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RESEARCH ARTICLE

Valuing the cultural services from urban blue-space ecosystems in Japanese megacities during the COVID-19 pandemic

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Abstract

1. The COVID-19 pandemic is an outstanding global threat for both human health and well-being. Under the pandemic, green spaces are known to mitigate the physical/mental stress of urban people. However, it remains unclarified how blue spaces such as coastal and river areas play a role in healing urban people's health and well-being during the pandemic.
2. Here, conducting an online-based survey in Japanese megacities, with 5756 responses received from residents of Tokyo, Yokohama, Osaka and Kobe, we examined the effects of personal characteristics of city residents on their visitation frequencies to blue spaces during and after the emergency periods, and compared visitation purposes and motivation between the coastal and river areas. Cumulative linear modelling revealed that people with more nature experiences in childhood and higher satisfaction of neighbourhood coasts and rivers visited urban blue spaces more frequently. In addition, those who lived with pre-school and primary school children also visited urban blue spaces more frequently than those without, likely for letting them play in blue spaces. These people primarily visited them to decrease their stress and to maintain their health by contacting with nature while keeping social distance to avoid being infected. Moreover, the visitation purpose and motivation partly differed between the coastal and river areas, which could be explained by the accessibility to and perception of blue spaces for urban people.
3. The present study implies that, as well as green spaces, blue spaces provided places that people in urban areas could use to mitigate their stress and disorder during the pandemic. Our findings underpin the necessity of preserving both of them in urban planning for further benefits relating to health and well-being.

KEYWORDS
blue space, COVID-19, cultural service, pandemic, urban ecosystems

All the authors equally contributed to the work. [Correction added on 21 July 2022, after first online publication: The equal contribution statement has been added.]

1 | INTRODUCTION

Since December 2019, the COVID-19 pandemic, caused by a novel coronavirus (SARS-CoV-2) severely affecting the human respiratory system (Lewnard & Lo, 2020), has been a significant threat worldwide. To date, this notorious virus has infected more than 400 million people and caused more than 5.7 million deaths globally (as of 11 February 2022; WHO Coronavirus Disease Dashboard). The unprecedented pandemic has drastically altered the lifestyle of citizens; to prevent the outbreak of the virus mediated by human-to-human transmissions, the government has restricted their economic, social activities and mobility by introducing policies such as lockdowns, forcing physical distancing (social distancing) and limiting the use of public space (Honey-Rosés et al., 2020; Musselwhite et al., 2020). In Japan, particularly from April to May 2020, when the first state of emergency took place, people were also asked to refrain from non-essential excursions. However, this was not compulsory and largely depended on a personal decision-making. Schools and businesses were requested to close unless it was necessary that they remained open, with some commercial facilities also closing (Soga, Evans, Tsuchiya, & Fukano, 2021). Although these political approaches have proven to be effective in decelerating the pace of COVID-19 spread (Hsiang et al., 2020; Koo et al., 2020), the situation has stagnated the economy, increased unemployment due to closure of industries, decreased the opportunity of education due to school closures, and negatively impacted the physical and mental health of urban people, such as disorders, depression and loneliness (Li & Wang, 2020; Rajkumar, 2020). These challenging situations pose serious stress on people that needs to be alleviated in a restricted manner.

Cultural ecosystem services can potentially function as a solution to physical and mental stress during the pandemic. Since ancient times, human beings have perceived the esthetical, spiritual, educative and scientific values of natural landscapes and ecosystems, and have enjoyed their multifaceted cultural services (Hernández-Morcillo et al., 2013; Völker & Kistemann, 2011). Many studies have indicated that contact with nature can reduce mental disorders and improve mental health (Barton & Pretty, 2010; Berman et al., 2008; Bratman et al., 2012; Maller et al., 2006). In the era of the COVID-19 pandemic, urban people tend to visit their surrounding environments and pursue their well-being (e.g. Grima et al., 2020; Soga, Evans, Cox, & Gaston, 2021; Soga, Evans, Tsuchiya, & Fukano, 2021; Venter et al., 2020). Natural environments offer one of the only available alternatives for urban people's recreation and socializing during the pandemic. It can also assist in avoiding 'three Cs' (i.e. closed spaces, crowds and close contact; Hayasaki, 2020), as proposed by the Japanese government to prevent a cluster infection of SARS-CoV-2. These studies have allowed us to reconsider the importance of urban natural areas for improved physical and mental health during the pandemic. However, much of the research has been limited to green spaces such as mountains, forests, parks and farmlands (WHO Regional Office for Europe, 2021).

There is an increasing awareness that urban blue spaces, such as the sea, coastlines and inland water bodies, can also positively influence the urban people's health during the pandemic (Pouso et al., 2021; Vert et al., 2020; WHO Regional Office for Europe, 2021). Blue spaces offer opportunities for water-related (e.g. recreational fishing and marine/river sports) and non-water-related (e.g. nature observation, walking, cycling) activities, aesthetic experiences (e.g. beauty, purity, magnificence and cruelty) and cultural heritage (Costanza, 1999; Millennium Ecosystem Assessment, 2005; Rock et al., 2020; Thiele et al., 2020). Although a few studies have recently reported the importance of blue spaces on the physical and mental health of urban residents (e.g. de Bell et al., 2017; Pasanen et al., 2019; Vert et al., 2020), the relationship between blue spaces and health has often been discussed from the ecological, toxicological and microbiological perspectives (e.g. Harwood et al., 2005; Ramos & Aguiló, 1988) with limited discussion from the perspective of human well-being, especially under the COVID-19 pandemic. Since the rise of the cradle of civilization, large cities have often been formed and developed in riparian and estuary zones and such blue spaces should be familiar and important ecosystems for urban people. Besides, riverine and coastal areas may easily offer enough space to avoid the three Cs contrary to green spaces within urban areas (e.g. parks, gardens, playgrounds). Together with green spaces, understanding the personal characteristics, purpose and motivation of urban people who access blue spaces enables us to recognize their importance in urban planning as a refuge to heal and socially interact in the context of the COVID-19 and a possibly future pandemic.

In this study, we targeted the four largest cities in two Japanese megacities (Tokyo, Yokohama, Osaka and Kobe). These densely populated cities in Japan were prioritized to maintain a state of emergency from April to May 2020 in the long term, relative to other prefectures in Japan. The research interest in this study encompasses the following questions. (i) What personal characteristics encourage urban people to access blue spaces increasingly during and after the state of emergency, (ii) What purpose and motivation do urban people have when accessing blue spaces during the state of emergency and (iii) What are the similarities and differences in cultural services that urban people can enjoy between coastal and river areas? We therefore targeted the megacities to investigate the frequencies of urban people visiting the coasts and rivers and their detailed contents during and after the emergency period. Furthermore, we discussed how urban blue spaces could function in improving physical and mental health for people during the COVID-19 pandemic.

2 | MATERIALS AND METHODS

2.1 | Study area

The studied areas comprised the top three (Tokyo, Yokohama and Osaka) and the sixth (Kobe) largest cities in Japan (Figure 1). Tokyo and Yokohama are part of the Tokyo megacity, the largest metropolitan area worldwide, with 38.0 million people inhabiting 8230 km^2; Osaka and Kobe are part of the Kansai region, Japan's second largest metropolitan area, with 15.0 million people inhabiting 3019 km^2 (Demographia World Areas, 2020). Tokyo (exactly 23 wards in central Tokyo were targeted here), the capital city of

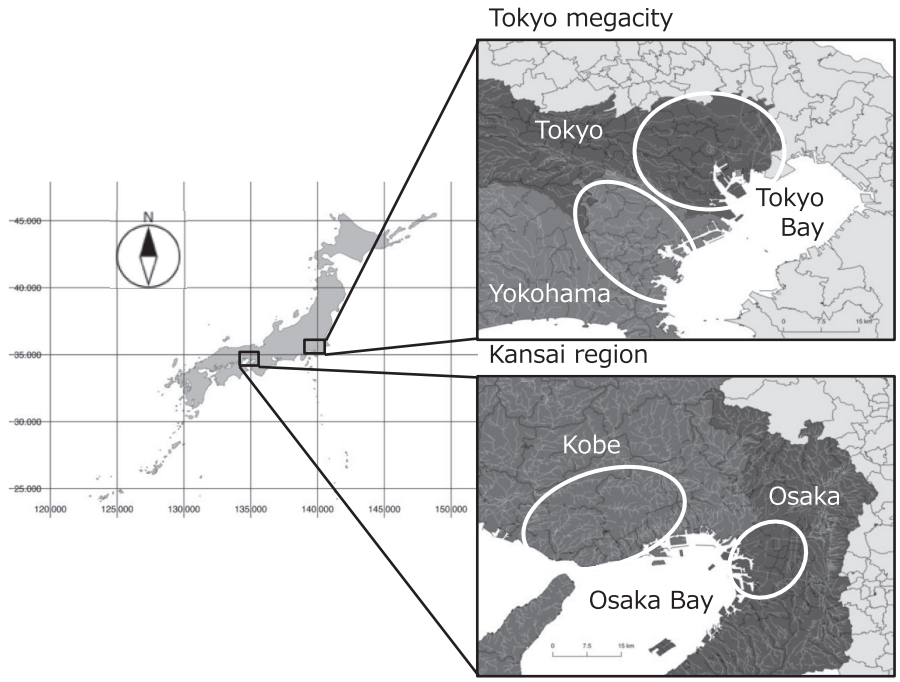

FIGURE 1 Location and demographics of the studied areas in Japan. Each target urban area is shown within white ellipse.

Japan, has approximately 9.3 million people inhabiting an area of 627.5 km^2 (Ministry of Internal Affairs and Communications Statistics Bureau, 2017). Yokohama is located near the capital, with 3.7 million people inhabiting an area of 435.5 km^2. Osaka and Kobe are central to the Kansai region, with approximately 2.7 and 1.5 million people inhabiting areas of 225.3 and 557.0 km^2, respectively (Figure 1). Tokyo has rivers with large watershed areas, such as the Ara, Sumida and Tama Rivers, and with smaller rivers in Yokohama, all of which flow into Tokyo Bay. In Osaka, the Yodo River, the largest river in the Kansai region, flows into Osaka Bay. Kobe facing Osaka Bay has several rivers with smaller watershed areas than other cities.

2.2 | Experimental design

The data were collected using an Internet-based social survey between 2 and 9 November 2020. At the time of data collection, COVID-19 infection was increasing again nationally after the state of the emergency was cancelled during May 2020. A total of 25,982 people in Tokyo, Yokohama, Osaka and Kobe were asked to answer 43 questions developed by the authors on awareness about and reality of the use of surrounding nature. Intage Inc., the largest research company in Japan, collected 5756 valid responses to the survey from residents of four megacities in Japan (Table S1). The response rate was 22.2%. The sample collection was designed to be proportional to the actual population distribution in each city by gender and age across 10-year increments. Sampling for women in Kobe over the age of 70 was approximately 12% below the original study design, but the remainder of the sampling was undertaken as planned. This study was approved by the Graduate School of Human Development and Environment, Kobe University, after undergoing a research ethics review (approval number: 458). This survey was commissioned by a specialized social research company, and data were collected from only those who consented to the survey in a manner that does not identify individuals, and were used solely for statistical analysis. The data were managed in such a way that they will not be used for any purpose other than the research purpose. The survey first explained to respondents the intention of the survey and that it would be tabulated in such a way that individual respondents could not be identified. A procedure was then followed whereby questions were only initiated if they were able to consent to the survey.

Each respondent was enquired regarding their personal information, including demographics, occupation, annual income, number of children and nature experiences in childhood (Table 1a). In addition, we asked the respondents regarding behavioural changes in stay-at-home duration and respective frequencies of visits to coastal and river areas during the first state of emergency (7 April to 21 May 2020 in Osaka and Kobe; 25 May 2020 in Tokyo and Yokohama) declared due to the COVID-19 pandemic, and after the emergency period (early July) (Table 1b). The frequencies of visits to coastal areas during and after the emergency period were referred to as During_Sea and After_Sea, respectively, while those to river areas during and after the emergency period were referred to as During_River and After_River, respectively.

2.3 | Statistical analyses

All statistical analyses were performed using R version 4.0.4 (R Core Team, 2021). The visitation frequencies to coastal and river areas during and after the emergency period were examined, followed by the changes in the frequencies, depending on the residents'

TABLE 1 Questionnaire items in this study regarding respondents' personal information and behavioural changes in relation to the COVID-19 pandemic

(a) Personal information	
Variable	**Definition**
Sex	Male = 1/Female = 2
Age (years)	From 20 to 92
Address	Identified at the zip-code level
Occupation	Office, public and contract workers = 1 Self-employed and professional workers = 2 Part-time job = 3 Under-/post-graduate and vocational school students = 4 Full-time homemakers = 5; Others = 6 (e.g. the unemployed)
Annual income	14 levels ranging from less than 1 million to more than 20 million Japanese yen (1 USD ≒ 110 JPY)
Number of infants, preschoolers, and primary school students per respondent	None = 1; One = 2; Two = 3; Three or more = 4
Nature experiences in childhood (before junior high school)	Including the experiences of collecting and/or rearing animals and plants, and recreation in mountains, coastal areas, rivers, farmlands and greened parks 10 levels from 1 to 10; a larger number indicates repeated experiences
(b) Behavioural changes in relation to the COVID-19 pandemic	
Variable	**Definition**
Changes in stay-at-home duration during the state of emergency compared to an ordinary year	Significantly decreased = 1; slightly decreased = 2 No change = 3; slightly increased = 4 Significantly increased = 5; practically stayed home = 6
Subjective (i.e. self-reported) satisfaction of coastal and river areas around the respondents' residential areas (referred to as sea and river subjective satisfaction)	Significantly lacking = 1; slightly lacking = 2 Not sure = 3; slightly satisfied = 4; significantly satisfied = 5
Frequencies of visits to coastal and river areas during and after the emergency period (referred to as During_Sea, During_River, After_Sea, and After_River)	Never = 1; once or twice = 2; every 2 weeks = 3 One to three times per week = 4; almost every day = 5
Changes in visiting frequencies to coastal and river areas (referred to as Change_Sea and Change_River)	Calculated by deducting the choice number in During_Sea or During_River from those in After_Sea or After_River 9 levels ranging from −4 to 4
Purpose of visitation[a]	Feeling at ease or just getting outdoors = 1 Walking = 2; walking with pet = 3; Jogging = 4 Cycling = 5; Exercising = 6; taking photos or sketching = 7 Collecting and/or observing animals and plants = 8 Fishing = 9; Cruising = 9′ (only for visits to coastal areas) Swimming or other marine/river sports = 10 Eating and/or drinking = 11 Preparing children's playgrounds = 12; others = 13
Motivation of visitation[a]	Contacting with nature = 1 Decreasing the respondent's stress = 2 Decreasing the stress of the respondent's family = 3 Maintaining physical health = 4; wanting to be alone = 5 Getting outdoors while avoiding three Cs = 6 Nowhere to go = 7; just killing time = 8 Wanting to see and talk with someone = 9 Getting outside freely = 10 Getting outside without spending money = 11; others = 12
Companion of visitation[a]	By him/herself = 1; with a partner = 2 With a child or children = 3 With other family member(s) = 4; with pet(s) = 5 With friend(s) = 6; others = 7
Transportation means[a]	By walking, jogging and/or running = 1 By cycling = 2; by car and/or motorbike = 3 By public transportation = 4
Transportation time[a]	Within 10 min = 1; within 30 min = 2 Within an hour = 3; longer than an hour = 4

[a]Only if the respondents visited coastal or river areas at least once during the emergency period.

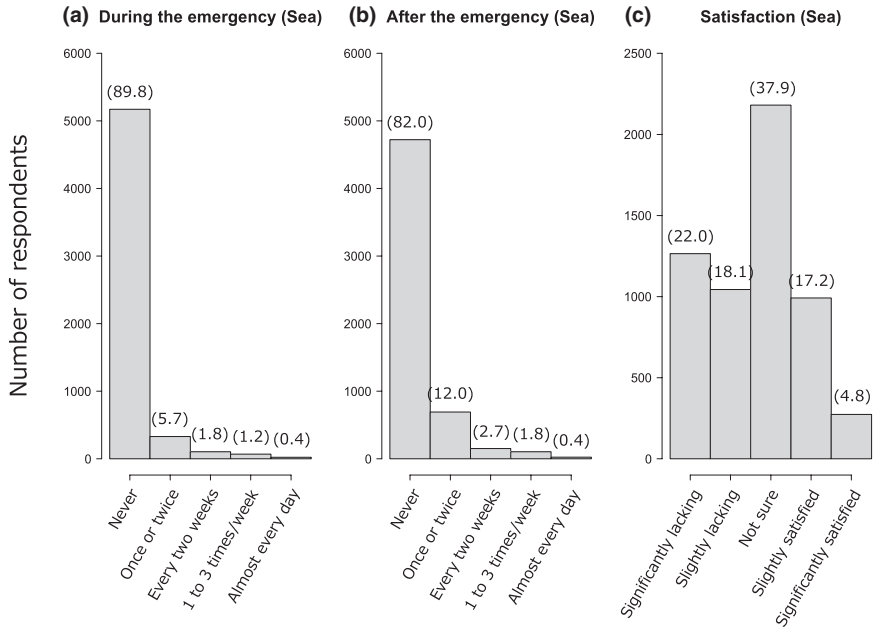

FIGURE 2 Histograms representing respective visitation frequency to coastal areas (a) during and (b) after the emergency period, and (c) self-reported (i.e. subjective) satisfaction of coastal areas. Numerals in parenthesis are the proportion of the respondents (%) selecting each choice. Sum of the proportions may not be 100% due to a small number of the respondents not answering to the questions.

personal characteristics. We performed a cumulative linear modelling (CLM) with an ordinal logit function, appropriate for modelling ordinal choices, using *clm* function in the package 'ORDINAL' (Christensen, 2019), where six types of dependent variables were set individually: During_Sea, After_Sea, Change_Sea, During_River, After_River and Change_River.

The variables Change_Sea and Change_River were defined as changes in the frequency of visits to coastal and river areas after the emergency, in comparison with those during the emergency; the higher the order, the higher the increment of visiting frequency to blue spaces following the cancellation of the emergency. For each dependent variable, we included sex, age, occupation, annual income, number of family members, nature experience, city area and stay-at-home duration as explanatory variables. In addition, sea or river satisfaction was included in the models that studied visitation frequencies to coastal or river areas. Moreover, During_Sea and During_River were only included in the models considering After_Sea and After_River, respectively, where we hypothesized that people who visited blue spaces during the emergency period were more likely to re-visit after the period.

Moreover, by targeting the respondents who visited coastal or river areas at least once during the emergency period ($N = 528$ for coastal and $N = 743$ for river areas in four urban areas), we examined how and why urban people accessed coastal and/or river areas during the emergency period. The online-based survey included questionnaires regarding purpose, motivation, companion, and transportation means and the time of visits to each blue space (Table 1b). We calculated the proportion of respondents selecting each choice to everyone who visited each type of blue space during the emergency period. Furthermore, we were interested in the background of urban people visiting blue spaces while avoiding three Cs. We performed generalized linear modelling (GLM) with a binomial function for the choice (1/0) of 'getting outdoors while avoiding three Cs'. We included sex, age, occupation, annual income, family member, nature experience, city area, stay-at-home duration and sea or river satisfaction as explanatory variables. We calculated the generalized variance inflation factors (GVIF) using *vif* function in the package 'CAR' (Fox & Weisberg, 2019), and confirmed that the multicollinearity among the variables was not high (1.025–2.342).

3 | RESULTS

3.1 | Visits by urban people to blue spaces during and after the state of emergency

Among all the respondents, 42.0% were employed as office workers, 56.5% lived alone or with another person, 5.2% had no childhood experiences with nature and 62.0% increased their stay-at-home duration during the emergency period (Figure S1). Most megacity residents in Japan had access to neither the coastal nor river areas during and after the emergency period, while the visitation frequencies increased slightly after the emergency (Figures 2 and 3). Sea and river satisfaction tended to be low, which depended on the city area (Figure S3).

CLMs showed that, both during and after the emergency period, the visitation frequencies to coastal and river areas were significantly higher in those with higher nature experiences in childhood and those who were more satisfied with the neighbouring coastal and river areas (Table 2). In addition, the respondents in Yokohama and Kobe visited coastal areas more frequently than those in Tokyo, and

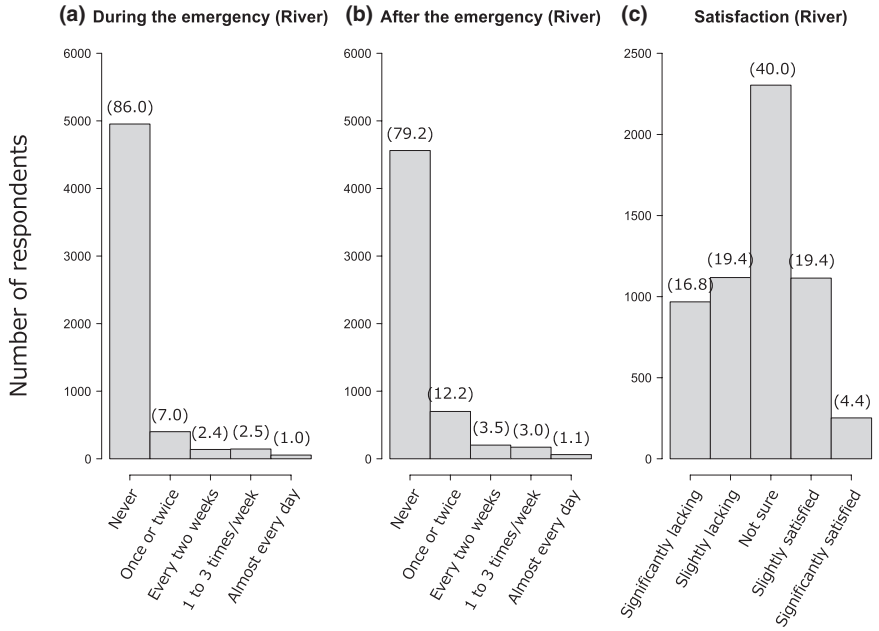

FIGURE 3 Histograms representing respective visitation frequency to river areas (a) during and (b) after the emergency period, and (c) self-reported (i.e. subjective) satisfaction of river areas. Numerals in parenthesis are the proportion of the respondents (%) selecting each choice. Sum of the proportions may not be 100% due to a small number of the respondents not answering to the questions.

those who lived with pre-school and primary school children also had a higher visitation frequency to blue spaces. During the emergency period, males visited both types of blue spaces more frequently than females, and self-employed and part-time job workers who might be economically less stable than office workers, visited coastal areas less frequently than office workers (Table 2a,c). Meanwhile, after the period, urban people who had more income, experienced longer stay-at home duration and visited blue spaces during the emergency period visited blue spaces significantly more frequently than those did not (Table 2b,d). Younger people visited coastal areas more frequently regardless of the emergency period, whereas no significant relationships were observed between age and visitation frequencies to rivers during and after the emergency period. Moreover, CLMs also showed that urban people who had lower nature experiences and shorter duration of stay-at-home increased their visits to coastal areas after the emergency period, whereas those with higher experiences and longer duration of stay-at-home increased their visits to river areas (Table 2e,f). In addition, younger people and those living with primary school children increased their visits to coastal and river areas, respectively, and people with higher income decreased their visits to coastal areas after the emergency period.

3.2 | Specific purpose and motivation of visits to blue spaces

Most respondents visited blue spaces to feel at ease or just get outdoors (53.2% for coasts and 33.5% for rivers) or walking (56.4% for coasts and 63.0% for rivers) (Figure 4). The subsequent purposes for coastal areas were fishing (14.4%), swimming or other marine sports (12.3%) and taking photos or sketching (10.0%), while river areas included collecting and/or observing animals and plants (18.3%), exercising (17.2%) and taking photos or sketching (10.1%). The main motivations for these activities were credited to contacting with nature (48.5% for coasts and 42.8% for rivers), decreasing the respondents' stress (46.4% for coasts and 45.4% for rivers) and getting outdoors while avoiding three C's (i.e. closed spaces, crowds and close contact) (35.2% for coasts and 34.9% for rivers). Moreover, the proportions of maintaining physical health (42.5%) and getting outdoors freely (40.9%) were particularly high for rivers than for coastal areas (28.2% and 28.0%, respectively). The respondents visited blue spaces mostly alone, or with a partner, or with child/children (Figure S4). Most river visitors used the areas closer in time and travelled on foot or by bicycle compared to sea visitors, who travelled in cars and public transportation more frequently and spent more time to arrive at their destination (Figures S5 and S6). GLMs showed that people who had higher experiences of nature interaction in childhood and subjective satisfaction with neighbourhood blue spaces tended to visit them more frequently with avoiding Cs (Table 3). In addition, part-time job workers visited coastal areas less frequently and people living with preschoolers visited river areas more frequently.

4 | DISCUSSION

4.1 | Visits by urban people to blue spaces during and after the state of emergency

In several countries, people increased their visits to green spaces during the COVID-19 outbreak compared to an ordinary year (Geng et al., 2021; Grima et al., 2020; Venter et al., 2020). In contrast, we found that most Japanese people did not access either of these

TABLE 2 Summary of the cumulative linear modelling (CLM)

	(a) During_Sea			(b) After_Sea		
Variables	**Estimate**	**SE**	***p* value**	**Estimate**	**SE**	***p* value**
Sex	−0.237	0.089	0.008**	−0.041	0.076	0.591
Age	−0.008	0.004	0.044*	−0.008	0.003	0.016*
Occupation (self-employed and professional workers)	−0.497	0.249	0.046*	0.171	0.181	0.343
Occupation (part-time job)	−0.571	0.215	0.008**	−0.206	0.171	0.227
Occupation (under-/post-graduate and vocational school students)	0.151	0.282	0.592	0.168	0.241	0.486
Occupation (full-time homemakers)	0.020	0.186	0.916	−0.185	0.163	0.257
Occupation (others)	0.062	0.173	0.721	−0.166	0.161	0.303
Income	0.022	0.017	0.196	0.043	0.015	0.004**
Number of infants	0.398	0.097	0.000***	0.116	0.102	0.257
Number of preschoolers	0.206	0.146	0.159	0.169	0.135	0.210
Number of primary school students	0.352	0.111	0.002**	0.120	0.107	0.260
Nature experience	0.071	0.022	0.002**	0.114	0.021	<0.001***
City (Yokohama)	0.291	0.152	0.055.	0.298	0.130	0.022*
City (Osaka)	0.123	0.166	0.459	0.186	0.136	0.170
City (Kobe)	0.300	0.149	0.044*	0.261	0.131	0.047*
Stay-at-home	0.016	0.042	0.703	0.148	0.038	<0.001***
Satisfaction to the sea	0.485	0.050	<0.001***	2.942	0.095	<0.001***
During_Sea				0.092	0.042	0.029*
	(c) During_River			**(d) After_River**		
Variables	**Estimate**	**SE**	***p* value**	**Estimate**	**SE**	***p* value**
Sex	−0.364	0.078	<0.001***	−0.139	0.077	0.070.
Age	0.004	0.003	0.237	0.004	0.003	0.270
Occupation (self-employed and professional workers)	−0.052	0.193	0.786	0.059	0.187	0.751
Occupation (part-time job)	−0.019	0.169	0.910	−0.174	0.172	0.311
Occupation (under-/post-graduate and vocational school students)	0.267	0.271	0.324	0.210	0.266	0.431
Occupation (full-time homemakers)	0.240	0.162	0.139	0.007	0.161	0.966
Occupation (others)	0.273	0.148	0.064.	−0.040	0.153	0.793
Income	0.026	0.015	0.077.	0.033	0.015	0.027*
Number of infants	0.427	0.090	0.000***	0.192	0.099	0.053.
Number of preschoolers	0.275	0.134	0.040*	0.153	0.140	0.274
Number of primary school students	0.239	0.110	0.030*	0.248	0.110	0.024*
Nature experience	0.125	0.021	<0.001***	0.129	0.021	<0.001***
City (Yokohama)	−0.092	0.123	0.455	−0.120	0.126	0.341
City (Osaka)	0.061	0.128	0.630	0.002	0.129	0.989
City (Kobe)	−0.439	0.001	<0.001***	−0.043	0.123	0.726
Stay-at-home	0.023	0.037	0.537	0.203	0.037	<0.001***
Satisfaction to the river	0.631	0.044	<0.001***	3.138	0.089	<0.001***
During_River				0.134	0.042	0.002**

TABLE 2 (Continued)

Variables	(e) Change_Sea			(f) Change_River		
	Estimate	SE	*p* value	Estimate	SE	*p* value
Sex	0.021	0.076	0.783	−0.098	0.080	0.219
Age	0.007	0.003	0.037*	0.003	0.004	0.356
Occupation (self-employed and professional workers)	−0.201	0.181	0.266	0.099	0.192	0.605
Occupation (part-time job)	0.140	0.166	0.398	−0.198	0.177	0.263
Occupation (under-/post-graduate and vocational school students)	−0.148	0.253	0.560	0.175	0.280	0.531
Occupation (full-time homemakers)	0.196	0.164	0.231	−0.072	0.168	0.666
Occupation (others)	0.178	0.161	0.266	−0.111	0.162	0.494
Income	−0.039	0.015	0.010**	0.026	0.016	0.095.
Number of infants	−0.076	0.110	0.488	0.176	0.107	0.099.
Number of preschoolers	−0.217	0.144	0.131	0.185	0.149	0.216
Number of primary school students	−0.104	0.118	0.377	0.282	0.116	0.016*
Nature experience	−0.097	0.020	<0.001***	0.107	0.021	<0.001***
City (Yokohama)	−0.256	0.131	0.050.	−0.122	0.135	0.366
City (Osaka)	−0.142	0.134	0.289	−0.030	0.137	0.824
City (Kobe)	−0.210	0.133	0.113	0.047	0.129	0.716
Stay-at-home	−0.153	0.038	<0.001***	0.222	0.040	<0.001***
Satisfaction to the sea	−0.061	0.043	0.153			
Satisfaction to the river				0.070	0.044	0.111

Notes: Dummy variables were assigned to the variable 'sex' (1. male; 2. female). Positive and negative values in the variables 'Occupation' and 'City' were estimated relative to '1. office, public and contract workers' and 'Tokyo', respectively. Asterisks indicate the statistical significance of the variables (*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$), and dots indicate their marginal significance ($p < 0.1$).

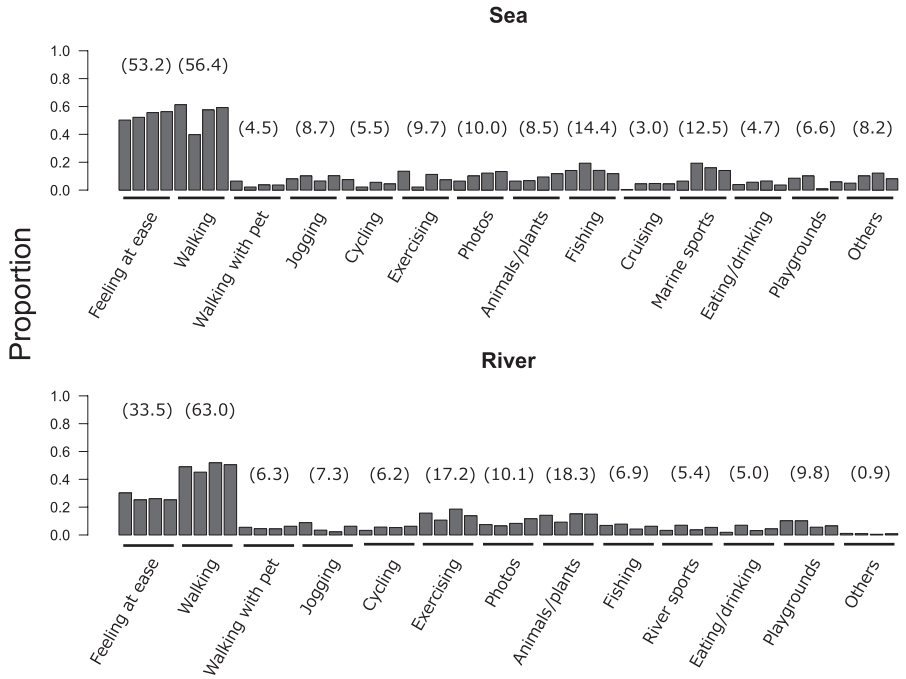

FIGURE 4 Bar plots representing the purpose of visiting coastal (upper) and river (lower) areas during the emergency period. In each group, four bar plots represent 'Kobe, Osaka, Tokyo and Yokohama' from the left to right. Numerals in parenthesis are the proportion of each answer (%), where four targeted cities were pooled.

TABLE 3 Summary of the generalized linear modelling (GLM)

Objectives	Visiting coastal areas with avoiding Cs				Visiting river areas with avoiding Cs			
Variables	GVIF	Estimate	SE	*p* value	GVIF	Estimate	SE	*p* value
Intercept		−6.394	0.625	<0.001***		−7.187	0.545	<0.001***
Sex	1.443	−0.028	0.128	0.829	1.467	−0.170	0.111	0.126
Age	1.582	−0.010	0.006	0.073.	1.583	−0.005	0.005	0.351
Occupation (self-employed and professional workers)	2.226	−0.168	0.346	0.627	2.342	0.243	0.270	0.368
Occupation (part-time job)		−0.686	0.318	0.031*		0.174	0.226	0.441
Occupation (under-/post-graduate and vocational school students)		−0.488	0.542	0.368		0.032	0.424	0.940
Occupation (full-time homemakers)		0.029	0.258	0.911		0.254	0.227	0.262
Occupation (others)		0.247	0.234	0.290		0.207	0.210	0.325
Income	1.055	0.006	0.016	0.693	1.059	−0.022	0.015	0.124
Number of infants	1.127	0.015	0.172	0.929	1.151	0.127	0.142	0.370
Number of preschoolers	1.208	0.296	0.222	0.183	1.258	0.429	0.186	0.021*
Number of primary school students	1.114	0.092	0.183	0.615	1.139	0.167	0.158	0.290
Nature experience	1.052	0.130	0.036	<0.001***	1.044	0.174	0.032	<0.001***
City (Yokohama)	1.181	0.410	0.236	0.082.	1.065	0.117	0.172	0.497
City (Osaka)		0.034	0.275	0.903		−0.159	0.195	0.416
City (Kobe)		0.603	0.225	0.007**		−0.415	0.182	0.023*
Stay-at-home	1.050	0.060	0.063	0.336	1.052	0.097	0.054	0.071.
Satisfaction to the sea	1.137	0.493	0.075	<0.001***				
Satisfaction to the river					1.025	0.630	0.065	<0.001***

Notes: Dummy variables were assigned to the variable 'sex' (1. male; 2. female). Positive and negative values in the variables 'Occupation' and 'City' were estimated relative to '1. office, public and contract workers' and 'Tokyo', respectively. Asterisks indicate the statistical significance of the variables (*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$), and dots indicate their marginal significance ($p < 0.1$).

blue spaces during and after the emergency period (Figures 2 and 3). Given that a similar trend is also reported in green spaces targeting Japanese megacities' residents (Soga, Evans, Tsuchiya, & Fukano, 2021), our findings would not be specific to blue spaces, but rather to the Japanese residents. In particular, the stay-at-home duration during the emergency period was unrelated to the visitation frequencies to blue spaces at the same time, but was positively related to those after the period (Table 2). The findings suggest that, contrary to foreign countries, the urban Japanese people strictly restricted their behaviour until the emergency was cancelled, by which their free time likely increased owing to reduced commute time and/or working tasks. Although the Japanese government did not prohibit citizens from going outdoors, most residents in Japanese megacities voluntarily and strictly obeyed the state of emergency declared by the government and suppressed their access to blue spaces, resulting in negative changes in opportunity (Soga, Evans, Cox, & Gaston, 2021). Their strict adherence towards the government's declaration was partly responsible for the significantly lower number of infection cases in Japan in comparison with other countries at that time (WHO Coronavirus Disease Dashboard). Contrary, urban people could visit remote places much less frequently and might have experienced a reduction in levels of physical condition and affected their mental health (Li & Wang, 2020; Rajkumar, 2020). In addition, the pandemic might have changed the motivation in human–nature interactions (Soga, Evans, Cox, & Gaston, 2021) for Japanese residents. The fear associated with the virus outbreak might reduce their willingness to access and engage with natural environments including blue spaces, negatively affecting the frequency of visits and the health of urban people.

However, depending on where they live, these negative changes in psychological and physical capacity (Soga, Evans, Cox, & Gaston, 2021) would rather have increased the need for an interaction with their neighbouring nature that is more human-mediated, such as urban green and blue spaces, during the pandemic. Our study demonstrated that not all people consistently restricted their visits and a certain number of people continued to access and use blue spaces. First, recent studies targeting green spaces indicate that a strong sense of nature interaction could be developed by nature experiences, especially in childhood relative to adulthood (e.g. Liefländer et al., 2013; Mayer et al., 2009; Sato et al., 2021). Our results regarding childhood nature experiences indicate that such relationships can also be established in blue spaces. It is intuitively reasonable that people with more nature experiences sought green/blue spaces according to the 'Biophilia hypothesis', predicting that human beings are universally and innately oriented to connect with nature (Kellert, 1995). Meanwhile, nature experiences in childhood

are considered to have gradually disappeared for urban residents worldwide (i.e. extinction of experience; Soga & Gaston, 2016), and are being replaced today by virtual alternatives such as television, computer games and the Internet (Ballouard et al., 2011; Pergams & Zaradic, 2006). Our finding implies that similar to urban green spaces, city residents especially who had less nature experiences in childhood and/or were less satisfied with neighbourhood coastal and river areas tended not to use blue spaces for improving their health.

In addition, residents living with preschoolers and primary school children used blue spaces more frequently, especially during the emergency period. School closures during the emergency period not only reduced the opportunity of education for children, but also increased their and parents' physical/mental stress owing to them staying at home with family (e.g. Ipsos MORI, 2020; Soga, Evans, Cox, & Gaston, 2021). Thus, it is likely that parents together with their young children visited blue spaces to mitigate family stress. After cancelling the state of emergency, the schools restarted, and therefore such stress-mitigating visitations were unnecessary, but the respondents living with primary school students continued their river visits (Table 2d). Possibly, sharing nature experiences with parents during the emergency period might have been a good opportunity to educate children on the environment; that is, river areas might have been an important topic in early childhood education (Cutter-Mackenzie & Edwards, 2013; Pearson & Degotardi, 2009). Altogether, such blue space experiences might substantially reduce children's stress, and promote their positive emotions and attitudes towards nature, like other nature experiences (Bixler et al., 2002; Ewert et al., 2005; Soga & Gaston, 2016).

There are also some certain differences in blue space use among cities and depending on personal characteristics during the pandemic. A decrease in visitation frequencies to coastal areas in Tokyo and Osaka relative to those in Yokohama and Kobe may be due to the difficulty in accessing coastal areas in Tokyo and Osaka where urban development and reclamation have particularly progressed. Poor accessibility to coasts for Tokyo and Osaka residents was also indicated by lower sea satisfaction for these two areas (Figure S3). As an alternative, residents in Tokyo might have increased their visits to river areas, given that there are some large rivers in Tokyo, and visitation frequency to river areas during the emergency period was significantly lower in Kobe than in Tokyo (Table 2c). In addition, women did not visit blue spaces during the emergency period, while the relationships were unclear after this period. This trend was also reported in green spaces in other foreign countries including the United Kingdom (e.g. Burnett et al., 2021); women appeared to interact less with nature than men during the pandemic. Such gender inequality in accessing green and blue spaces might be associated with women being more likely to follow government rules and avoid getting outdoors (Galasso et al., 2020), and/or were busier due to unexpected home activities and childcare during the emergency period than men (Ipsos MORI, 2020). In any case, these should have increased the mental burden and depression in women, which may have increased their visitation frequency to blue spaces after the period as compared to men. Moreover, elderly people visited coastal areas less frequently than younger generations during and after the emergency period, a trend that is also observed in green spaces (e.g. Burnett et al., 2021), while the relationships were unclear in river areas. Although they are more vulnerable to COVID-19 than younger generations, it was not surprising that they refrained outdoor visits but preferred some extent of physical activity to maintain their health. We performed additional GLMs with a binomial function using the dataset regarding the specific purposes to visit blue spaces, and confirmed that the relationship between the choice of '2. walking' and the age was significantly positive for river areas ($p < 0.001$) but not for coastal areas ($p = 0.994$). Neighbourhood river areas might thus have been an appropriate environment for the elderly to perform light exercise such as walking. Meanwhile, if accessible, they would also walk along the coasts, given that visitors regularly accessed the coasts on foot in Kobe, where subjective satisfaction of the sea was relatively higher (Figure S5).

Surprisingly, CLMs also revealed that nature experiences in childhood and stay-at-home duration had opposite effects on the changes in visitation frequencies following cancellation of the emergency between coastal and river areas. These results imply that, although relieving the restrictions after cancelling the emergency prompted residents to visit both blue spaces, the primary destination may differ depending on their nature experiences and stress levels which is likely associated with stay-at-home duration (Buckner et al., 2021). For example, although most sea coasts and rivers in Japanese megacities have been anthropologically modified with concrete structures, there might be more apparent green spaces such as riparian grasslands and waterweeds around them in rivers than in coastal areas. In addition, despite biodiversity being considerably higher in coastal areas than in river areas, animal/plants around river areas can be observed more easily from the ground than those in the coasts. Thus, urban residents with higher nature experiences in childhood and stay-at-home duration might have probably selected rivers than coasts as an environment to interact with neighbourhood nature and animals/plants more actively and spontaneously.

4.2 | Specific purpose and motivation of visits to blue spaces

We were also interested in, and examined the purpose and motivation of urban residents visiting blue spaces during the emergency period. At first, megacity residents visited blue spaces mainly for 'feeling at ease or just getting outdoors' and/or 'just walking'. That is, urban people did not necessarily visit blue spaces for a specific activity related to each ecosystem but seemed to leisurely spend their time and/or walked around the area. This result likely corresponds to the fact that urban people aimed to contact and feel such blue space for reducing their own stress (Figure 5). The proportions for these two purposes were over 50% for the sea visitors, while proportions of respondents who enjoyed feeling at ease and/or just getting outdoors (*c*. 30%) were approximately half of those people

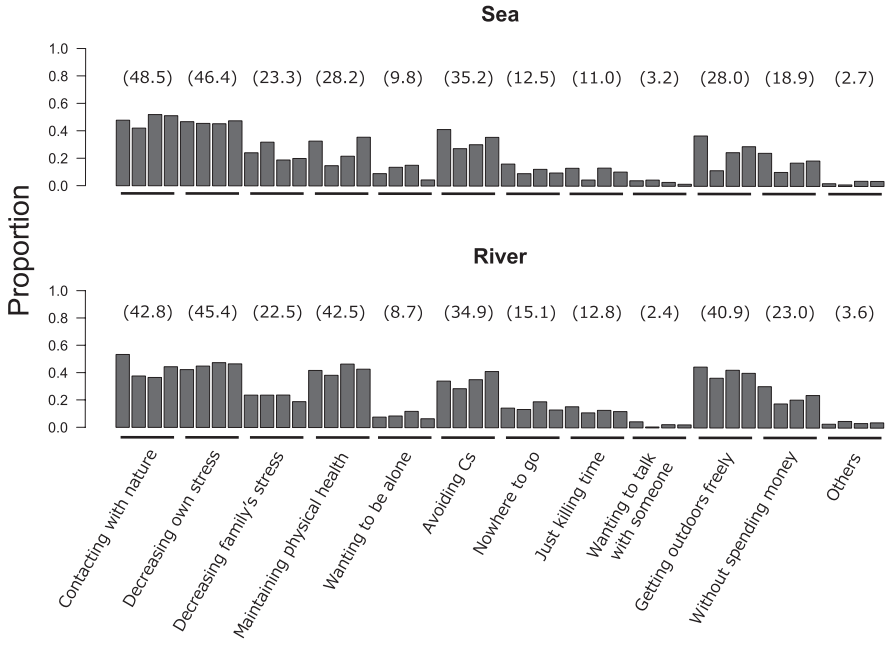

FIGURE 5 Bar plots representing the motivation of visiting coastal (upper) and river (lower) areas during the emergency period. In each group, four bar plots represent 'Kobe, Osaka, Tokyo and Yokohama' from the left to the right. Numerals in parenthesis are the proportion of each answer (%), where four targeted cities were pooled.

aiming to visit the river by walking (*c*. 60%). For example, openness and broadness of the sea, the sound of its calm waves, and scenic water view might have provided the residents with a sense of relief and recovery from their daily lives, which might encourage them to spend time calmly and leisurely on coasts (Rock et al., 2020; Völker & Kistemann, 2011). In contrast, higher proportions of visitors walking to the river could partly be contributed by the elderly, as described above. In fact, the river visitors were more inclined to maintain their health and get outdoors freely than sea visitors (Figure 5).

The next main purposes of visitation were also different between coastal and river areas; urban people visited coastal areas to engage in fishing, swimming and marine sports, while they visited river areas to exercise and collect/observe animals and plants. Much sea visitors accessed coasts by car and motorbike, which could easily accommodate the equipment/instrument required for fishing and marine sports. In contrast, rivers seemed to be closer enough for our target residents to travel on foot (Figures S5 and S6) and there are fewer rivers in Japan with a broad spatial scale enough to enjoy river sports, such as rafting and canoeing than those overseas. Thus, cultural services from coastal and river areas were mostly similar, but rather different depending on the accessibility of blue spaces. Moreover, the specific features of riverine ecosystems, including apparent green spaces and animal/plants observed from the ground relative to coastal ecosystems (described above), might promote urban residents to enjoy the collection of aquatic/terrestrial species more frequently around river areas.

Furthermore, we focused on blue-space visitors who took care of avoiding Cs during the emergency period. They would intend to use the cultural ecosystem services to decrease their physical/mental stress while maintaining social distancing. As with the result during the emergency period, people with higher experiences of nature interaction in childhood and satisfaction of neighbourhood blue spaces were more motivated. Although human beings universally and potentially want to closely feel the nature, urban people might find it difficult to use the ecosystem service to decrease their stress without their longstanding nature experiences and/or higher subjective satisfaction around them. Our findings suggest that, even in urban areas, people with higher childhood nature interactions are more likely to access blue spaces and to use their ecosystem services positively, even in adulthood, as a nature-based solution for improving their mental health while being careful about the infection than those without any nature experience.

5 | CONCLUSIONS

The present study is among the few studies to reveal the cultural services availed from coastal and river areas under behavioural restrictions due to the COVID-19 pandemic, and offers general and valuable evidence indicating the potential of such blue spaces in urban areas to improve human health and well-being (Figure 6). We found that a certain number of residents visited blue spaces under strict behavioural restrictions, indicating the importance of cultural services from coastal and river areas, as well as green spaces, at the time of emergency, especially when they were surrounded by sufficient blue spaces. In addition, to the best of our knowledge, our study is the first to show the differences in the purpose and motivation of urban populace visitors between coastal and river areas, reflecting the differences in their cultural ecosystem services during the pandemic. These findings imply that, at least in Japan, urban people may tend to recognize and potentially use coastal areas for

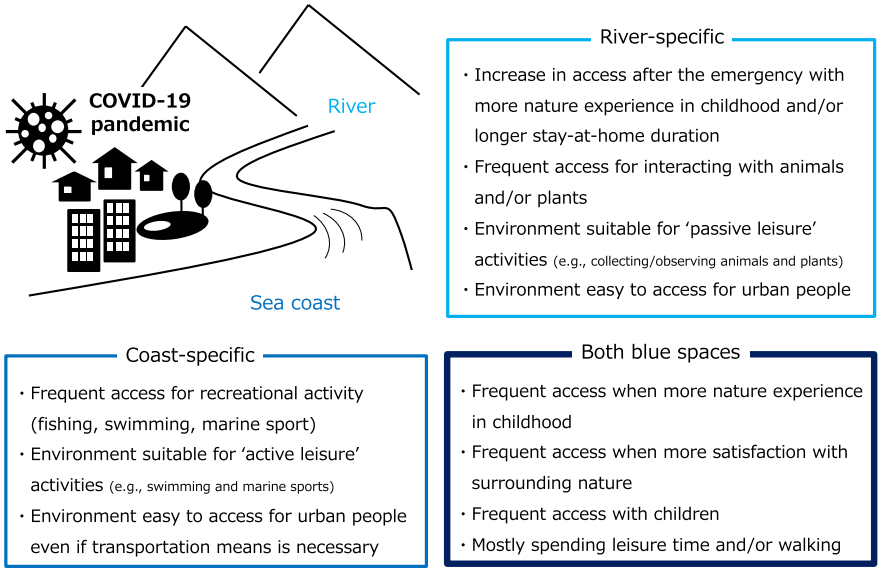

FIGURE 6 Schematic depiction of the finding of this study. Under the COVID-19 pandemic, a certain number of Japanese urban people accessed coastal and riverine areas, both of which provided them with cultural ecosystem services that could mitigate their stress, reduce the incidence of health problems, and improve their overall physical and mental health. Generally, people with more nature experiences in childhood, more satisfaction with their surrounding nature and/or more children frequently accessed both blue spaces. In contrast, there were also some differences in the purpose and motivation for accessing them between coastal and riverine areas, from which Japanese urban people may recognize and use the former as 'active leisure' for energy release while the latter as 'passive leisure' for energy recovery and recess.

'active leisure' for their energy release while riverine areas are used for 'passive leisure' for their energy recovery and recess (e.g. Shin & You, 2013). Although these differences could be derived mainly from nature experiences in childhood, accessibility and perception of urban people, further studies will be required (e.g. landscape broadness and structure, water quality, and biodiversity).

There remain some challenges and perspectives in our study. First, access patterns for urban blue spaces were not directly compared with those for urban green spaces. Elucidating the similarities and differences in the use of urban blue and green spaces would allow more comprehensive understanding of human–nature interactions (Pouso et al., 2021; WHO Regional Office for Europe, 2021). Second, although changes in the frequency of visits to coastal and river areas after the emergency relative to those during the emergency (i.e. Change_Sea and Change_River) were calculated, we also acknowledge that these variables cannot be quantitative. For example, respondents reporting a change from 'Almost every day' to 'One to three times per week' and those reporting that from 'Once or twice' to 'never' will both have been scored at −1, but their answers would have different meanings. Precise quantification of the frequency of visits and its temporal change would be difficult but might have offered additional insights into the behavioural changes by urban people during the pandemic. Third, until now, the Japanese government has declared a state of the emergency four times in total. The repeated and intermittent emergency could further alter the attitude and behaviour of Japanese people towards the pandemic. The improvement of medical systems, including increases in vaccine coverage, and likely habituation of urban people to the emergency may encourage people to go out for leisure and business but make them not necessitate green and blue spaces for their improved health.

Nonetheless, our findings would provide clues and implications to consider how we human being should face on and utilize urban blue spaces for managing their physical and mental stress in the long term during the COVID-19 pandemic. Urban blue and green spaces will undoubtedly play a substantial role in reducing stress and disorders during the long-lasting pandemic; the same would be true for other diseases caused by contact and/or droplet like COVID-19. Regardless of green or blue spaces, getting outdoors to establish contact and/or just experiencing nature would benefit urban people to decrease the risk of cluster infection. Our study suggests an important inference on future urban planning and environmental education for children. It is well known that documenting the patterns and processes of natural ecosystems in urban areas and conserving urban ecosystems can help urban residents improve their health and well-being; however, most urban ecological research has focused on green spaces such as urban forests and parks (e.g. Güneralp & Seto, 2013; McKinney, 2008; Niemelä, 1999; Zhou et al., 2017), and our study sheds new light on the importance of conserving and managing blue spaces for better urban planning. As a physical and mental support for urban people, natural landscapes and ecosystems of blue and green spaces must be preserved and inherited to subsequent generations, which will reconnect people with nature and provide us with further benefits relating to health and well-being in the future.

AUTHORS' CONTRIBUTIONS

A.U., M.S., and T.M. conceived the study, completed the questionnaire and conducted the data sampling; T.J. and A.U. analysed the

datasets; T.J. wrote the first draft of the manuscript. All authors have edited and provided feedback on the manuscript.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The dataset, including raw data and questionnaire, is embargoed at the time of writing due to the authors preparing further papers using this study's raw data. The papers will be submitted to the preprint server Jxiv (https://jxiv.jst.go.jp/index.php/jxiv) in May 2023 and accordingly all the data will be archived at Dryad (https://datadryad.org/stash). Until that time, raw data regarding our online based survey are available from the authors upon request.

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SUPPORTING INFORMATION

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