 3.02 of the variable worth and 60.31% of the total variance in the four measures. The loadings, or simple correlations, between each of the four measures and the component were greater than 0.3, and their residential correlations were less than 0.3. These findings indicate that the principal component score for participants' openness toward water-based coherent urbanism effectively represents all four measures. The score was calculated by summing the weighted measures generated by multiplying each of the four measures with its corresponding coefficients as weights.

7.5 Mediation analysis

Franck (1984) highlighted the importance of studying the indirect effects of environment on behavior to address the criticism of environmental determinism as a dominant assumption in environment-behavior studies. To identify how public realm design mediated the seemingly environmentally deterministic relationship between watershed location and water-based place attachment, mediation analyses were conducted in SPSS Statistics 22 using a macro written by Preacher and Hayes (2008). Researchers typically use a mediation model to identify the underlying mechanism of an observed relationship between an independent variable and a dependent variable by including one or more mediators as explanatory variables (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). In the first set of mediation analyses, the mediating effect of aquaphilic urbanism on the relationship between watershed location and water-based place attachment was tested. The second set of meditation analyses was conducted to reveal the mechanisms underlying the relationship between water-based place attachment and people's openness toward water-coherent urbanism.

8 RESULTS

8.1 Aquaphilic urbanism as a mediator of the effect of watershed location on water-based place attachment

Model A in Figure 3 shows that water-based place attachment seemed to be environmentally determined by watershed location measured by the grouping variable of a city's water density. However, this significant indirect effect, or ostensible phenomenon of environmental determinism, was fully mediated by aquaphilic urbanism as a water-based sense of place evoking aquaphilia.

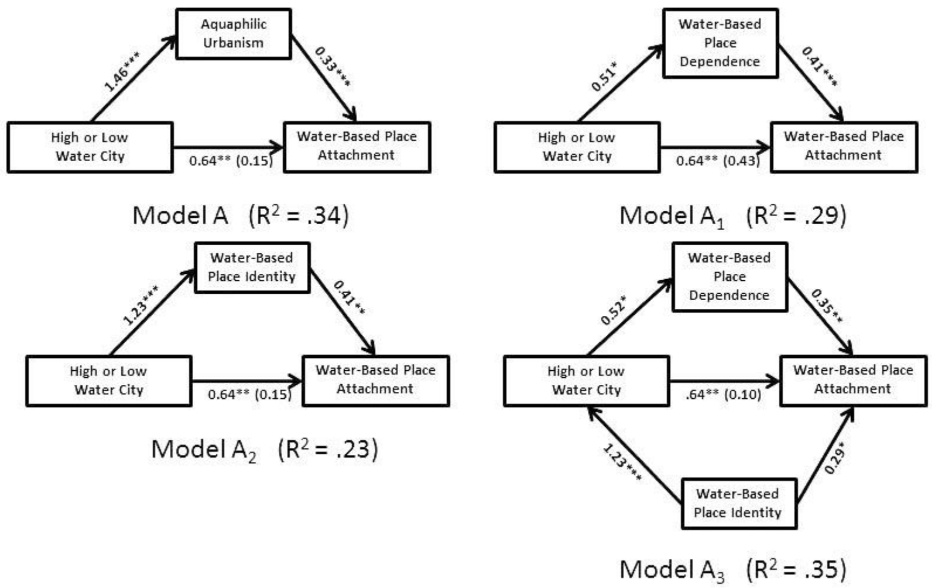

Figure 3. Mediation analysis results for aspects of aquaphilic urbanism as mediators on the relationship between watershed location or water density and water-based place attachment (*p<0.001; ** p<0.01; * p<0.05).**

Such a sense of place encompasses water-based place identity (a composite construct of water-based mappability and identifiability) and water-based place dependence (a composite construct of water-based stress reduction and spatial orientation) (β_a= 1.46, p_a<0.001; β_b= 0.33, p_b<0.001; β_c= 0.64, p_c<0.01; $\beta_{c'}$= 0.15, $p_{c'}$ >0.05; R_2=0.34, F(2, 57)=14.96, p<0.001). The results suggest that a watershed location with a higher level of water density does not always lead to a higher level of water-based place attachment due to the potential mediating effect of aquaphilic urbanism. In other words, upstream cities (with a lower water density than downstream cities) can evoke a greater level of aquaphilia by adopting aquaphilic urbanism.

8.2 Functional or aesthetic aspects of aquaphilic urbanism as adaptation motivators

Model A_1 in Figure 3 reveals that water-based place dependence fully mediated 29% of the contribution of watershed location (high- or low-water city) to aquaphilia (β_a= 0.51, p_a<0.05; β_b=0.41, p_b<0.001; β_c= 0.64, p_c<0.01; $\beta_{c'}$= 0.15, $p_{c'}$ >0.05; R^2=0.29, F(2, 57)=11.75, p<0.001). In model A_2, 23% of the influence of watershed location (high- or low-water city) on aquaphilia was fully mediated by water-based place identity (β_a= 1.23, p_a<0.001; β_b= 0.41, p_b<0.01; β_c= 0.64, p_c<0.01; $\beta_{c'}$= 0.15, $p_{c'}$ >0.05; R^2=0.23, F(2, 57)=8.37, p<0.001). Compared to water-based place identity, the mediating effect of water-based place dependence was 6% higher. When both mediators were included in model A_3, they accounted for a total of 35% of the high- and low-water city's influence on aquaphilia (β_{a1}= 0.52, p_{a1}<0.05; β_{b1}= 0.35, p_{b1}<0.01; β_{a2}= 1.23, p_{a2}<0.001; β_{b2}= 0.29, p_{b2}<0.05; β_c= 0.1, p_c>0.05; $\beta_{c'}$= 0.10, $p_{c'}$ >0.05; R^2=0.35, F(2, 57)=9.89, p<0.001). The combined effect of both mediators (35%) was only 6% higher than the mediating effect of water-based place dependence alone (29%). Like the CPA results, a comparison of all four models confirms that the functional and aesthetic aspects of aquaphilic urbanism are largely overlapping rather than mutually exclusive. Consequently, it is appropriate to investigate aquaphilic urbanism as a higher-order construct of both aspects.

8.3 Water-based place attachment as the function of aquaphilic urbanism for adaptation

In Figure 4, model B (R^2=0.10, F(2, 57)=3.16, p<0.05) indicates that a water city's watershed location did not influence public acceptance of water-coherent urbanism because being a high- or low-water city had no significant indirect or direct effect on people's openness toward water-coherent urbanism (β_c= 0.31, p_c>0.05; $\beta_{c'}$= 0.05, $p_{c'}$ >0.05); however, model B's *a* path indicates that high-water cities in downstream locations were more likely to embody aquaphilic urbanism than low-water cities further upstream (β_a= 1.46,

p_a<0.001), and its *b* path shows that aquaphilic urbanism had a significant positive effect on openness toward water-coherent urbanism (β_b= 0.18, p_b<0.05). Model C shows that the significant influence of aquaphilic urbanism on openness toward water-coherent urbanism was an indirect effect fully mediated by water-based place attachment (β_a= 0.36, p_a<0.001; β_b= 0.31, p_b<0.05; β_c= 0.19, p_c<0.01; $\beta_{c'}$= 0.08, $p_{c'}$ >0.05; R^2=0.17, F(2, 57)=5.76, p<0.01). The findings of models A, B, and C suggest that water-coherent urbanism could be introduced to the mainstream for public acceptance through water-based place attachment as the product of aquaphilic urbanism.

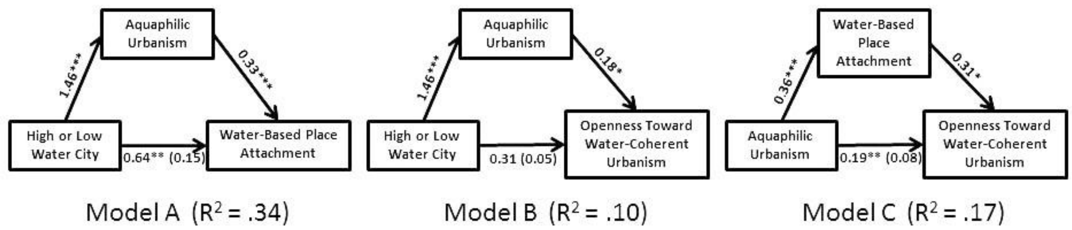

Figure 4. Mediation analysis results for exploring relationships among watershed locations, water-based place attachment, aquaphilic urbanism, and openness toward water-coherent urbanism (*p<0.001; ** p<0.01; * p<0.05).**

8.4 Water-based place attachment facilitates climate adaptation through water-based place identity

Figure 5 compares model C with models C_1 and C_2. Model C indicates that water-based place attachment fully mediated 17% of the indirect effect of aquaphilic urbanism on participants' openness toward water-coherent urbanism. Model C_1 shows that water-based place attachment had no mediating effect when water-based place dependence replaced aquaphilic urbanism as the independent variable (β_a= 0.47, p_a<0.001; β_b= 0.39, p_b<0.01; β_c= 0.17, p_c>0.05; $\beta_{c'}$= -0.01, $p_{c'}$ >0.05; R^2=0.16, F(2, 57)=5.44, p<0.01). In contrast, water-based place attachment mediated 20% of the effect of water-based place identity on participants' openness to water-coherent urbanism in model C_2 (β_a= 0.45, p_a<0.001; β_b= 0.28, p_b<0.05; β_c= 0.31, p_c<0.01; $\beta_{c'}$= 0.20, $p_{c'}$>0.05; R^2=0.20, F(2, 57)=6.97, p<0.01) as opposed to 17% in model C with aquaphilic urbanism as the independent variable. In summary, functionally-derived water-based place attachment did not fully mediate the indirect impact of water-based place dependence on the participants' acceptance of water-coherent urbanism. In contrast, aesthetically-derived, water-based place attachment evidently fully mediated the indirect effect of water-based place identity on participants' openness toward water-coherent urbanism. The findings reveal that water-based place identity underpins the influence of water-based place attachment on people's openness toward water-coherent urbanism. Technocratic discourses around water retention alone are insufficient. The aesthetic influence of aquaphilic urbanism is essential for motivating public support for a more widespread application of water-coherent urbanism.

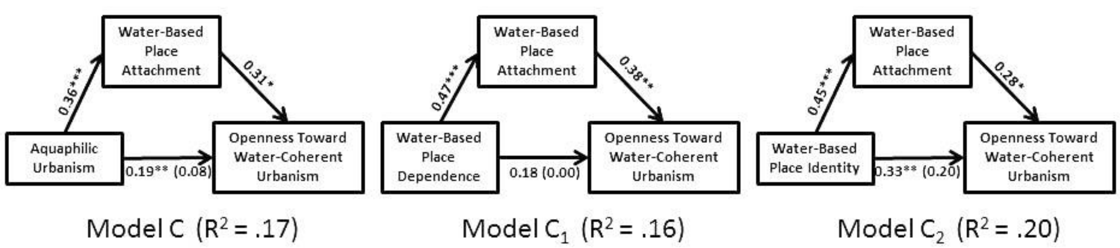

Figure 5. Mediation analysis results for the mediating effect of water-based place attachment on the relationship between aspects of aquaphilic urbanism and openness toward water-coherent urbanism. (*p<0.001; ** p<0.01; * p<0.05).**

9 DISCUSSION

Water-based place identity and dependence are valid measures for the interrelated aesthetic and functional sub-aspects of aquaphilic urbanism (Model A_3 in Figure 3). Aquaphilic urbanism was thus empirically substantiated as an urban design approach that integrates water to enhance waterscape salience in two-dimensional cognitive maps and eye-level cognitive images. In addition, this approach facilitates urbanites' stress regulation and spatial orientation.

As shown by Model A in Figure 4, compared with upstream cities, downstream water cities with a greater proportion of water bodies are more likely to embody aquaphilic urbanism; however, aquaphilic urbanism can help defy this ostensible phenomenon of environmental determinism. Upstream cities with a low water density can be retrofitted with aquaphilic urbanism to potentially evoke more water-based place attachment, thus enhancing the appeal to individuals and businesses.

Water-based place dependence does not encourage more application of water-coherent urbanism through water-based place attachment (Model C_1 in Figure 5). However, it mediates the indirect effect of watershed location on water-based place attachment more effectively than water-based place identity (Model A_3 in Figure 3). Cities with little space or precipitation for large-scale water retention can still evoke water-based place attachment through smaller-scale waterscapes that facilitate stress reduction and spatial orientation. These local waterscapes may help drought-prone cities become more livable and more attractive tourist destinations. In addition, they can potentially contribute to the social coherence of cities by facilitating environmental adaptation for those most in need of stress reduction and spatial orientation assistance, including newcomers and other spatially-challenged populations. Future research should investigate how to design these waterscapes to better help with stress reduction and spatial orientation with less consumption of land and water. One possible approach is to quantify water surface areas and their impacts on stress reduction and spatial orientation.

The potential of water-based place attachment to help promote upstream retention depends mainly upon the aesthetic aspect of aquaphilic urbanism (Model C_2 in Figure 5). Without considering how the configurations of waterscapes and water networks influence their spatial salience, technocratic discourses related to water retention for flood mitigation can be limited in generating public support for more water retention in the public realm. By making upstream water retention projects more mappable and identifiable, we can instigate an upward spiral for flood mitigation hydrologically and economically. These spatially salient water features will help generate more public demand and proactive financing to help promote upstream water retention. More aesthetically-driven water retention projects upstream then lead to support for more upstream water retention. This positive feedback creates self-perpetuating momentum for mainstreaming upstream water retention, making flood mitigation downstream more hydrologically feasible and cost-effective. Water retention has the potential to introduce economic benefits to upstream areas by increasing their land and property values. The largest increases (28%) in house prices have been attributed to the presence of a garden facing water or being connected to a sizable lake, with considerable increases (8-10%) for houses that overlook water (Luttik, 2000).

As a theoretical sampling frame did not exist, a quasi-random sampling approach was used to acquire the participant sample. This convenient sampling approach likely limited the extent to which the results could be generalized beyond the sample. A more rigorous sampling approach should be used to replicate this research design for a greater number of participants and cities to generalize beyond the sample. The degree to which watershed location or water density influences water-based place identity and dependence may need to be further clarified in future research. One possible focus is to target smaller sites, where the amounts of water and surface areas can be precisely quantified. This research direction could potentially determine whether water-based place identity is a construct likely to involve more water exposure than water-based place dependence. This comparison can help determine more nuanced design guidelines for maximizing the performance and minimizing the cost of aesthetically-driven water retention projects. For example, it would be helpful for place-makers to know the minimum water density and duration of water exposure needed to induce sufficient water-based place attachment to motivate public acceptance of water-coherent urbanism. Furthermore, future studies should investigate the effects of waterscape types on water-based mappability and identifiability to identify the most effective waterscape types for evoking water-based place attachment.

10 CONCLUSION

10.1 Proactive financing for more coherent upstream cities

The cost-prohibitive nature of massive flood-mitigation structures and the lack of substantial proactive funding for climate adaptation have significantly delayed the implementation of flood mitigation projects in flood-prone downstream areas. This study demonstrates the potential of incorporating upstream water retention through private development and public realm improvement activities in upstream areas. This approach provides proactive funding mechanisms to help mitigate downstream flooding while building more environmentally, economically, and socially coherent upstream cities.

10.2 Impetus of voluntary migration to safer locations

Temporary and permanent migration to safer places has been deemed the most effective means for individuals to adapt to potentially life-threatening environmental changes in developing countries (Black, Bennett, Thomas, & Beddington, 2011; Laczko & Aghazarm, 2009). Compared with emergency evacuation and displacement prevention, voluntary migration has been recommended as a more holistic approach to adaptation and disaster planning for developed countries (Savvas, 2003). Unlike developing nations, where voluntary migration has become increasingly driven by individuals' desires to circumvent climate change impacts, voluntary migration in developed countries has been progressively influenced by proximity-seeking to natural amenities among those individuals with growing wealth (Howe, McMahon, & Propst, 2012).

10.3 Natural amenities as relocation consideration

Nord and Cromartie (1997) define natural amenities as moderate, sunny winters and summers with low humidity, as well as diverse topography with mountains and abundant water. Except for water, other natural amenities cannot easily be created by humans. Natural amenities, water-based resources in particular, significantly explain economic and population growth (Deller, Tsai, Marcouiller, & English, 2001; Marcouiller, Kim, & Deller, 2004). Such a water amenity-driven migration pattern has, however, been thought to potentially increase unemployment, as rural water amenities did not seem to increase employment opportunities (Deller et al., 2001). At the same time, Cohen (2000) noted that an increasing number of jobs had been migrating to high-amenity cities due to the theses cities' appeal to well-educated workers in search of amenities as a key relocation consideration. Upstream areas within commuting distance to employment centers of downstream cities may be the most promising locations for using water retention projects to instigate voluntary migration for climate adaptation.

10.4 Integrating multiple migration incentives

Combined with other migration incentives, such as employment opportunities or tax breaks, the implementation of upstream water urbanism may help contribute to a greater long-term positive pull toward safer high grounds in currently amenity-poor upstream areas. This integrated and proactive approach to voluntary migration could potentially help upstream cities attract more individuals and businesses. This approach also has the potential to minimize involuntary displacement and damage to lives and properties in downstream areas faced with increasing climate change impacts.

11 REFERENCES

Black, R., Bennett, S., Thomas, S., & Beddington, J. (2011). Climate change: Migration as adaptation. *Nature,* 478(7370), 447-449.

Brunyé, Mahoney, Augustyn, & Taylor. (2009). Emotional state and local versus global spatial memory. *Acta Psychologica*, 130(2), 138-146.

Clayton, K., & Woodyard, M. (1981). The acquisition and utilization of spatial knowledge. *Cognition, social behavior, and the environment*, 151-161.

Cohen, N. (2000). *Business location decision-making and the cities: bringing companies back*: Brookings Institution Center on Urban and Metropolitan Policy.

De Jonge, D. (1962). Images of Urban Areas Their Structure and Psychological Foundations. *Journal of the American Institute of Planners*, 28(4), 266-276.

Deller, S. C., Tsai, T.-H. S., Marcouiller, D. W., & English, D. B. (2001). The role of amenities and quality of life in rural economic growth. *American Journal of Agricultural Economics,* 83(2), 352-365.

Diamond, D. M., Fleshner, M., Ingersoll, N., & Rose, G. M. (1996). Psychological Stress Impairs Spatial Working Memory: Relevance to Electrophysiological Studies of Hippocampal Function. Behavioral Neuroscience, 110(4), 661-672. doi: 10.1037/0735-7044.110.4.661.

Douglas, Bruce, Mark T. Kearney, and Stephen P. Leatherman, eds. 2000. Sea Level Rise: History and Consequences, Vol. 75. Academic Press.

Downs, R., & Siegel, A. (1981). On mapping researchers mapping children mapping space. *Spatial representation and behavior across the life span: Theory and application*, 237-248.

Franck, K. A. (1984). Exorcising the ghost of physical determinism. *Environment and Behavior*, *16*(4), 411-435.

Golledge, R. G. (1992). Place recognition and wayfinding: Making sense of space. *Geoforum,* 23(2), 199-214.

Hart, R. A. (1981). Children's spatial representation of the landscape: Lessons and questions from a field study. *Spatial representation and behavior across the life span: theory and application/edited by LS Liben, AH Patterson, N. Newcombe*.

Hartmann, T. (2010). Reframing polyrational floodplains: Land policy for large areas for temporary emergency retention. *Nature and Culture,* 5(1), 15-30.

Hegarty, M., Richardson, A. E., Montello, D. R., Lovelace, K., & Subbiah, I. (2002). Development of a self-report measure of environmental spatial ability. Intelligence, 30(5), 425-447. doi: https://doi.org/10.1016/S0160-2896(02)00116-2.

Howe, J., McMahon, E. T., & Propst, L. (2012). *Balancing nature and commerce in gateway communities*: Island Press.

Hume, C., Ball, K., & Salmon, J. (2006). Development and reliability of a self-report questionnaire to examine children's perceptions of the physical activity environment at home and in the neighbourhood. *International Journal of Behavioral Nutrition and Physical Activity,* 3(1), 16.

Luttik, J. (2000). The value of trees, water and open space as reflected by house prices in the Netherlands. Landscape and urban planning, 48(3), 161-167.

McGraw, K. O., & Wong, S. P. (1996). Forming inferences about some intraclass correlation coefficients. *Psychological methods*, 1(1), 30.

Milgram, S., & Jodelet, D. (1976). Psychological maps of Paris. Environmental psychology: people and their physical settings, 104-124.

Nord, M., & Cromartie, J. (1997). Graphically Speaking: Migration: The increasing importance of rural natural amenities. *Choices*, *12*(3).

Jolliffe, I. (2002). *Principal component analysis*: Wiley Online Library.

Jorgensen, & Stedman. (2006). A comparative analysis of predictors of sense of place dimensions: Attachment to, dependence on, and identification with lakeshore properties. *Journal of Environmental Management*, 79(3), 316-327.

Jorgensen, & Stedman. (2001). Sense of place as an attitude: Lakeshore owners attitudes toward their properties. *Journal of Environmental Psychology*, 21(3), 233-248.

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and psychological measurement*.

Kaplan, S. (1984). Affect and cognition in the context of home: The quest for intangibles. *Population and Environment,* 7(2), 126-133.

Kaplan, S. (1995). The restorative benefits of nature: toward an integrative framework. *Journal of Environmental Psychology,* 15(3), 169-182.

Kellert, S. R. (1995). *The biophilia hypothesis*: Island Press.

Korpela, K. (1989). Place-identity as a product of environmental self-regulation. *Journal of Environmental Psychology, 9*, 241-256.

Korpela, K., Hartig, T., Kaiser, F., & Fuhrer, U. (2001). Restorative Experience and Self-Regulation in Favorite Places. Environment and Behavior, 33(4), 572-589.

Kozlowski, L. T., & Bryant, K. J. (1977). Sense of direction, spatial orientation, and cognitive maps. Journal of Experimental Psychology: Human Perception and Performance, 3(4), 590-598. doi: 10.1037/0096-1523.3.4.590.

Laczko, F., & Aghazarm, C. (2009). *Migration, environment and climate change: Assessing the evidence*: International Organization for Migration Geneva.

Lynch, K. (1960). The Image of the City (pp. 91-117). Cambridge, MA: MIT Press.

MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variable effects. *Psychological methods,* 7(1), 83.

MacLean, R. (2011). Venice of the North. Retrieved 01/17, 2013, from http://blog.goethe.de/meet-the-germans/archives/173-Venice-of-the-North.html

Marcouiller, D. W., Kim, K.-K., & Deller, S. C. (2004). Natural amenities, tourism and income distribution. *Annals of Tourism Research,* 31(4), 1031-1050.

Masood, K., Ahmed, B., Jongyong Choi, R., & Gutierrez-Osuna, R. (2012). Consistency and Validity of Self-reporting Scores in Stress Measurement Surveys (Vol. 2012, pp. 4895-4898).

McGraw, K. O., & Wong, S. P. (1996). Forming inferences about some intraclass correlation coefficients. *Psychological methods,* 1(1), 30.

Nicholls, R. J., & Cazenave, A. (2010). Sea-level rise and its impact on coastal zones. *science, 328*(5985), 1517-1520.

Ogunseitan, O. A. (2005). Topophilia and the quality of life. *Environmental Health Perspectives, 113*(2), 143.

Osmond, H. (1963). What's New in Psychiatric Research. Mind: psychiatry in general practice, 275.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior research methods,* 40(3), 879-891.

Raplee, P. (2010). Ghent, Belgium: attractions, tours, and even a time lord. Retrieved 01/16, 2013, from http://www.offbeattravel.com/ghent-belgium-tours-attractions-activities.html

Rasmussen, K. (1931). *The Netsilik Eskimos: Social Life and Spiritual Culture: Report of the Fifth Thule Expedition 1921-24*: Nordisk forlag.

Ruggeri, D. (2014). The 'My Mission Viejo'Project. Investigating the Potential of Photovoice Methods in Place Identity and Attachment Research. *Journal of Urban Design*, *19*(1), 119-139.

Savvas, D. (2003). Hydroponics: A modern technology supporting the application of integrated crop management in greenhouse. *Journal of Food Agriculture and Environment,* 1, 80-86.

Scannell, Leila, & Gifford, Robert. (2010). Defining place attachment: A tripartite organizing framework. Journal of Environmental Psychology, 30(1), 1-10.

Southworth, M., Cranz, G., Lindsay, G., & Morhayim, L. (2012). People in the Design of Urban Places. *Journal of Urban Design,* 17(4), 461-465.

Stedman, R. C., & Ingalls, M. (2013). Topophilia, biophilia and greening in the red zone. *Greening in the Red Zone: Disaster, Resilience, and Community Greening*.

Tuan, Y.-F. (1974). Topophilia and Environment. *Topophilia. A Study of Environmental Perception, Attitudes and Values*, 92-112.

Vaske, J., & Kobrin, K. (2001). Place Attachment and Environmentally Responsible Behavior. The Journal of Environmental Education, 32(4), 16-21.

Wang, C., & Burris, M. A. (1997). Photovoice: Concept, methodology, and use for participatory needs assessment. *Health education & behavior*, *24*(3), 369-387.

Wilson, E. (1984). *Biophilia*: Harvard University Press.