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Thinking from the perspective of imaginary future generations changes the public perception of sustainable management of water supply infrastructure – A large-scale questionnaire survey in a municipality of Japan

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A R T I C L E I N F O

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A B S T R A C T

The aim of the present study was to apply the perspective of Imaginary Future Generations (IFGs), a method that has proved effective in generating "futurability," to a large-scale questionnaire survey of residents in a Japanese municipality, in order to analyze the influence of IFGs on attitudes toward water supply infrastructure maintenance and management, the willingness to pay higher water rates, and attitudes toward regional integration of water supply services. In questionnaires distributed to 2000 randomly selected households in Suita City, Osaka Prefecture, respondents were asked to answer questions from the perspectives of both current generations and IFGs. The responses were then compared to statistically analyze the effects of adopting the perspective of IFGs. The results showed that incorporating the perspective of future generations makes it possible to increase the degree of acceptance among residents of increases in water rates, regional integration of water supply services, and other essential issues related to the management of water supply infrastructure, as well as to enable more flexible consideration of long-term water supply initiatives. The present study also demonstrated the influence of the pattern of description of the future society. For the group of respondents that held a pessimistic vision of the future from the perspective of IFGs, the effectiveness of applying IFGs for increasing support for water rate increases and the perception of a water rate increase being acceptable (%) was particularly high. These results can offer valuable insights for future examination of policies relating to sustainable water supply infrastructure maintenance.

1. Introduction

A variety of sustainability issues have emerged in modern society (Clark & Dickson, 2003; Komiyama & Takeuchi, 2006; Rockström et al.,2009; Steffen et al., 2015; Richardson et al., 2023). Many of these are long-term issues that can span generations. As water supply is a vital form of infrastructure, its sustainable maintenance and management is an essential challenge that is also a long-term and intergenerational issue. Much of Japan's water supply infrastructure was developed intensively during the period of rapid economic

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growth that began around the mid-20th century. Now that more than 50 years have passed since much of this infrastructure was constructed, a large quantity of water supply infrastructure in Japan has become due for renewal at the same time (Tsukuda & Sakai, 2020). This presents numerous challenges, such as setting priorities for renewal and meeting costs. Since a large amount of the water supply piping was installed in Japan during the high-economic growth years, the renewal of all this piping that has exceeded its statutory useful life will take a long time and cost a huge amount of money, leaving many local governments around Japan with a serious problem (Hosoi et al., 2011). Failure to properly replace aging pipes increases the risk of leaks and heightens the possibility of water supply interruptions due to pipeline ruptures during earthquakes.

The management of public water supplies in Japan is financed by revenues from water charges (water rates) that are paid in accordance with the amount of water used, as per the Local Public Enterprise Act. However, in many Japanese municipalities, water revenues are dropping due to declining populations (as a result of a falling birthrate and aging population), as well as to the widespread adoption of water-saving equipment and growing awareness of water conservation (Suita City,2019). For this reason, the management of water supply services is likely to become increasingly difficult, making the management and renewal of water supply infrastructure a major long-term challenge.

To address this situation, namely to improve the water supply management situation and ensure a more sustainable water supply system, many local governments in Japan are raising water rates and discussing ways to increase management efficiency and strengthen the foundations of management through regional collaboration and integration in water supply services (Ministry of Health, Labour and Welfare, 2016). At the same time, getting water users to understand and accept higher water rates is difficult, because of the additional financial burden it places on them. This issue of water supply infrastructure maintenance and management is essentially about sustainability, involving questions of intergenerational relationships and conflicts of interest (Hara et al., 2025). That is, the issue needs to be assessed and examined from a long-term perspective, taking into account not only the interests of current generations but also those of future generations. It is therefore necessary to approach this issue from a long-term perspective that transcends generations to explore optimal measures for sustainable maintenance and management.

Assessments of water supply infrastructure maintenance and management have been conducted. These include, for example, studies that aimed to maximize the total benefit of pipeline renewal plans under cost constraints in Japan (Odanagi et al., 2003). Further, methods for sustainability assessment have been studied in the field of water supply and wastewater treatment systems (Attri et al., 2022; Balkema et al., 2002). Water tariffs have also been addressed from the perspective of sustainability and equity (Zetland & Gasson, 2013). Urban water tariffs also vary across cities and regions, depending on the local conditions and objectives (Hoque & Wichelns, 2013). However, the evaluations in these studies were all based on the perspective of current generations, ignoring the perspective of future generations. In addition, methods such as participatory planning (Hassenforder et al., 2016; Neverre, 2024), decision support systems (Pearson et al., 2010; Willuweit and O'Sullivan, 2013), scenario analysis (Momeni, et al., 2021; Rigo et al., 2022) and backcasting (Kok et al., 2011; van Vliet and Kok, 2013) have been developed to address water resource management and related policy planning. Although these methods have proven effective in envisioning the future and addressing options to be taken, they do not explicitly address how to reconcile intergenerational conflicts of interest (Uwasu et al., 2020; Kuroda et al., 2021). However, the maintenance and management of water supply infrastructure is a long-term challenge that involves intergenerational conflicts of interest. Failing to consider the interests of future generations could lead to "future failure" (Saijo, 2020), given human characteristics such as impulse or shortsightedness (Sapolsky, 2012) and optimism about the future (Sharot, 2011). For this reason, it is necessary to develop a methodology for assessment and policy formulation that incorporates the perspective of future generations.

In recent years, to overcome intergenerational conflicts of interest by incorporating the perspective of future generations in decision-making and assessment of long-term multi-generational challenges, "Future Design" has been proposed. A person exhibits "futurability" when he or she experiences an increase in happiness as a result of deciding and acting to forego current gains in order to enrich future generations, and Future Design is the design and praxis of a society generating futurability (Saijo, 2020). One of the most promising mechanisms for generating futurability is the creation of 'Imaginary Future Generations' (IFGs), stakeholders who are tasked with representing future generations and assessing the decisions of the present from the perspective of future generations. Through experiments, fields experiments and practices, the effectiveness of adopting IFGs in terms of activating futurability has been demonstrated (Kamijo et al., 2017, Hara et al., 2019, Saijo, 2020, Shahen et al., 2021, Shahrier et al., 2017, Timilsina et al., 2022; Hiromitsu, 2019). For example, an economic experiment found that the adoption of the IFGs method can change the group's decision, taking into account the benefits of future generations (Kamijo et al., 2017). The first practice involving local residents in the town of Yahaba, Iwate Prefecture, Japan, shows that the adoption of IFGs can lead to new proposals with stronger motivations for social change while considering the preferences of future generations, compared to the case of discussion from the perspective of current generations (Hara et al., 2019). These previous studies show that the adoption of IFGs could lead to changes in individuals' preferences and decision making, presumably due to the generation of futurability.

The IFGs method has been applied in decision-making processes and exercises in a variety of public policy fields, such as town planning (Hara et al., 2021; Hiromitsu et al., 2021), disaster prevention (Tateyama et al., 2019), city hall planning (Nishimura et al., 2020), renewable energy policy (Uwasu et al., 2020), water environmental management (Kuroda et al., 2021), waste management (Pandit et al.,2021) and environmental planning (Hara et al., 2023). Related studies and practices have demonstrated that the adoption of the IFGs is effective for generating futurability in people to facilitate decision-making and consensus building that gives due consideration to the interests of future generations. IFGs was also applied in a study focused on the issue of water supply infrastructure management, with local government officials involved in water supply services participating in discussions (Hara et al., 2025). That study showed that the adoption of IFGs can help water utilities to implement more flexible policymaking from a long-term perspective and give more importance to the perspective of water users. Its results also suggested that the adoption of IFGs enables policies and measures relating to water infrastructure management to be examined from a more long-term and comprehensive perspective.

However, to ensure the sustainability of water supply management, it is vital to obtain the understanding not only of government officials but also of the local residents who use the water. For current generations, it is particularly difficult to understand and accept the need for regional integration of water supply infrastructure and increases in water rates, which many local governments in Japan are now discussing, due to the cost burdens involved. Consequently, it is important that water users think about the issue of water supply infrastructure management as a the long-term one, and about the development of future policies and measures to address it. If the adoption of an IFGs perspective can help water users (residents) to clearly grasp the longer-term challenges of water supply infrastructure management, then IFGs can help to build consensus between local governments and residents regarding visions and policy proposals for future water supply projects and management.

In accordance with the above, the present study was conducted by distributing a questionnaire survey to residents of a Japanese municipality to analyze whether the application of IFGs changes attitudes toward water supply maintenance and management, attitudes toward current water rates, willingness to pay higher water rates, and attitudes toward regional collaboration and integration in water supply services. Questionnaires were distributed to 2000 randomly selected households in Suita City, Osaka Prefecture, requesting answers to questions related to the above matters from the perspectives of both current generations and IFGs. The survey responses were then compared to analyze the impact of IFGs. Results of previous studies have also suggested that the effectiveness of applying IFGs varies according to how visions of the future are described (Kuroda et al., 2021). However, this has only been verified qualitatively thus far. Therefore, in the present study, we also set out to shed light on how visions of a future society (from an IFGs perspective) influence questionnaire responses. More specifically, we identified several factors (indicators) that define a future society and designed the questionnaire so as to acquire quantitative data about patterns of future visions based on these indicators. This allowed us to quantitatively clarify how the pattern of description of the future influences the effectiveness of applying IFGs.

The findings from the present study offer new insights into the effectiveness of applying IFGs adding to the knowledge that had already been accumulated and provide a foundation for new approaches and methodologies for developing policies for the sustainable maintenance and management of water supply infrastructure and for building consensus for future planning.

2. Research method

2.1. Surveyed municipality

The municipality selected for study, Suita City, is an urban center located in the northern part of Osaka Prefecture. Its population was over 380,000 as of 2022 (Suita City, 2022) and it is a thriving commercial city that is home to both the production plants of major beverage manufacturers and several universities. The city also includes the site of the 1970 Japan World Exposition, which is now a sightseeing attraction known as Expo '70 Commemorative Park, as well as stadiums and large shopping malls around its periphery. In these respects, Suita City is a rather typical urban center in Japan, which means that the results of this case study can yield suggestions that would be readily applicable to many other municipalities of similar size.

As the first "new town" developed in Japan, Suita City's infrastructure was constructed rapidly in the 1960s. Many decades have passed since the city's water supply infrastructure was constructed, so many water facilities are aging and in need of renewal. Out of a total network of approximately 738.6 km of water pipes, 286.3 km are aged as of 2022, meaning that the pipes have exceeded their statutory useful life of 40 years (Suita City, 2024). In Suita City, the amount of water supplied by the municipal system has been declining due to a decrease in water usage by large-scale users, such as commercial facilities, greater awareness of water conservation, and the widespread adoption of water-saving equipment. To sustain its management of the water supply system, Suita City raised water rates by an average of 10.0 % in stages between April 2016 and April 2020, and has raised rates further by 15.2 % on average since April 2020. These increases were aimed at securing sufficient financial resources for developing facilities and strengthening the foundations of management (Suita City,2019). In these ways, Suita City is a municipality that is actively tackling the challenges of water supply management.

2.2. Questionnaire and analysis data

The data used for the analysis in the present study are the results of the "Questionnaire Survey of Residents for the Realization of Water Supply Sustainability in Suita City" conducted jointly by the authors and the Suita City Waterworks Bureau on the residents of Suita City, Osaka Prefecture in 2022. The purpose of the survey was to assess the current level of awareness of water supply services and to shed light on how the adoption of an IFGs perspective can change this awareness. The questionnaire was conducted over the period of July to August 2022. Survey respondents were given the choice of answering the printed questionnaire distributed by postal mail or responding online using the QR code included with the questionnaire. Questionnaires were distributed to 2000 Suita City residents (households) aged 18–79 randomly selected by the Suita City Waterworks Bureau from the city's resident registry. The total number of valid returned questionnaires was 696 (collection rate: 34.8 %). However, the total number of valid responses varied from question to question because responses with inappropriate descriptions were eliminated before analysis was performed.

The questionnaire consisted of questions about individual (personal) attributes and questions about water supply services and related future policies. (See Appendix 1 for a copy of the questionnaire.) Table 1 lists the questions that were selected for analysis in the present study in accordance with its aims. Since results of previous studies on Future Design practices (Kuroda et al., (2021)) have indicated that the pattern of description of visions of the future influences the effectiveness of applying IFGs, the question "Images of the future state of Suita City" (Q1) was designed to verify this by quantitative analysis. For this question, we presented eight aspects (indicators) of the future society vision and asked respondents to rate each one on a scale of 1–5 to express their vision of the city's

Table 1
List of questions and multiple-choice answers selected for analysis.

Question		Options 1	2	3	4	5
Q 1	【Images of the future state of Suita City】 How do you think Suita City will be like approximately 30years form now, in 2050?					
	① Population of Suita City ② No. of buildings in Suita City ③ No. of commercial facilities in Suita City ④ Connections with people outside family and workplace	Much more	Somewhat more	No change	Somewhat less	Much less
	⑤ Public services such as parks and community centers	Much better	Somewhat better	No change	Somewhat worse	Much worse
	⑥ Economic situation of Suita City	Much richer	Somewhat better	No change	Somewhat worse	Much worse
	⑦ Use of solar (PV) power generation and renewable energy in Suita City ⑧ Disasters due to earthquakes, windstorms, and floods in Suita City	Much more	Somewhat more	No change	Somewhat less	Much less
Q 2	【Amount of payment for water supply service】 How much does your household pay in water rates every two months (not including sewerage charges)?	Approximately ¥__________				
Q 3	【Impression of the current level of water rates】 How do you feel about the current level of water rates that your households pays?	I think it's very low	I think it's somewhat low	Not sure	I think it's somewhat high	I think it's very high
Q 4	【Pros and cons of water rates increases】 Would you find it acceptable to pay more than you do now for your water?	Yes, definitely	Yes, probably	Not sure	No, probably not	No, definitely
Q 5	【Allowable increase in water rates】 How much would you be prepared to pay for your water rates in addition to what you are paying now (i.e., the amount you wrote for your answer to Q2)?	An additional amount of approximately ¥ _ _ _ _ _ _ _ _				
Q 6	【Pros and cons of "regional collaboration"】 Do you think that Suita City should pursue "regional collaboration" in the future?	Yes, definitely	Yes, probably	Not sure	No, maybe not (caution is needed)	No, definitely not
Q 7	【Decision criteria about water pipe renewal】 If you were in charge of the Suita City water supply system, which of the criteria would you consider the most important for renewal and maintenance?		Piping that leads to water outages	The scale of damage when water outages occur		
			Piping needed for critical water supply services	Piping used for supplying water to hospitals, elementary schools, and other facilities used as emergency evacuation centers in the event of a disaster		
			No. of water users	The number of people or households that water pipes deliver water to		
			Quantity of water supplied	Quantity of water that piping delivers		
			Degree of deterioration	Age of water pipes		
			Earthquake resistance	Strength of piping in the event of an earthquake		
			Leakage hazard level	Danger if water leaks from piping		

future. We selected the eight aspects by taking into account social, economic and environmental factors, all of which are essential for envisaging societal sustainability. We also considered factors that are significant in the context of Suita City and Japan. The question "Amount of payment for water supply service" (Q2) was used as a base quantity for calculating the acceptable water rate increase (%), as described below. The next five questions were intended to assess attitudes toward water supply-related issues: "Impression of the current level of water rates" (Q3), "Pros and cons of water rates increases" (Q4), "Allowable increase in water rates" (Q5), "Pros and cons of 'regional collaboration'" (Q6), and "Decision criteria about water pipe renewal" (Q7). These questions all deal with perceptions about water supply services and the sustainability of water supply maintenance and management. While the questions "Impression of the current level of water rates" (Q3), "Pros and cons of water rates increases" (Q4), and "Allowable increase in water rates" (Q5) are important in discussions of water supply management, they are also very relevant to the perceptions of water supply users. The question "Pros and cons of 'regional collaboration" (Q6) refers to the sharing (integration) of facilities and operational infrastructure between multiple adjoining municipalities to increase water supply service efficiency and strengthen the foundations of water supply system management. "Regional collaboration," by definition, refers to working together across municipal boundaries or undertaking projects in a unified manner to overcome the challenges facing water utilities and ensure sustainable operations. This includes service, operational, and administrative integration, as well as shared facilities. Note that the concept of "regional collaboration" is explained in the questionnaire (Appendix 1). The question of "regional collaboration" is certainly an important theme for the future of water supply services, but since it involves initiatives that transcend municipal boundaries and require major changes to the current system, it needs to be considered from a long-term perspective. The question "Decision criteria about water pipe renewal" (Q7) relates to the criteria for prioritizing the maintenance and management of water supply pipes. Necessary explanations are provided with all the above questions as appropriate. For example, the fact that water rates have been revised twice in the past decade or so is mentioned, and basic information about the criteria generally used for assessing the need for water pipe renewal is provided with the questionnaire.

Table 1 shows the overall structure of the data from the questionnaire used for the analysis. In order to evaluate the effectiveness of applying IFGs, all the questions apart from Q2 were answered from two perspectives, that of current generations and that of IFGs. The respondents were first asked to answer from the perspective of current generations (i.e., their normal perspective). They were then asked to read a two-page of explanation about Future Design and IFGs. Specifically, the respondents read the following instructions to understand the meaning of IFGs (See pages 10 and 11 of the Appendix 1 for details of the instructions and figure described in the text below):

"*As the figure below shows, decisions are usually made by trying to predict and examine the future from (1) "the viewpoint of a current generation." In contrast, (2) "Imaginary Future Generations" allows us to examine the present from the perspective of a future generation, by time-traveling into the future, to the year 20XX (remaining the same age), and imagining ourselves living in the world of that time. For example, if you take on the viewpoint of an imaginary future generation living in the world of 2050, you can "look back" through the past to the years 2022 and 2030 to consider questions such as, "Should we have done such-and-such in 2030?" "For the questions on the following pages, imagine that you have time-traveled into the future, to the year 2050. Answer the questions from the viewpoint of a future generation living in Suita City in 2050.*"

After reading the explanation, the respondents were asked to answer the same questions from the perspective of IFGs in 2050 (imagining themselves as living in Suita City in 2050). In other words, they were asked to answer the questions after imagining that 2050 was the "present." The questions answered from the current generations and IFGs perspectives were the same except that the verb tense of the questions was changed in accordance with the frame of reference of the respondents (see Appendix 1). Appendix 2 is a correspondence table between each question in Table 1 (Q1-Q7) and the corresponding items in the questionnaire used for analysis.

2.3. Analysis method

There were two main aims of the present research as explained in 1. Introduction section. The first was to examine whether the application of IFGs can change the attitudes of city residents toward water supply services in relation to the long-term challenges of water infrastructure maintenance and management. The second was to shed light on how patterns of describing visions of a future society influence the effectiveness of applying IFGs, and particularly, how they affect attitudes and decision-making relating to water supply services. The following analyses were performed to achieve these two aims.

Table 2
Visions of the future state of Suita City (2050) (comparison of current generations and IFGs perspectives).

		n	*Mean* (SD)		*t*		*df*
			Current generations	IFGs			
(1)	Population of Suita City	685	2.92 (1.05)	3.15 (1.07)	−6.940	***	684
(2)	No. of buildings in Suita City	682	2.67 (0.92)	2.92 (0.98)	−8.515	***	681
(3)	No. of commercial facilities in Suita City	680	2.90 (0.95)	3.03 (1.01)	−4.951	***	679
(4)	Connections with people outside family and workplace	676	3.49 (0.87)	3.55 (0.93)	−2.030	*	675
(5)	Public services such as parks and community centers	683	2.81 (0.88)	2.86 (0.95)	−1.541	*n.s.*	682
(6)	Economic situation of Suita City	684	3.11 (0.87)	3.20 (0.93)	−3.089	**	683
(7)	Use of solar (PV) power generation and renewable energy in Suita City	684	2.43 (0.74)	2.36 (0.83)	2.521	*	683
(8)	Disasters due to earthquakes, windstorms, and floods in Suita City	684	2.56 (0.73)	2.54 (0.76)	0.787	*n.s.*	683

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 3
Attitudes to water supply services in Suita City (comparison of current generations and IFGs perspectives).

	n	*Mean* (SD)		*t*		*df*
		Current generations	IFGs			
Impression of the current level of water rates (Q3)	681	3.25 (0.92)	2.59 (1.20)	13.505	***	680
Pros and cons of water rates increases (Q4)	681	2.98 (1.20)	2.54 (1.13)	11.722	***	680
Allowable increase in water rates (%) (Q5)	201	29.78 (38.07)	32.91 (37.87)	−1.574	*n.s.*	200
Pros and cons of "regional collaboration(Q6)	666	2.03 (0.98)	1.94 (0.97)	3.447	***	665

***$p < .001$, **$p < .01$, *$p < .05$

Table 4
Decision criteria about water pipe renewal (comparison of current generations and IFGs perspectives).

–	n	*Mean* (SD)		*t*		*df*	Order of priority	
		Current generations	IFGs				Current generations	IFGs
Piping that leads to water outages	638	3.16 (1.68)	3.09 (1.69)	1.294	*n.s.*	637	2	2
Piping needed for critical water supply services	638	2.77 (1.66)	2.69 (1.67)	1.642	*n.s.*	637	3	3
No. of water users	638	1.05 (1.46)	1.08 (1.47)	−0.715	*n.s.*	637	6	6
Quantity of water supplied	638	0.57 (1.10)	0.60 (1.12)	−0.835	*n.s.*	637	7	7
Degree of deterioration	638	3.27 (1.59)	3.17 (1.69)	2.150	*	637	1	1
Earthquake resistance	638	2.05 (1.60)	2.20 (1.67)	−3.338	***	637	4	4
Leakage hazard level	638	2.02 (1.64)	2.03 (1.64)	−0.250	*n.s.*	637	5	5

***$p < .001$, **$p < .01$, *$p < .05$

(1) For Aim 1, we compared the responses from the current generations and IFGs perspectives for six questions (all questions except Q2) to identify changes in attitudes due to the application of IFGs. We performed a statistical analysis by means of a t-test using the statistical analysis software suite SPSS (IBM), treating the five multiple-choice options as equally spaced scale values. The results are presented in Section 3.1.
(2) For Aim 2, we divided respondents into two clusters based on responses to the question "Images of the future state of Suita City" (Q1), answered from the IFGs perspective, and compared the responses of the two. Cluster analysis was performed using Ward's method and the scientific data analysis software PAST (version 4.16c) of the Natural History Museum, University of Oslo. We performed a statistical analysis using the statistical analysis software suite SPSS (IBM), again treating the five multiple-choice options as equally spaced scale values. The results are presented in Section 3.2.

3. Results

3.1. *Effectiveness of applying IFGs: a comparative analysis*

3.1.1. *Vision of Suita City in 2050*

We compared the questionnaire responses to the question "Images of the future state of Suita City" (Q1) from the current generations and IFGs perspectives using a *t*-test (Table 2). For each question, only respondents who answered from both the current generations and IFGs perspectives were included in the analysis.

For Q1, significant differences were found in the following six items: (1) Population of Suita City (t = -6.940, p < 0.001), (2) No. of buildings in Suita City (t = -8.515, p < 0.001), (3) No. of commercial facilities in Suita City (t = -4.951, p < 0.001), (4) Connections with people outside family and workplace (t = -2.030, p < 0.05), (6) Economic situation of Suita City (t = -3.089, p < 0.01), and (7) Use

Table 5
Visions of the future (2050) of Suita City (comparison of two clusters).

–	*Mean* (SD)		*t*		*df*
	Cluster A (n = 230)	Cluster B (n = 448)			
Population of Suita City	2.00 (0.59)	3.74 (0.73)	−33.263	***	551.07
No. of buildings in Suita City	2.00 (0.55)	3.38 (0.80)	−26.328	***	621.69
No. of commercial facilities in Suita City	2.09 (0.64)	3.51 (0.79)	−25.265	***	551.88
Connections with people outside family and workplace	2.92 (0.91)	3.87 (0.76)	−14.403	***	676
Public services such as parks and community centers	2.24 (0.82)	3.17 (0.85)	−13.557	***	676
Economic situation of Suita City	2.48 (0.78)	3.56 (0.78)	−17.018	***	676
Use of solar (PV) power generation and renewable energy in Suita City	2.16 (0.70)	2.46 (0.87)	−4.878	***	561.08
Disasters due to earthquakes, windstorms, and floods in Suita City	2.55 (0.80)	2.54 (0.75)	0.229	*n.s.*	676

***$p < .001$, **$p < .01$, *$p < .05$

Table 6
Attitudes to water supply policies in Suita City in 2022 (comparison of two clusters).

	Cluster	Generation	n	*Mean* (SD)	*t*	*df*
Impression of water rates	Cluster A	Current generations	226	3.23 (0.94)	7.306 ***	225
		IFGs	226	2.65 (1.17)		
	Cluster B	Current generations	446	3.28 (0.91)	11.374 ***	445
		IFGs	446	2.56 (1.23)		
	Cluster A	IFGs	226	2.65 (1.17)	0.913 *n.s.*	670
	Cluster B	IFGs	446	2.56 (1.23)		
Pros and cons of water rates increase	Cluster A	Current generations	226	3.09 (1.14)	6.485 ***	225
		IFGs	226	2.70 (1.09)		
	Cluster B	Current generations	445	2.93 (1.23)	9.753 ***	444
		IFGs	445	2.45 (1.13)		
	Cluster A	IFGs	226	2.70 (1.09)	2.682 **	669
	Cluster B	IFGs	445	2.45 (1.13)		
Allowable increase in water rates (%)	Cluster A	Current generations	63	20.04 (26.14)	-3.337 **	62
		IFGs	63	24.26 (29.23)		
	Cluster B	Current generations	138	34.23 (41.75)	-0.928 *n.s.*	137
		IFGs	138	36.87 (40.70)		
	Cluster A	IFGs	63	24.26 (29.23)	-2.493 *	162.664
	Cluster B	IFGs	138	36.87 (40.70)		
Pros and cons of "regional collaboration"	Cluster A	Current generations	220	2.13 (0.95)	2.557 *	219
		IFGs	220	2.01 (0.93)		
	Cluster B	Current generations	438	1.97 (0.99)	2.351 *	437
		IFGs	438	1.90 (0.98)		
	Cluster A	IFGs	220	2.01 (0.93)	1.454 *n.s.*	458.025
	Cluster B	IFGs	438	1.90 (0.98)		

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

of solar (PV) power generation and renewable energy in Suita City ($t = 2.521$, $p < 0.05$). The responses from the IFGs perspective tended to be significantly more pessimistic ("less" or "worse") compared to those from the current generations perspective for items (1) to (4) and (6). In contrast, responses about the use of solar power and renewable energy (item (7)) tended to be significantly more optimistic or positive from the IFGs perspective compared to the current generations perspective. On the whole, when the respondents adopted the IFGs perspective, they tended to become more pessimistic about urban development (items (1) to (3) and (6)) and about human relations (item (4)), but more optimistic (positive) about environmental measures (item (7)).

3.1.2. Attitudes toward water supply policies (water rates, regional collaboration)

We compared attitudes toward water supply policies in Suita City from the perspectives of current generations and IFGs by means of a *t*-test (Table 3). The questions used for this analysis were "Amount of payment for water supply service" (Q2), "Impression of the current level of water rates" (Q3), "Pros and cons of water rates increases" (Q4), "Allowable increase in water rates" (Q5), and "Pros and cons of 'regional collaboration'" (Q6). The allowable increase in water rates (%) was calculated from responses to "Amount of payment for water supply service" (Q2) and "Allowable increase in water rates" (Q5), taking into account differences in rates due to the number of household members. Note that for each question, only respondents who answered questions from both the current generations and IFGs perspectives were included in the analysis.

The *t*-test results revealed significant differences in the responses to three questions: "Impression of the current level of water rates" (Q3) ($t = -13.505$, $p < 0.001$), "Pros and cons of water rates increases" (Q4) ($t = -11.722$, $p < 0.001$), and "Pros and cons of 'regional collaboration" (Q6) ($t = -3.447$, $p < 0.001$). The responses from the IFGs perspective tended to perceive water rates as cheaper than responses from the current generations perspective. They also tended to be significantly more positive about paying higher water rates and promoting regional collaboration (integration) in water supply infrastructure and services. However, there was no significant difference in responses about how much of a rise in water rates (%) would be acceptable (Q5).

3.1.3. Evaluating decision criteria about water pipe renewal

We compared the evaluation scores for the criteria for deciding the priorities for water pipe renewal given from the current generations and IFGs perspectives using a *t*-test (Table 4). The question used for this analysis was Q7. We calculated the average score for each criterion by allocating a score of 5 points to a ranking of No. 1, 4 points for No. 2, 3 points for No. 3, 2 points to No. 4, 1 point for No. 5, and 0 points for the other criteria. Only respondents who gave responses from both current generations and IFGs perspectives were included in the analysis ($n = 638$). The *t*-test results showed significant differences in evaluation scores for two criteria: "Degree of deterioration" ($t = -2.150$, $p < 0.05$) and "Earthquake resistance" ($t = -3.338$, $p < 0.001$). Compared to responses from the current generations perspective, responses from the perspective of IFGs tended to rank "Degree of deterioration" (pipe aging) as less important but "Earthquake resistance" as more important. However, the overall ranking of priorities was the same from the two perspectives.

3.2. Analysis of the relationship between pattern of future description and effectiveness of IFGs

3.2.1. Cluster analysis based on the visions of Suita City in 2050

We performed a cluster analysis on the multiple-choice answers to items (1) to (8) of “Images of the future state of Suita City” (Q1) from the IFGs perspective as scaled scores using PAST (ver. 4.17). A total of 678 respondents who gave responses to all the items of Q1 from the IFGs perspective were included in the analysis. Two groups, extracted at a distance of 45.0, were designated as Cluster A and Cluster B. There were 230 respondents in Cluster A and 448 in Cluster B, indicating that residents with a pessimistic vision of the future were a clear majority. The mean values of responses and *t*-test results are shown in Table 5.

There were significant differences in the following seven items: (1) Population of Suita City ($t = -33.263$, $p < 0.001$); (2) No. of buildings in Suita City ($t = -26.328$, $p < 0.001$); (3) No. of commercial facilities in Suita City ($t = -25.265$, $p < 0.001$); (4) Connections with people outside family and workplace ($t = -13.620$, $p < 0.001$); (5) Public services such as parks and community centers ($t = -13.724$, $p < 0.001$); (6) Economic situation of Suita City ($t = -17.039$, $p < 0.001$); and (7) Use of solar (PV) power generation and renewable energy in Suita City ($t = -4.878$, $p < 0.001$). There were no significant differences in responses to (8) Disasters due to earthquakes, windstorms, and floods in Suita City. The results for items (1) to (7) show that Cluster A tended to imagine a significantly more positive future than Cluster B. The median value of responses, 3, indicates that Cluster A tended to portray a more positive image for all items, whereas Cluster B tended to describe a more negative image for all but items (7) and (8). On this basis, we can define Cluster A as a group with an optimistic vision of future of Suita City from the IFGs perspective and Cluster B as a group with a pessimistic vision of the future of Suita City from the IFGs perspective.

Table 7
Evaluation of decision criteria and priority rankings for water pipe renewal.

			Generation	n	*Mean* (SD)	*t*	*df*	Order of priority
①	Piping with severely affected by water outage	Cluster A	Current generations	210	3.00 (1.81)	1.574 *n.s.*	209	2
			IFGs	210	2.83 (1.79)			2
		Cluster B	Current generations	421	3.23 (1.61)	0.306 *n.s.*	420	2
			IFGs	421	3.21 (1.63)			1
		Cluster A	IFGs	210	2.83 (1.79)	-2.571 *	383.478	2
		Cluster B	IFGs	421	3.21 (1.63)			1
②	Piping needed for critical water supply services	Cluster A	Current generations	210	2.84 (1.66)	2.476 *	209	3
			IFGs	210	2.62 (1.67)			3
		Cluster B	Current generations	421	2.75 (1.66)	0.374 *n.s.*	420	3
			IFGs	421	2.73 (1.68)			3
		Cluster A	IFGs	210	2.62 (1.67)	-0.796 *n.s.*	629	3
		Cluster B	IFGs	421	2.73 (1.68)			3
③	No. of water users	Cluster A	Current generations	210	1.09 (1.46)	-1.731 *n.s.*	209	6
			IFGs	210	1.22 (1.54)			6
		Cluster B	Current generations	421	1.03 (1.46)	0.383 *n.s.*	420	6
			IFGs	421	1.01 (1.43)			6
		Cluster A	IFGs	210	1.22 (1.54)	1.645 *n.s.*	390.662	6
		Cluster B	IFGs	421	1.01 (1.43)			6
④	Quantity of water supplied	Cluster A	Current generations	210	0.64 (1.19)	-1.391 *n.s.*	209	7
			IFGs	210	0.74 (1.25)			7
		Cluster B	Current generations	421	0.54 (1.06)	0.118 *n.s.*	420	7
			IFGs	421	0.54 (1.05)			7
		Cluster A	IFGs	210	0.74 (1.25)	2.061 *	360.18	7
		Cluster B	IFGs	421	0.54 (1.05)			7
⑤	Degree of deterioration	Cluster A	Current generations	210	3.28 (1.63)	0.814 *n.s.*	209	1
			IFGs	210	3.20 (1.73)			1
		Cluster B	Current generations	421	3.27 (1.58)	2.106 *	420	1
			IFGs	421	3.15 (1.68)			2
		Cluster A	IFGs	210	3.20 (1.73)	0.351 *n.s.*	629	1
		Cluster B	IFGs	421	3.15 (1.68)			2
⑥	Earthquake resistance	Cluster A	Current generations	210	2.21 (1.57)	-1.276 *n.s.*	209	4
			IFGs	210	2.31 (1.79)			4
		Cluster B	Current generations	421	1.98 (1.61)	-2.961 **	420	5
			IFGs	421	2.15 (1.64)			4
		Cluster A	IFGs	210	2.31 (1.73)	1.167 *n.s.*	629	4
		Cluster B	IFGs	421	2.15 (1.64)			4
⑦	Leakage hazard level	Cluster A	Current generations	210	1.82 (1.59)	-1.179 *n.s.*	209	5
			IFGs	210	1.93(1.62)			5
		Cluster B	Current generations	421	2.10 (1.65)	0.476 *n.s.*	420	4
			IFGs	421	2.07 (1.65)			5
		Cluster A	IFGs	210	1.93 (1.62)	-1.047 *n.s.*	629	5
		Cluster B	IFGs	421	2.07 (1.65)			5

***$p < .001$, **$p < .01$, *$p < .05$

3.2.2. Attitudes toward water supply policies (water rates, regional collaboration)

For our analysis to compare the responses before and after the shift in perspective from current generation to IFGs for each of Clusters A and B and to compare the responses of the two clusters about attitudes toward the water supply-related policies of Suita City (water rates, regional collaboration) from the IFGs perspective (Table 6), we performed *t*-tests. The questions we focused on for this analysis were “Amount of payment for water supply service” (Q2), “Impression of the current level of water rates” (Q3), “Pros and cons of water rates increases” (Q4), “Allowable increase in water rates” (Q5), and “Pros and cons of ‘regional collaboration’” (Q6). For each question, only respondents who gave answers from both the current generations and IFGs perspectives were included in the analysis.

The shift in perspective caused significant changes to results for the question “Impression of the current level of water rates” (Q3) both in Cluster A ($t = 7.306, p < 0.001$) and in Cluster B ($t = 11.374, p < 0.001$). For both clusters, the shift from the current generations perspective to the IFGs perspective caused a significant change in attitude toward the level of water rates in 2022 (when the questionnaire was conducted). The level of water rates was perceived as “cheaper” after the shift. However, there was no significant difference between the two clusters, suggesting that differences in how the future is envisioned did not influence attitudes toward water rates.

On the question “Pros and cons of water rates increases” (Q4), there were significant differences between the two responses (current generations and IFGs) for each of Cluster A ($t = 6.485, p < 0.001$) and Cluster B ($t = 9.753, p < 0.001$). Significant differences were also found in the comparison between clusters from the IFGs perspective ($t = 2.682$, $p < 0.01$). For both clusters, there was a significant change in attitude toward greater acceptance of water rate increases above the 2022 level after the shift from current generations perspective to the IFGs perspective. The comparison between clusters revealed that Cluster B showed a significantly greater change toward acceptance of higher water rates than Cluster A.

On the question “Allowable increase in water rates (Q5),” which was calculated from Q2 and Q5, there was a significant increase in the acceptable rate increase due to the shift to IFGs perspective in Cluster A ($t =$ -3.337, $p < 0.01$), as well as a significant difference between the two clusters in responses from the IFGs perspective ($t =$ -2.493, $p < 0.05$). However, the acceptable rate of Cluster A from the IFGs perspective was still markedly lower than the acceptable rate of Cluster B from the current generations perspective. In other words, despite the fact that the acceptable rate rise of Cluster A increased significantly as a result of the shift in perspective, the acceptable rate rise was still lower than that of Cluster B before the perspective shift. Cluster B did not show a significant increase in acceptable rate increase as a result of the perspective shift, but it is reasonable to consider the mean value of acceptable rate rise as having already been high before the perspective shift.

On the question “Pros and cons of ‘regional collaboration’” (Q6), significant changes due to the shift in perspective were observed in both Cluster A ($t = 2.351$, $p < 0.05$) and Cluster B ($t = 2.351$, $p < 0.05$). The attitudes of both clusters tended to become more favorable to regional collaboration (integration) from 2022 after the shift to the IFGs perspective. However, there were no significant differences between the two clusters, which suggests that the way future visions of society were described had no influence on this question.

As shown above, there were no significant differences between the clusters on the questions “Impression of the current level of water rates” (Q3) and “Pros and cons of ‘regional collaboration” (Q6). This suggests that the pattern of describing the future society as part of the IFGs exercise did not influence attitudes toward these particular issues. However, significant differences between the two clusters were observed on the questions “Pros and cons of water rates increases” (Q4) and “Allowable increase in water rates (Q5),” indicating that the pattern of future description did effect attitudes toward these issues.

3.2.3. Evaluation of decision criteria for water pipe renewal priorities

To assess the responses to the question “Decision criteria about water pipe renewal” (Q7 in Table 1), we calculated the mean evaluation score for each criterion by assigning a score of 5 points to a No. 1 ranking, 4 points to No. 2, 3 points to No. 3, 2 points to No. 4, 1 point to No. 5, and 0 points to the other criteria. Only respondents who gave answers from both the current generations and IFGs perspectives were included in the analysis. For each cluster, we compared the responses before and after the shift in perspective, and we also compared the responses of the two clusters from the IFGs perspective. The results are summarized in Table 7.

Looking at the differences in mean evaluation scores between the two perspectives (generations) for each cluster, the significant changes were a decrease in the score for (2) Piping needed for critical water supply services ($t = 2.476, p < 0.05$) in the case of Cluster A, and a decrease in the score for (5) Degree of deterioration ($t = 2.106$, $p < 0.05$) and an increase in the score for (6) Earthquake resistance ($t =$ -2.571, $p < 0.01$) in the case of Cluster B. In our comparison of the two clusters, there were significant differences in the scores for (1) Piping with severely affected by water outage ($t =$ -2.571, $p < 0.05$) and (4) Quantity of water supplied ($t =$ -2.061, $p < 0.05$). A look at the ranking of the priority of criteria revealed no difference in ranking between perspectives in the case of Cluster A. In the case of Cluster B, the No. 1 and No. 2 rankings, (5) Degree of deterioration and (1) Piping with severely affected by water outage, respectively, were reversed after the shift in perspective, and so too were the No. 4 and No. 5 rankings, (7) Leakage hazard level and (6) Earthquake resistance, respectively. The items that were subject to changes in mean score large enough to change the criteria rankings were (5) Degree of deterioration (decrease) and (6) Earthquake resistance (increase) in Cluster B. The comparison between the two clusters based on the responses from the IFGs perspective showed significant differences in two items: (2) Piping needed for critical water supply services ($t =$ -2.571, $p < 0.05$) and (4) Quantity of water supplied ($t = 2.061$, $p < 0.05$). Cluster B had a significantly higher mean score for (2) Piping needed for critical water supply services and Cluster A had a significantly higher mean score for (4) Quantity of water supplied.

4. Discussion

4.1. Effectiveness of applying IFGs

We consider first the change in the attitudes of residents after the application of IFGs. In the visions of society in 2050 described by the respondents, the shift to an IFGs perspective tended to make them more pessimistic about the future development of the city and the future state of human relations. One explanation for this apparent pessimism could be that the change in perspective effectively removed an optimism bias (Sharot, 2011) toward the future. In contrast, the attitude toward environmental measures tended to become more positive. Although a more detailed analysis of the reasons for this observation is needed, one likely factor is the widespread knowledge of the SDGs and the commitment to concrete goals such as "carbon neutrality by 2050," along with the recognition that such goals need to be achieved. In fact, a survey conducted in Japan in 2023 revealed that over 90 % of respondents were aware of the SDGs (Dentsu, 2023).

Next, we examine changes in attitudes toward policies related to water supply services (i.e., water rates and regional collaboration). The application of IFGs significantly increased the tendency to view the water rate level of 2022 when the questionnaire was conducted as cheap ("the rate was cheap") and the tendency to agree to increasing water rates beyond the 2022 level. However, the shift to an IFGs perspective made no significant difference to the acceptable increase (%) in water rates, although a slightly higher acceptable increase was observed. In other words, the application of IFGs shifted perception toward the view that a reasonable cost burden is necessary, based on a sense of crisis about the management of water supply infrastructure, but not to the point of making people feel willing to pay significantly more for water. The fact that the application of IFGs made respondents more favorably disposed to regional collaboration (integration) of water supply services suggests that this kind of policy could attract strong support if assessed from a long-term perspective. In a previous Future Design practice, employees of the Suita City Water Works Bureau discussed future water supply services and policies (Hara et al., 2025). The study showed that the importance of the "Status of and trends in initiatives by other entities," an evaluation criterion used for water supply policies, increased with the introduction of the IFGs' perspective. Since this criterion relates to the "regional collaboration" policy in this study, we assume that the findings of this study are consistent with those of the previous study in this respect. As for the decision criteria for water pipe renewal, the importance of "Degree of deterioration" decreased, whereas that of "Earthquake resistance" increased after the adoption of an IFGs perspective. The application of IFGs did not change the ranking of priorities, however.

The above results indicate that incorporating the perspective of future generations can increase the acceptability of water rate increases and regional collaboration (integration) of water supply services, both of which are vital issues for water infrastructure maintenance and management—and enable more flexible consideration of long-term water supply-related policies. However, the shift in perspective from current generations to IFGs did not significantly change the acceptable increase in water rates. Additionally, while the present study analyzed changes in perceptions, further research is needed to determine whether the application of IFGs can facilitate real behavioral change, including follow-up surveys. The application of IFGs was also observed to be somewhat effective in changing the evaluation of decision criteria for water pipe renewal. For example, there was an observed increase in importance given to the criterion of earthquake resistance, likely due to a stronger perception of future earthquake risk after the adoption of an IFGs perspective stimulated a more concrete examination of the future. In fact, earlier studies have shown that the adoption of IFGs enhances perception about future risks (Hara et al., 2023), which is consistent with this finding.

4.2. Impact of IFGs on patterns of describing the future of society

In this section, we will discuss the impact of differences between a group of respondents that held an optimistic vision of the future from the IFGs perspective (Cluster A) and a group that held a pessimistic vision of the future from the IFGs perspective (Cluster B). As explained in Section 3.2.1, Cluster B had a larger number of respondents ($n = 448$) than Cluster A ($n = 230$). Earlier studies have demonstrated that the IFGs mechanism is effective in generating futurability and countering shortsightedness (Saijo, 2020; Kamijo et al., 2017; Hara et al., 2019), which is consistent with more respondents imagining a pessimistic vision of the future. However, since the way that respondents define their vision of the future society is influenced by a variety of factors, including personal attributes, it is necessary to accumulate further knowledge and be careful in making interpretations.

Next, we examine the impact of patterns of describing the future on changes in attitudes toward water supply management policy (water supply rates and regional collaboration). The following items suggest that patterns of describing the future can influence the activation of futurability generated by the application of IFGs. In Cluster A (optimistic vision), significant changes were observed in responses to all the questions as a result of the shift in perspective, whereas in Cluster B (pessimistic vision), significant changes were observed with all questions except for "Allowable increase in water rates" (Q5). If we focus on "Allowable increase in water rates" (Q5), we find that Cluster A was influenced by IFGs, with the acceptable rate increase rising by a significant amount, from 20.04 % to 24.26 %. In the case of Cluster B, on the other hand, the acceptable increase (34.26 %) was already high for responses from the current generations perspective, and substantially higher than the value of Cluster A. Thus, there was a substantial difference in views on the acceptable increase in water rates according to the pattern of describing visions of the future (i.e., differences between Clusters A and B). This result suggests that people in Cluster A may have had a relatively low sense of crisis regarding economic aspects of water infrastructure maintenance and management. It is likely that even after the adoption of an IFGs perspective, Cluster A was not able to develop the same attitude (level of concern) regarding water supply infrastructure maintenance and management as the people of Cluster B, who held a relatively pessimistic view of the future, with a strong sense of crisis even from the current generations perspective.

In the responses of Cluster B to "Decision criteria about water pipe renewal", the adoption of the IFGs perspective resulted in a change in the importance (priority) of criteria. Specifically, the mean evaluation score for the criterion "Degree of deterioration" decreased, whereas that for "Earthquake resistance" increased, suggesting that the application of IFGs influenced the evaluation of decision criteria for this cluster. Since this cluster is associated with a relatively pessimistic vision of the future, it is likely that the various conceivable future risks, including earthquakes and other disasters, caused a change in the priority ranking of decision criteria for water pipe renewal.

Summarizing, there were significant differences between the clusters in responses to the questions "Pros and cons of water rates increases" (Q4) and "Allowable increase in water rates" (Q5), indicating that Cluster B, which described a more pessimistic vision of the future from the perspective of IFGs, tended to feel the need for a more urgent response to sustainable water supply management. A change in the priority ranking of decision criteria for renewal of water pipes was also observed with Cluster B, suggesting that defining a pessimistic vision of the future may tend to enhance the generation of futurability. These are consistent with the results of the previous study (Kuroda et al., 2021), although further study is needed to verify this hypothesis.

4.3. Findings and future prospects

It is clear from the results of the present study that the adoption of IFGs in our questionnaire to shift the perspective of respondents alters their attitudes toward water supply infrastructure maintenance and management, as well as their degree of tolerance and judgments about future measures required to ensure the sustainability of water supply services, such as water rate increases and regional collaboration (integration). The study findings offer new insights into existing Future Design-related research from a number of viewpoints. Firstly, up to now, many of the studies on the effectiveness of applying IFGs have been designed based on multi-member discussions and exchanges of opinions in experiments, field experiments, and practices. A new finding obtained by the present study was that, to some extent, the application of IFGs is effective in shifting the perspectives of "individuals" responding to questionnaires. In addition, earlier studies (e.g., Kuroda et al., 2021) have suggested that there can be multiple patterns of describing visions of a future society including optimistic and pessimistic when adopting IFGs, but discussion of this has been limited to qualitative analysis. However, in the present study, by quantitatively identifying multiple factors (indicators) that make up a societal vision of the future, we succeeded in quantitatively demonstrating that the patterns of future description can be divided into optimistic and pessimistic, and that these patterns of description can also influence the effectiveness of applying IFGs. Particularly if the vision of the future is pessimistic, the future of water supply services may be seen with a stronger sense of crisis or urgency, thereby amplifying the effectiveness of adopting IFGs. These new findings offer valuable suggestions for strategies for planning policy and building consensus in relation to water infrastructure maintenance and management, a long-term challenge that is subject to intergenerational conflicts of interest.

Challenges for further research include understanding the correlations between individual (personal) attributes, patterns of describing the future, and the activation of futurability by the application of IFGs. The relationship between individual attributes and futurability was discussed in earlier studies (Hara et al., 2023, 2021; Nakagawa et al., 2019; Hiromitsu et al., 2021; Kuroda et al., 2021), but this connection has never been investigated in the context of research on water supply issues. There is also a need to accumulate more knowledge on how the effectiveness of applying IFGs varies according to the patterns of shifting perspectives within individual respondents, as discussed in this study, and the exercises focused on multi-member discussions and decision-making. By identifying the advantages and disadvantages of each method in detail through further case studies and research, we can build the necessary knowledge about how to effectively approach long-term challenges such as water supply infrastructure maintenance and management through the application of Future Design methods of policymaking. As shown in the Appendix 1, we offered minimal information about water supply services to ensure a common level of knowledge among respondents (e.g., providing just a simple explanation about regional integration), but it is likely that the level of knowledge about water supply services and administration varies significantly between residents to begin with. Since we assume that such differences in knowledge level influence judgments and perceptions, we need to acquire further knowledge from the viewpoint of how such differences would affect.

5. Conclusion

For this study, we conducted a questionnaire survey of residents of Suita City, a typical urban center in Japan, relating to the sustainable maintenance and management of water supply infrastructure and services, and performed statistical analyses to assess the effectiveness of applying a future generations perspective. In particular, we analyzed the kinds of changes that occur with a shift from the perspective of current generations to that of IFGs in attitudes toward water supply infrastructure management, willingness to pay for water rate increases, and the perceptions of policies such as regional collaboration (integration) in water services. Additionally, we investigated how patterns of future descriptions from the perspective of IFGs influence such changes in attitude and perception, to gain insight into the relationship between patterns of defining the future and activation of futurability in survey respondents. The results showed that incorporating the perspective of future generations can increase the acceptability among residents (i.e., water supply users) of water rate increases and regional collaboration in (integration of) water supply services (both of which are vital issues for water supply infrastructure management) and enable more flexible consideration of long-term water supply-related policies. We also observed changes in attitudes toward decision criteria for water pipe renewal, for example, an increase in the importance of earthquake resistance. Furthermore, we demonstrated that the effectiveness of applying IFGs varies according to how the future is described or imagined. More specifically, the effectiveness of IFGs for a group of respondents who held a more pessimistic vision of the future was shown to be relatively high in terms of "Pros and cons of water rates increases" (Q4) and "Allowable increase in water rates" (Q5).

The maintenance and management of water supply infrastructure is a long-term challenge that impacts not only today's society but also future generations. It is important that the residents (water users) of a municipality maintain a high level of awareness of water supply issues. The results of the present study suggest that adopting the perspective of future generations can help water users take a long view of water supply issues and consider future water supply-related policy questions more flexibly. Looking ahead, further case studies need to be conducted to examine effective approaches to policymaking and building consensus for facilitating sustainable water supply management by investigating the correlations between individual attributes, patterns of describing the future, and the activation of "futurability." The present study should serve as an important foundation for such research.

CRediT authorship contribution statement

Yukari Fuchigami: Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Taiga Ikenaga:** Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Masashi Kuroda:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Keishiro Hara:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.futures.2025.103709.

Data availability

Data will be made available on request.

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