Photoable Urban Green–Blue Spaces:
Investigating Social Media Photographs of 186 Cities Worldwide

Weijing
W A N G

THE
UNIVERSITY OF
EDINBURGH

Abstract

Urban green–blue spaces (UGBSs) are increasingly integrated into the urban fabric transformation, playing a pivotal role in shaping everyday interactions and experiences with nature in the Anthropocene era. Crowdsourcing, facilitated by digital technologies, has emerged as a novel methodological advance for accessing subjective place-based information, allowing the public to produce and share photographs at an unprecedented scale. As people can now readily capture and disseminate images on social media from virtually any location, these photographs contribute to the digital representation of places. Many studies have leveraged social media imagery to explore mental maps of cities, place perceptions, and ecosystem services. This raises fundamental questions: What are the UGBSs that promote photography across cities? What are the similarities and differences among cities' photogenic UGBSs? And how do cities' photogenic UGBSs relate to the happiness of their inhabitants? This study investigates these questions through an analysis of 203,020 photographs, taken from social media, of sites across 186 cities over a five-year period (2014 to 2018). Employing Google Cloud Vision and topic modelling with a state-of-the-art neural network model, photographs are clustered and used to identify cross-city features. The correlation between prevalence of photogenic UGBSs and levels of happiness is investigated using linear regression analysis. The results show that UGBSs eliciting photography practice are predominantly characterised by water-related subjects, confirming a widespread aesthetic appreciation for urban blue spaces. Perceptions of UGBSs exhibit significant variability among cities, offering a metric to assess environmental policy efficacy. Lastly, a positive association is found in high-income contexts between number of social media photographs of UGBSs and subjective well-being, while this correlation is not significant in middle- and low-income contexts. This sheds light on human–nature relationships by providing global evidence of how aesthetic appreciation of urban nature influences human well-being.

Introduction

The Anthropocene is a term that has been proposed to describe a geological epoch during which human activities have transformed the earth's geology and ecosystem in unprecedented ways. Urbanisation, including intensified construction and population growth, is a planet–wide trend, though characterised by uneven spatial development (Brenner and Schmid 2015). The increasing

concentration of the urban population, human activities and intensification of infrastructural construction in urban areas are transforming landscapes' spatial connectivity and modularity in the Anthropocene era (Elmqvist et al. 2021). One significant aspect of this change has been landscape fragmentation, which results in a variety of environmental and ecological problems. These include impoverished biodiversity and habitat loss (Liu et al. 2016; McDonald et al. 2013), the urban heat island effect (Tran et al. 2006; Yao et al. 2020), and soil erosion in urban areas (Seifollahi-Aghmiuni et al. 2022). Fragmentation and scarcity of green-blue spaces also lead to social problems, such as barriers to appreciating nature in urban areas (Turner et al. 2004) and mental distress (White et al. 2021). To date, many studies have investigated the benefits of ecosystem services offered by urban green-blue spaces (UGBSs), which are utilised by local governments as a key part of strategies to improve the liveability of cities (Assessment 2005; Labib et al. 2020; Pacione 2003).

In this context, urbanisation is not merely fragmenting natural landscapes. Rather, it creates new patterns of spaces and habitats that situate novel biotic communities (e.g., non-native species) and afford human-nature interactions that rarely happen in other places (Müller et al. 2013). Design practices in essence impact on urban biodiversity and local ecosystems by utilising alienated plant species, globalised materials (e.g., concrete) and artificial constructions (e.g., flowerbeds and trails). Cultural factors also shape the appearance of urban nature. Dating back to the eighteenth century, French impressionists popularised a style of painting without straight lines, and an appreciation for various characteristics of a perfect natural environment, such as tranquillity and the sublime (Hunt 1992, 243–272; Smith 2021). Currently, the most influential landscape style is a simplified version of the English landscape, characterised by curvilinear, scattered groves, flower borders, bridges and pavilions (Müller et al. 2013). This style has transformed the landscapes of modern cities. For example, Central Park, designed by Frederick Law Olmsted, became an international cultural phenomenon that has influenced the styles of urban parks since the nineteenth century (Schenker 2009).

Historically, the prominent divide in urban park styles has been between the regular style of garden design and the picturesque camp, including English Landscape and Chinese Classic Gardens. However, even the most obvious boundaries between different park styles are blurred due to the globalisation of plant materials, homogenisation of recreation cultures, common challenges (e.g., decreases in biodiversity) and the shifting aesthetic values of different design languages (Müller et al. 2013). The aesthetic experience of green-blue spaces is closely connected to individual and cultural biases (Jorgensen 2011). For instance, wildness induces contradictory perceptions of a natural landscape among people with different backgrounds (Buijs et al. 2009; Zheng et al.

2011). The results of one study showed that participants preferred, and achieved better psychological outcomes through, being in or on the edge of wild nature (e.g., a forest), compared to being within tended nature, validating the appreciation of biodiversity (Chiang et al. 2017). Another study, carried out across several multicultural European cities, demonstrated a positive correlation between the strength of participants' preferences for particular landscapes and the level of biodiversity within those landscapes, with the latter linked inextricably to perceptions of wildness (Fischer et al. 2018). Studies by Hwang et al. (2019) and Jiang and Yuan (2017) illustrated how ordinary people perceive the aesthetic value of wildness, while Li et al. (2019) demonstrated a greater awareness among professionals in Beijing, compared to non-professionals, of the aesthetical features of spontaneous vegetation. On the other hand, a study conducted in Japan showed that wildness and biodiversity are among the least preferred features for green roofs. More importantly, information and environmental education are factors likely to moderate people's aesthetical perception of natural environments (Arts et al. 2021; Ryan 2012). In short, people's landscape preferences have become more complex than they used to be as global urbanisation and development of communication technology impact urban environments and the ways that people acquire information.

The advent of digital technology has encouraged people to document and share content through social media. The kinds of social media that relate content to specific locations (such as geo-tagged and time-embedded Flickr photos) are not merely offering spatio-temporal information, but also data capturing momentary snapshots of human activities and social processes (Stefanidis et al. 2013). For example, information from geo-tagged user-generated content can contribute to identification of places (Kennedy et al. 2007), events (Becker et al. 2010), mobility patterns (Yang et al. 2019), and perceptions of environment (Figueroa–Alfaro and Tang 2017). A growing number of studies have utilised user-generated photos to explore physical spaces as they represent users' interests, preferences and perceptions in real life (Huang et al. 2021; Tieskens et al. 2018; Wartmann and Mackaness 2020). One recent study found that the content of photos harvested from social media predicts the aesthetic quality of the British landscape (Havinga et al. 2021). The results of another study, conducted in the UK and using data from the website Scenic-Or-Not, which allows users to rate "scenicness" for geo-tagged photos of UK locations, showed that more 'scenic' environments significantly correlated to better well-being (Seresinhe et al. 2015). This supports the hypothesis that the aesthetics of UGBSs may have consequences for subjective well-being. Applying data from the same source, a further study found a positive association between happiness and scenic locations in natural environments and urban areas (Seresinhe et al. 2019). Crowdsourced data, especially images, are used as a proxy of

aesthetic appreciation of landscapes, but the correlation between user-generated photos of green–blue space and subjective well-being is rarely validated. More importantly, few studies have investigated the characteristics of scenic landscapes through the lens of visual social media in digitally networked everyday lives (Coyne 2010). In the context of this study, "photoable" spaces are those that are visually captivating and aesthetically pleasing, making them popular subjects for photography. They are likely to be attractive, inspiring or scenic, and they might include a wide range of landscapes or waterscapes. Therefore, the key research questions are:

- What do photoable green–blue spaces look like?
- How do the characteristics of photoable green–blue spaces differ across cities? and
- Is there an association between the number of photoable spaces and subjective well-being?

Methods

Landscape photo collection and content detection

Data were retrieved from Flickr, which is a social media platform created in 2004 for hosting and sharing photos. The study used Flickr's official APIs to collect photos and affiliated information across 186 cities globally from January 2014 to December 2018. The cities were selected based on survey data in the World Happiness Report (De Neve and Krekel 2020) for the years 2014 to 2018. This included at least 300 observations per city illustrating levels of subjective well-being. To capture photos taken in cities, this study retrieved data within a 32-kilometre radius—the maximum range permitted for point-based geographic queries using the Flickr API—based on the urban area of Tokyo, which spans approximately 35 kilometres and is the largest city by urban area. By adjusting search parameters, only those photos that users had made publicly visible were retained. Finally, a total of 203,020 photographs of sites across 186 cities for the five year-period from 2014 to 2018 were collected through Flickr for content analysis.

To extract content from photographs, this study utilised Google Cloud Vision, retrieving up to ten labels per image through its "Detect Labels" feature. This method involves a pre-trained machine-learning model that identifies objects. activities and other content within images (Figure 1). Then, an $N \times N$ adjacency matrix was created based on the co-occurrence of labels, where N represents the number of unique words (Shahid et al. 2017). Then, the study filtered landscape photographs by clustering labels using the K-Means algorithm. This partitioned N points into K clusters in an iterate process and minimised the sum of squared errors within each cluster. The K-Means algorithm was performed

using the scikit-learn package in Python, and the number of clusters K was determined as nine following the method of Shahid et al. (2017). Photographs in clusters with labels related to green and blue spaces (such as botany, grassland, mountain, lake and coastal) were retained for topic modelling. A total of 1,810 photos (ten from each city with more than ten photos) were randomly sampled to verify the accuracy of label detection. The clustering of green–blue space tags accurately identified 98% of nature-related photos.

Figure 1. a. Word cloud of labels derived from landscape photographs and generated by Google Cloud Vision; b. Samples of landscape photographs obtained from Flickr.

Topic modelling

To better understand the nuances among photographs related to UGBSs, this study further conducted a fine-grained content analysis by applying the *BERTopic* algorithm. This unsupervised machine-learning model discovers latent topics in textual materials by leveraging transformers and c-TF-IDF to create dense clusters of interpretable topics and keeping important words in topic descriptions (Grootendorst 2022). Firstly, the model transforms input documents into numerical representations. The embedding model used in this study was *all-mpnet-base-v2*, as it performs better in capturing semantic similarity between documents.[1] The vectorizer model used was *Keyphrase Vectorizer*, which can accommodate multiple words to allow for nuanced distinctions between topics. Then UMAP (Uniform Manifold Approximation and Projection) was used to reduce the dimensionality of document embeddings as it can capture both the local and global high-dimensional space in lower dimensions.[2] Embeddings, which in this study refer to the high-dimensional vectors used to represent textual data in a continuous space, were then used to cluster semantically similar documents. Specifically, texts with similar meanings, which are close to each other in the embedding space, were clustered. The third step involved calculating the importance of terms in each cluster leveraging a class-based TF-IDF method, thereby facilitating easier interpretation of the topics of the clusters.

1 See details at https://www.sbert.net/docs/pretrained_models.html.

2 See details at https://maartengr.github.io/BERTopic/getting_started/dim_reduction/dim_reduction.html.

Statistical analysis

This study excluded from statistical analysis cities with less than 50 photos related to green–blue spaces. As a result, the dataset contained 30,735 photos of green–blue spaces across 175 cities. Firstly, to explore the association between aesthetic appreciation of UGBSs and subjective well-being, a linear regression analysis was performed using the lme4 package in R, after testing data normality (skewness value = -0.13, fell within ± 2). However, previous study shows the complexity of the nature–health relationship (White et al. 2021). Taking the frequency of green–blue space photos as a proxy of perceived appreciation of UGBSs, this study further explores its relationship with subjective well-being, taking economic factors into account. Drawing on prior evidence of a strong association between income and subjective well-being (Clark et al. 2008; Jebb et al. 2018), cities were grouped based on four income levels—high, upper middle, lower middle and low—based on the World Bank's country-level income classifications for the years 2017 to 2018. Subsequently, the frequency of green–blue space photographs and categorical income levels were entered as predictors in the analysis. Subjective well-being score was entered as the outcome variable. This was derived from cities' global happiness rankings (Helliwell et al. 2020), which show the average life evaluations of residents during the period 2014 to 2018, based on at least 300 observations. A linear regression analysis incorporating an interaction effect between number of blue–green space photographs and income levels was conducted. Finally, One-way ANOVA was performed to examine whether significant differences exist in the average subjective well-being scores across various levels of income.

Results

Correlations between photos of green–blue spaces and subjective well-being

Two models were constructed to explore the nature–health relationship. Figure 2a (Model 1) shows the association between the logarithm of the frequency of green–blue space photos and subjective well-being score, where the p-value is 8.47e-05 (< 0.05) with an adjusted R-squared of 0.08. It suggests that the frequency of green–blue photos is significantly associated with subjective well-being. Figure 2b (Model 2) shows the relationship between subjective well-being score, logarithm of the frequency of green–blue space photos, and income levels, including their interaction effects. It provides a more nuanced understanding of how income levels influence the nature–health relationship. The fitted lines have different slopes and positions, suggesting an interaction effect between photo frequency and income level in predicting subjective well-being. The association between the frequency of green–blue space photos and subjective well-being is positively significant at high income level, where the p-value

is 0.027 (< 0.05). However, the associations are not significant at other income levels. Although a positive association exists at high, upper middle and lower middle income levels respectively, the association is negative at low income level. This indicates the complexity of the nature–health relationship at different income levels. Compared with the previous regression model, this model explained a substantial proportion of the variance in subjective well-being score, evidenced by the adjusted R squared rises from 0.08 to 0.603. Finally, the results of One-way ANOVA revealed a significant effect of income on subjective well-being (p-value < 0.001).

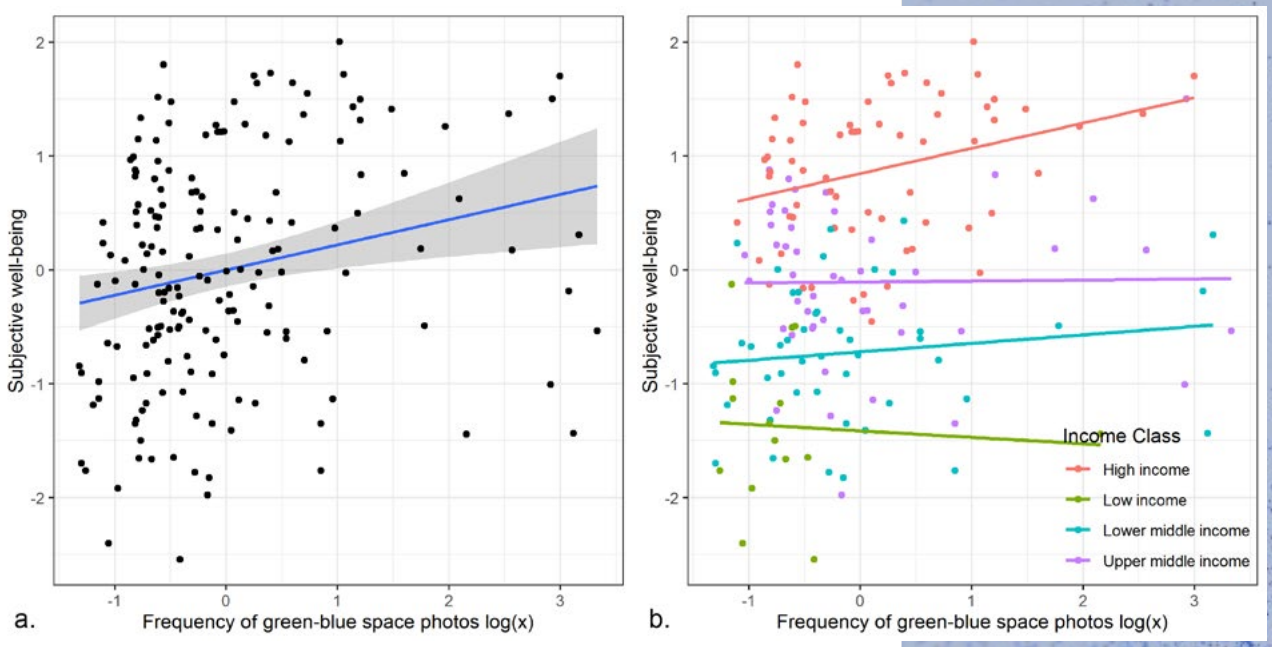

Figure 2. Linear regression of subjective well-being and frequency of green–blue photos in general (a) and at four income levels (b). a. The blue line represents fitted regression, and the grey bands represent the 95% confidence interval limits. b. The four lines represent fitted regression at different income levels, respectively.

Topics of landscape photographs

Figure 3 illustrates a fine-grained visualisation of clusters of photograph topics, based on analysis of the semantic content of UGBSs. It depicts the distribution of topics in two-dimensional space, revealing the relationships among various topics. The closer two vectors are in this space, the more similar the meanings of their respective topics. The photographs' top ten topics are identified and highlighted. These topics indicate two distinct types of landscape spaces in urban environments: blue spaces and green spaces. Notably, the category of blue space contains a wider array of top topics, when compared to green space, suggesting a more diverse aesthetic appreciation for blue space. Specifically, scenes featuring animals, activities, and structures related to blue spaces as well as different waterfronts (e.g., coastal and riverbank

sites) are frequently documented and preferred. Conversely, green space photographs predominantly capture mountainous terrains and the aesthetics of trees. Figure 4 illustrates the proportion of photographs across the top ten topics in sampled cities. The description of outliers reveals a common perception of urban green spaces across these cities.

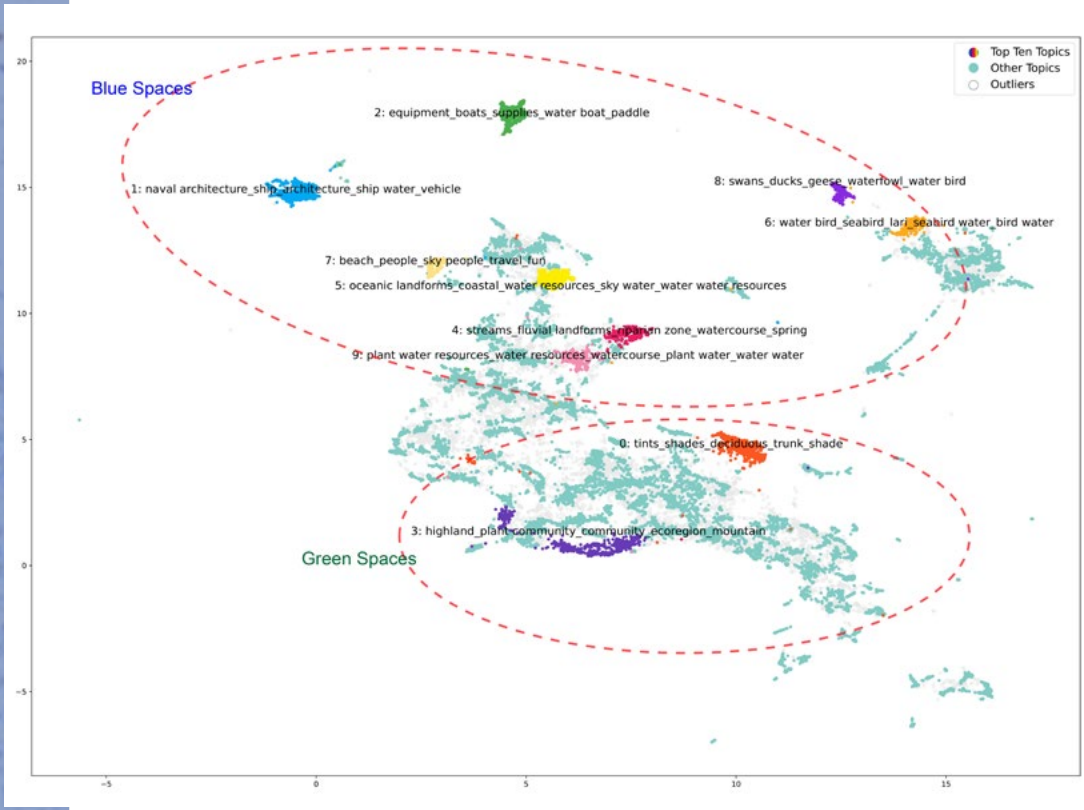

Figure 3. Visualisation of topics of UGBS photographs and their relationships: the top ten topics are highlighted in different colours.

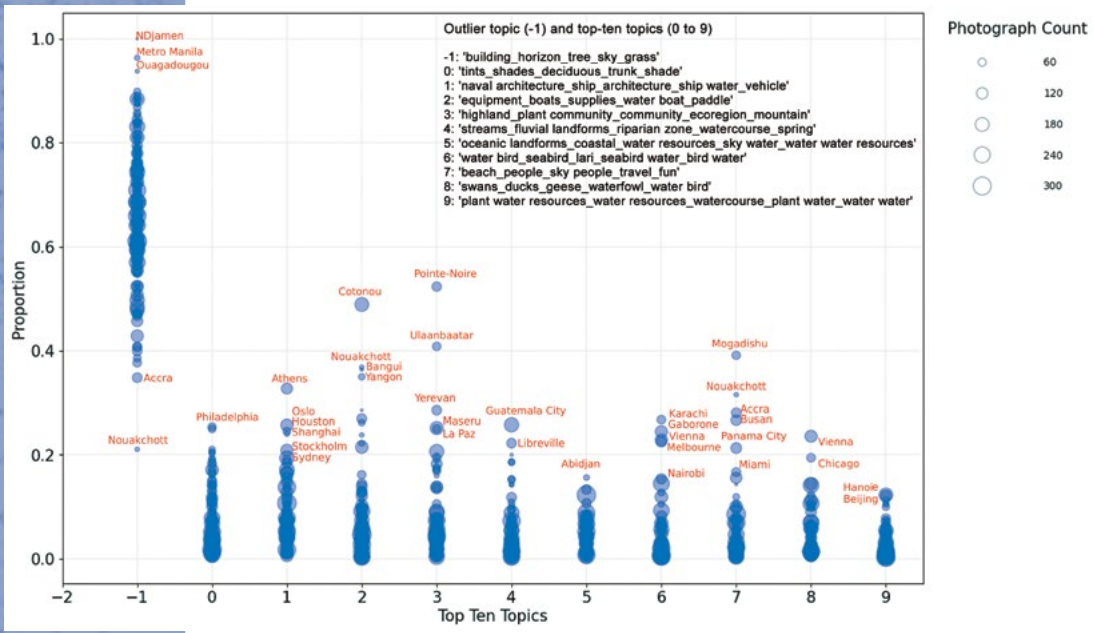

Figure 4. Proportion of photographs depicting the top ten topics across different cities, with each circle representing a single city.

Discussion

Blue space as key context for photography practice

The first research question (What does a photoable green–blue space look like?) was answered. Green and blue spaces were the two main contexts identified from photos of landscapes in cities. The importance of blue space is confirmed as an important aspect of perceived landscape values, evidenced by the result of topic modelling: eight out of the top ten topics prominently featured water. Diverse experiences of nature in blue space were documented and shared through social media. The variety of water-related topics captured in these photographs suggests the rich affordability of blue space, such as for water activities or bird watching. It is worth noting that boating (Clusters 1 and 2) and bird watching (Clusters 8 and 6) are densely clustered and far away from other topics within the two-dimensional space modelled in Figure 3, demonstrating their importance as human–environment interactions constituting thematic genres of photography practice in blue space. Regarding potential demand for blue space, the results of the present study are consistent with those of previous studies. For example, our findings accord with Mishra et al.'s (2023) demonstration of how interventions in the water interface area can trigger diverse resultant activities through improving blue space accessibility, place quality and connectivity to the sea (visually and physically), thus increasing the number and density of visitors toward the water's edge. As shown in Figure 3, photo topics that depict coastal landscapes (Cluster 5), riverside views (Cluster 4) or waterscapes (Cluster 9) are in proximity with each other, suggesting a favoured combination of plants, water and landform elements in landscape photos. This is consistent with earlier evidence that the presence of water and high landform features significantly boosts a landscape's scenicness (Herzog 1985; Wherrett 2000). Even cues of the presence of water (e.g., patterns of vegetation and topographic variation) are strong predictors of aesthetic preference (Dramstad et al. 2006).

Images of green–blue spaces across different cities

This study employed photographs of green–blue spaces derived from social media as a proxy of aesthetic appreciation. These typically are of high quality and meaningful to those who take them, and often effectively capture the aesthetically-valuable aspects of their subjects. Turning to this paper's second research question, the results of topic modelling (Figure 4) illustrate large variations across different cities in relation to the main topics of interest in UGBSs. The heterogeneousness of green–blue space is confirmed. The results show clear variation in dominant photo topics among cities, offering useful indications of what people perceive as the most meaningful, scenic and iconic landscapes in different urban contexts. This finding is consistent with recent

studies on the various elements that shape digital photography practice, including people's imagination of places, photography skills, aesthetics and local cultures (Liu 2022). The dominant image of UGBSs may, furthermore, be explained as resulting from local environmental policies, as well as offering a possible means for examining the effectiveness of these policies. For example, in Philadelphia, the dominant image of urban green–blue space is related to trees and forests (Figure 4, Topic 0). Starting in 2011, Philadelphia became the first city in the United States to implement a green approach in urban planning, involving the use of green infrastructure to manage runoff. The city's implementation of green infrastructure policies was accompanied by an increase in tree canopy (Shade and Kremer 2019). Tree canopy is one of the stable land cover types in the spanning 40 years prior to 2011 and has been advanced through the strategic plan for the growth and care of urban forest (Locke et al. 2023).

Aesthetic appreciation of nature and subjective well-being

The third research question concerned whether there is an association between number of photoable green–blue spaces and subjective well-being level. The results of regression analysis show a significant link between a larger number of landscape photos, including green and blue spaces, and higher subjective well-being level across sampled cities at a higher income level. One possible explanation for this is that people documented their positive experiences of visiting green and blue spaces. Evidence from White et al.'s 2021 study showed that the frequency of recreational visits to green and blue spaces within a four-week period was positively associated with well-being. Furthermore, the evidence of photography practice captures and confirms specific ways that people interact with nature, as exhibited, for example, in photographs of bird-related topics and boating. A longitudinal study carried out by Zieris et al. (2023) showed how bird watching, as a means of experiencing nature, can be beneficial for the well-being of nursing home residents, fulfilling the innate human need for contact with nature . It can be hypothesised that photography practice not only documents human–environment interactions that potentially benefit human well-being but also acts as a creative mode of appreciating nature. This is in line with findings from previous studies showing how people try to make and express their sense of place in the process of making and sharing photographic images (Liu 2022).

Limitations and future directions

This study relies on photographs obtained from one social media platform, which may introduce biases into topic identification results. Other social media sites offering photo-sharing services include Facebook, Instagram and Twitter. Leveraging multi-

sourced data might mitigate bias related to users and photo content (Ghermandi et al. 2022). However, these platforms have imposed stringent limitations on content collection and API access, thus restricting access to their rich resources. Moreover, it is important to consider how the specialities of social media platforms differ, and the influence this has on how users understand and utilise them in everyday practice. For example, both professional and amateur photographers often use Flickr as an online archive for their photos, whereas social-oriented platforms, such as Instagram, are favoured for sharing images with a wider range of audiences. This should be taken into consideration when researching landscape preferences, since certain platforms and functionality may lead to homogenous visual representations of human–environment interactions (Arts et al., 2021). Finally, there may in future be greater limitations on automated content retrieval, particularly with the increasing value of crowdsourced data in business. Further, social media data mining primarily relies on official APIs provided by social media platforms, and researchers may lose access to online datasets if these APIs become unavailable.

Future research may employ neural network models to associate textual and visual information in landscape studies. Applying pre-trained image recognition services (e.g., the Google Cloud Vision service used in this study) generates general tags or descriptions of photos. However, there is a need to fine-tune these models to attain more detailed and context-specific image tags or descriptions for landscape photos, thereby better capturing the nuances of landscape preference. Furthermore, the potential negative impacts of photo-taking behaviour, a prevalent means of interacting with the natural environment, on the experience of non-photographing visitors remain unexplored. Lastly, few studies incorporate everyday practices when examining the aesthetic appreciation of landscape. Hence, empirical evidence from different cultural contexts warrants further investigation. Besides, although using country-level income can be indicative of income levels, it is not entirely accurate and leads to bias at the city level, particularly in the comparison of cities within the same country. Future studies might profitably pursue a more fine-grained investigation into the association between quantity of photogenic UGBSs and subjective well-being levels.

Conclusion

Focusing on the intersection of digital technologies, landscape preferences and imaginations of place, this study investigated the content of photographs obtained from social media across 186 cities worldwide and explored the association between subjective well-being and photoable places by coupling automated image recognition and regression model. Regression analysis showed that number of landscape photos was significantly associated with subjective well-being scores across sampled cities at higher income level. This would appear to show that the more photogenic

a city's UGBSs, the happier its citizens, while also suggesting that aesthetic appreciation of urban green–blue space ceases to be significantly related to happiness at low income levels. One possible explanation for this is that photoable green–blue spaces closely relate to the aesthetic appreciation of urban nature. Previous studies have proposed that the aesthetic value of green–blue spaces is one of the benefits provided by cultural ecosystem services (Cooper et al. 2016; Wolff et al. 2015). Previous studies demonstrating the association between scenicness and well-being have been conducted in developed countries, characterised by relatively high income levels among residents (Seresinhe et al. 2015). Content analysis and topic modelling of tags identified from photographs reveal nuances in preferences for blue and green spaces, respectively. The results show a homogenous preference for trees and mountainous landscapes in green spaces, while preferences related to blue spaces are more diverse. Urban planners and designers might profitably employ these findings to focus on those elements shown to elicit aesthetic appreciation and its associated benefits for subjective well-being.

REFERENCES

Arts, I., A. Fischer, D. Duckett, and R. Van Der Wal. 2021. 'Information technology and the optimisation of experience: The role of mobile devices and social media in human–nature interactions.' *Geoforum* 122: 55–62.

Arts, I., A. Fischer, D. Duckett, and R. Van der Wal. 2021. 'The Instagrammable outdoors: Investigating the sharing of nature experiences through visual social media.' *People and Nature* 3 (6): 1244–1256.

Assessment, M. E. 2005. *Ecosystems and human well-being: wetlands and water*. World Resources Institute.

Becker, H., M. Naaman, and L. Gravano. 2010. 'Learning similarity metrics for event identification in social media.' *Proceedings of the third ACM international conference on Web search and data mining.*

Brenner, N., and C. Schmid. 2015. 'Towards a new epistemology of the urban?' *City* 19 (2–3): 151–182.

Buijs, A. E., B. H. Elands, and F. Langers. 2009. 'No wilderness for immigrants: Cultural differences in images of nature and landscape preferences.' *Landscape and urban Planning* 91 (3): 113–123.

Chiang, Y.–C., D. Li, and H.–A. Jane. 2017. 'Wild or tended nature? The effects of landscape location and vegetation density on physiological and psychological responses.' *Landscape and Urban Planning* 167: 72–83.

Clark, A. E., P. Frijters, and M. A. Shields. 2008. 'Relative income, happiness, and utility: An explanation for the Easterlin paradox

and other puzzles.' *Journal of Economic literature* 46 (1): 95–144.

Cooper, N., E. Brady, H. Steen, and R. Bryce. 2016. 'Aesthetic and spiritual values of ecosystems: Recognising the ontological and axiological plurality of cultural ecosystem "services"'. *Ecosystem Services* 21: 218–229.

Coyne, R. 2010. *The tuning of place: sociable spaces and pervasive digital media.* Cambridge, MA: MIT Press.

De Neve, J.–E., and C. Krekel. 2020. 'Cities and happiness: a global ranking and analysis.' In *World Happiness Report 2020:* 14.

Dramstad, W. E., M. S. Tveit, W. Fjellstad, and G. L. Fry. 2006. 'Relationships between visual landscape preferences and map-based indicators of landscape structure.' *Landscape and urban planning* 78 (4): 465–474.

Elmqvist, T., E. Andersson, T. McPhearson, X. Bai, L. Bettencourt, E. Brondizio, . . . and N. Grimm. 2021. 'Urbanization in and for the Anthropocene.' *npj Urban Sustainability* 1 (1): 6.

Figueroa–Alfaro, R. W., and Z. Tang. 2017. 'Evaluating the aesthetic value of cultural ecosystem services by mapping geo-tagged photographs from social media data on Panoramio and Flickr.' *Journal of Environmental Planning and Management,* 60 (2): 266–281.

Fischer, L. K., J. Honold, R. Cvejić, T. Delshammar, S. Hilbert, R. Lafortezza, . . . and A. P. van der Jagt. 2018. 'Beyond green: Broad support for biodiversity in multicultural European cities.' *Global Environmental Change* 49: 35–45.

Ghermandi, A., Y. Depietri, and M. Sinclair. 2022. 'In the AI of the beholder: A comparative analysis of computer vision-assisted characterizations of human–nature interactions in urban green spaces.' *Landscape and Urban Planning* 217: 104261.

Grootendorst, M. 2022. 'BERTopic: Neural topic modeling with a class-based TF-IDF procedure.' *arXiv preprint arXiv:2203.05794.*

Havinga, I., D. Marcos, P. W. Bogaart, L. Hein, and D. Tuia. 2021. 'Social media and deep learning capture the aesthetic quality of the landscape.' *Scientific reports* 11 (1): 20000.

Helliwell, J. F., R. Layard, J. Sachs, and J. E. De Neve. 2020. *World happiness report 2020.*

Herzog, T. R. 1985. 'A cognitive analysis of preference for waterscapes.' *Journal of environmental psychology* 5 (3): 225–241.

Huang, J., H. Obracht–Prondzynska, D. Kamrowska–Zaluska, Y. Sun, and L. Li. 2021. 'The image of the City on social media: A comparative study using "Big Data" and "Small Data" methods in the Tri-City Region in Poland.' *Landscape and Urban Planning* 206: 103977.

Hunt, J. D. 1992. *Gardens and the picturesque: studies in the history of landscape architecture.* Cambridge, MA: MIT Press.

Hwang, Y. H., Z. E. J. Yue, S. K. Ling, and H. H. V. Tan. 2019. 'It's ok to be wilder: Preference for natural growth in urban green spaces in a tropical city.' *Urban Forestry & Urban Greening* 38: 165–176.

Jebb, A. T., L. Tay, E. Diener, and S. Oishi. 2018. 'Happiness, income satiation and turning points around the world.' *Nature Human Behaviour 2 (*1): 33–38.

Jiang, Y., and T. Yuan. 2017. 'Public perceptions and preferences for wildflower meadows in Beijing, China.' *Urban Forestry & Urban Greening 27*: 324–331.

Jorgensen, A. 2011. 'Beyond the view: Future directions in landscape aesthetics research.' *Landscape and urban planning* 100 (4): 353–355.

Kennedy, L., M. Naaman, S. Ahern, R. Nair, and T. Rattenbury. 2007. 'How flickr helps us make sense of the world: context and content in community-contributed media collections.' *Proceedings of the 15th ACM international conference on Multimedia.*

Labib, S., S. Lindley, and J. J. Huck. 2020. 'Spatial dimensions of the influence of urban green-blue spaces on human health: A systematic review.' *Environmental research* 180: 108869.

Li, X.–P., S.–X. Fan, N. Kühn, L. Dong, and P.–Y. Hao. 2019. 'Residents' ecological and aesthetical perceptions toward spontaneous vegetation in urban parks in China.' *Urban Forestry & Urban Greening* 44:, 126397.

Liu, C. 2022. 'Imag (in) ing place: Reframing photography practices and affective social media platforms.' *Geoforum* 129: 172–180.

Liu, Z., C. He, and J. Wu. 2016. 'The relationship between habitat loss and fragmentation during urbanization: an empirical evaluation from 16 world cities.' *PLoS One* 11 (4): e0154613.

Locke, D. H., L. A. Roman, J. G. Henning, and M. Healy. 2023. 'Four decades of urban land cover change in Philadelphia.' *Landscape and Urban Planning* 236: 104764.

McDonald, R. I., P. J. Marcotullio, and B. Güneralp. 2013. 'Urbanization and global trends in biodiversity and ecosystem services.' In *Urbanization, biodiversity and ecosystem services: challenges and opportunities: a global assessment*, edited by Thomas Elmqvist et al.: 31–52. Dordrecht: Springer.

Mishra, H. S., S. Bell, B. R. Roberts, and M. P. White. 2023. 'Theory-based design for promoting positive behaviours in an urban blue space: Pre-and-post observations of a community co-created intervention in Plymouth, United Kingdom.' *Landscape and Urban Planning* 233: 104708.

Müller, N., M. Ignatieva, C. H. Nilon, P. Werner, and W. C. Zipperer. 2013. 'Patterns and trends in urban biodiversity and landscape design.' In *Urbanization, biodiversity and ecosystem services: challenges and opportunities: a global assessment*, edited by Thomas Elmqvist et al.: 123–174. Dordrecht: Springer.

Pacione, M. 2003. 'Urban environmental quality and human wellbeing—a social geographical perspective.' *Landscape and urban planning* 65 (1–2): 19–30.

Ryan, R. L. 2012. 'The influence of landscape preference and environmental education on public attitudes toward wildfire management in the Northeast pine barrens (USA).' *Landscape and Urban Planning* 107 (1): 55–68.

Schenker, H. 2009. *Melodramatic Landscapes: Urban Parks in the Nineteenth Century.* Charlottesville, VA: University of Virginia Press.

Seifollahi–Aghmiuni, S., Z. Kalantari, G. Egidi, L. Gaburova, and L. Salvati. 2022. 'Urbanisation-driven land degradation and socioeconomic challenges in peri-urban areas: Insights from Southern Europe.' *Ambio* 51 (6): 1446–1458.

Seresinhe, C. I., T. Preis, G. MacKerron, and H. S. Moat. 2019. 'Happiness is greater in more scenic locations.' *Scientific reports 9 (1): 1–11.*

Seresinhe, C. I., T. Preis, and H. S. Moat. 2015. 'Quantifying the impact of scenic environments on health.' *Scientific reports 5* (1): 1–9.

Shade, C., and P. Kremer. 2019. 'Predicting land use changes in Philadelphia following green infrastructure policies.' *Land* 8 (2): 28.

Shahid, N., M. U. Ilyas, J. S. Alowibdi, and N. R. Aljohani. 2017. 'Word cloud segmentation for simplified exploration of trending topics on Twitter.' *IET Software* 11 (5): 214–220.

Smith, S. P. 2021. 'Landscapes for "likes": capitalizing on travel with Instagram.' *Social Semiotics* 31 (4): 604–624.

Stefanidis, A., A. Crooks, and J. Radzikowski. 2013. 'Harvesting ambient geospatial information from social media feeds.' *GeoJournal* 78 (2): 319–338.

Tieskens, K. F., B. T. Van Zanten, C. J. Schulp, and P. H. Verburg. 2018. 'Aesthetic appreciation of the cultural landscape through social media: An analysis of revealed preference in the Dutch river landscape.' *Landscape and urban planning* 177: 128–137.

Tran, H., D. Uchihama, S. Ochi, and Y. Yasuoka. 2006. 'Assessment with satellite data of the urban heat island effects in Asian mega cities.' *International journal of applied Earth observation and Geoinformation*, 8 (1): 34–48.

Turner, W. R., T. Nakamura, and M. Dinetti. 2004. 'Global urbanization and the separation of humans from nature.' *Bioscience* 54 (6): 585–590.

Wartmann, F. M., and W. A. Mackaness. 2020. 'Describing and mapping where people experience tranquillity. An exploration based on interviews and Flickr photographs.' *Landscape Research* 45 (5): 662–681.

Wherrett, J. R. 2000. 'Creating landscape preference models using internet survey techniques.' *Landscape research* 25 (1): 79–96.

White, M. P., L. R. Elliott, J. Grellier, T. Economou, S. Bell, G. N. Bratman,. . . and M. Lõhmus. 2021. 'Associations between green/blue spaces and mental health across 18 countries.' *Scientific reports* 11 (1): 8903.

Wolff, S., C. Schulp, and P. Verburg. 2015. 'Mapping ecosystem services demand: A review of current research and future perspectives.' *Ecological Indicators* 55: 159–171.

Yang, C., M. Xiao, X. Ding, W. Tian, Y. Zhai, J. Chen,. . . and X. Ye. 2019. 'Exploring human mobility patterns using geo-tagged social media data at the group level.' *Journal of Spatial Science* 64 (2): 221–238.

Yao, L., T. Li, M. Xu, and Y. Xu. 2020. 'How the landscape features of urban green space impact seasonal land surface temperatures at a city-block-scale: An urban heat island study in Beijing, China.' *Urban Forestry & Urban Greening* 52: 126704.

Zheng, B., Y. Zhang, and J. Chen. 2011. 'Preference to home landscape: wildness or neatness?' *Landscape and Urban planning* 99 (1): 1–8.

Zieris, P., S. Freund, and E. Kals. 2023. 'Nature experience and well-being: Bird watching as an intervention in nursing homes to maintain cognitive resources, mobility, and biopsychosocial health.' *Journal of Environmental Psychology* 91: 102139.