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Policy design and decision criteria for sustainable water supply from the perspective of "imaginary future generations" - A deliberation experiment with policymakers in a municipality, Japan

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ABSTRACT

To maintain sustainable water supply systems, it is indispensable to design relevant policies with a long-term perspective. In this paper, we present a novel approach to design policies on sustainable water supply by adopting "Imaginary Future Generations (IFGs)" which has been proven effective in generating futurability of individuals. We conducted deliberation experiments focused on envisioning future water supply services and policies with the participation of employees of the Suita City Water Works Bureau and analyzed the impacts of adopting IFGs on policy design and policymaking criteria. Based on the discussion results and questionnaires administrated to the participants, we demonstrate that the perspective of IFGs could lead to producing vary different visions of water supply system in 2050 and different policy measures compared to the perspective of current generations, due mainly to the change in the decision criteria. The results show that the method could stimulate awareness of water supply use and services at the household level by citizens and the proposal of measures based on a sense of crisis about the future. We conclude that the method could facilitate more effective and flexible policy formulation aimed at realizing a sustainable water supply system from a long-term perspective by generating futurability.

1. Introduction

Ensuring a healthy water supply is fundamental to sustainable development (UNESCO-WWAP, 2012). Accordingly, maintenance and management of water supply system constitute a vital issue in shaping a sustainable society. Much of Japan's infrastructure was developed in a relatively narrow window of time during a period of rapid economic growth. Now, several decades later, much of this infrastructure is in need of renewal (Tsukuda and Sakai, 2020). This problem applies to public water supply infrastructure in Japan. Most of the water pipes laid during the economic boom years were cement-mortar lined ductile iron pipes. The task of replacing all these water pipes that have exceeded their statutory service life is a time-consuming one. For many Japanese municipalities, the renewal of water piping has become a pressing challenge (Hosoi et al., 2011). However, although the maintenance of water supply infrastructure requires a large amount of money, the volume of water that municipalities supply and earn revenue from (through municipal water rates) is declining as a result of shrinking populations, a shift to underground water use by large water consumers, and

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reduced water consumption due to greater awareness of water conservation and widespread adoption of water-saving technology (Suita City, 2019). Water utilities in Japan are financed through revenues based on water rates applied to the volume of water consumed. The management of water utilities is therefore likely to become increasingly difficult over the coming years. With the aim of improving this situation, there has been considerable discussion about wide-area collaboration on water supply projects and raising water rates (Ministry of Health, Labour and Welfare, 2016). However, these are questions that need to be debated from a long-term perspective because they are relevant not only to the people of today but also to future generations. In other words, it is essential to discuss visions of water supply systems for a future society and policies for infrastructure maintenance and management from a long-term perspective of sustainability that takes into account the interests of future generations.

Studies have examined quantifying the total benefits of pipeline renewal and maximizing the total benefits of pipeline renewal plans under cost constraints based on water supply revenues (Odanagi et al., 2003; Hosoi et al., 2011). However, these earlier studies examined and assesses the future only from the perspective of current generations, i.e., they do not explicitly incorporate the perspective of future generations. We hypothesize that incorporating the preferences of future generations could change the criteria and trade-offs between relevant policy decisions. It is thus essential to develop a method for designing policies for sustainable management of water supply systems from a long-term perspective, incorporating the viewpoint of future generations.

Various methodologies, including those involving participatory scenario planning and backcasting, have been studied and practiced to envision a future society (Kishita et al., 2016; Reed et al., 2013; Robinson et al., 2011; Carlsson-Kanyama et al., 2008; Quist and Vergragt, 2006; Okada et al., 2020), and they have also been used to formulate future visions and plans for urban planning and infrastructure management (Mannucci et al., 2023; Sykes et al., 2019; Ratcliffe and Krawczyk, 2011). In addition, sustainability assessment methodologies have been developed in the context of water supply and sanitation (Sun et al., 2024; Ren et al., 2017; Attri et al., 2022). However, few of these methods and practices explicitly deal with intergenerational conflicts of interest and trade-offs (Kuroda et al., 2021; Uwasu et al., 2020; Hara et al., 2019). Water supply infrastructure management requires multi-decade planning. Particularly for maintenance, the question of what decision criteria to use in formulating plans for water supply systems and strategies for their management is very important. For sustainable maintenance of water supply infrastructure, future planning needs to incorporate a long-term perspective that considers future generations and intergenerational trade-offs.

To address persistent long-term sustainability issues (Rockström et al., 2009; Steffen et al., 2015; Komiyama and Takeuchi, 2006), such as climate change, “Future Design” has been proposed in recent years. Given human traits such as impulses (Sapolsky, 2012) and optimism about the future (Sharot, 2011), as well as existing social systems such as markets, it is fundamentally difficult to make decisions that take into account the preferences of future generations (Saijo, 2020). A person exhibits futurability when he or she experiences an increase in happiness as a result of deciding and acting to forego current gains to enrich future generations, and Future Design is the praxis of generating futurability of individuals through designing social systems (Saijo, 2020). One of the methods which has been proven to be effective to activate futurability is called “imaginary future generations (IFGs).” IFGs are stakeholders tasked with representing future generations in decision-making and negotiations with current generations. Previous studies through experiments (Kamijo et al., 2017), field experiments (Shahrier, et al., 2017; Nakagawa et al., 2019; Timilsina et al., 2022), large-scale questionnaire surveys (Uwasu et al., 2024) and practices (Hara et al., 2019, 2021; Uwasu et al., 2020; Nishimura et al., 2020; Hiromitsu et al., 2021) have shown that adopting IFGs is an effective approach to incorporate the preferences of future generations in decision-making by generating futurability. Several forms of adopting the IFGs mechanism have been proposed. In Hara et al. (2019), a group of current generations and a group of IFGs negotiated to reach consensus on policy measures for a regional revitalization plan. The "future ahead and back mechanism" allows individuals to shift their perspective from the IFGs to the current generations, which has been shown to be effective in generating futurability (Shahrier et al., 2023). The “intergenerational accountability” mechanism (Timilsina et al., 2023), on the other hand, allows individuals to express reasons for decisions and advice for future generations. The mechanism has also been shown to be effective in generating futurability based on lab-in-the-field experiments. However, various studies have shown the effectiveness of using IFGs in different practices and in real decision making in the context of intergenerational issues. In addition, the areas of application of IFGs are very broad, regardless of the issues and types of problems. Actually, IFGs has been applied to a variety of policy fields, including urban planning, environmental planning, carbon neutral policy design, water environmental management, waste management and disaster prevention (Hara et al., 2023a, Hara et al., 2023b; Hiromitsu et al., 2021; Kuroda et al., 2021; Tateyama et al., 2019; Pandit et al., 2021). However, its application to water supply infrastructure planning has been limited. In particular, the maintenance of water supply infrastructure in the face of budgetary constraints and a declining population is an important issue from a sustainability perspective. Past studies have also suggested that policy design discussions from the perspective of imaginary future generations (IFGs) can stimulate essential discussions that are not merely extensions of existing policies, taking into account benefits from a long-term perspective. There is also evidence that such a perspective of “futurability” is useful for finding new directions for policy decision criteria by increasing empathy for future generations. We hypothesize that the generation of futurability through the adoption of IFGs should provide essential insights into the direction of policy on water supply planning. To clarify these points, it is important to apply the perspective of IFGs in discussions about future visions of water supply systems and management.

Against this background, this study aimed to analyze the effectiveness of applying the mechanism of IFGs in the specific context of Suita City, Osaka Prefecture, Japan, by conducting a deliberation experiment on water supply visions and policies with the participation of employees of the city’s Water Works Bureau. Based on the results of discussions and questionnaire surveys of the participants, we set out to answer the following three Question 1) Does the application of the IFGs mechanism change how the city’s Water Works Bureau staff envision the future of the city and its water supply in 2050? 2) Does the application of IFGs change decisions about the measures needed now and their priorities? 3) Does the application of IFGs change the priority of decision-making criteria related to water administration policy? The results of this study offer insight into the effectiveness and value of the new methodology of applying

IFGs in policy discussions about intergenerational trade-offs related to sustainable water infrastructure maintenance and management.

2. Methods

2.1. Rationale for adopting IFGs – a review of previous studies

Various studies, including experiments, field experiments, and practices, have shown that the introduction of IFGs could lead to sustainable choices and decision making that take into account the benefits of future generations. Kamijo et al. (2017) conducted a laboratory controlled experiment and showed that adoption of IFGs could increase the likelihood of groups making decisions that consider the benefits of future generations, even if their own monetary payoffs would decrease. Field experiments also show that the introduction of IFGs can lead to sustainable decisions that consider the benefits of future generations (e.g., Timilsina et al., 2023). Future Design practices have also shown some effects of adopting IFGs in real-world deliberation and decision-making. For example, Hara et al. (2021) showed that experiencing the perspective of IFGs could lead to the creation of a higher overarching perspective between current and future generations, which is called "shared viewpoint". Hypothetically, the shared viewpoint created as a result of experiencing IFGs would be related to sustainable decision making that considers the benefits of future generations. Hiromitsu et al. (2021) found that deliberations among IFGs showed interest in issues related to common fundamental needs across generations. Uwasu et al. (2020) showed that in deliberations on the installation of renewable energy in a Japanese municipality, scenarios proposed by IFGs were more proactive in terms of paying the costs incurred to enable the realization of policies necessary to achieve a long-term vision. This suggests that the adoption of IFGs could incentivize individuals for societal transformation towards a desired future society. Hara et al. (2023a) showed that in the policy discussion to envision the decarbonized society in 2050, the policy measures proposed by the local government officials representing IFGs shifted from individual measures to proposals for new systems that do not yet exist, even if they require high hurdles for the current generation. It was also suggested that individual perceptions such as "a sense of crisis about the future" could be enhanced by experiencing the perspective of IFGs. We argue that these effects would be related to the generation of futurability (Saijo, 2020).

In light of these findings, we can assume that the adoption of IFGs would be effective in designing sustainable water supply policies in the case study area that require a long-term perspective to reconcile intergenerational conflicts, as explained in the Introduction section.

2.2. Setting up

Suita City is a city located in the north of Osaka Prefecture in Japan with a population of approximately 370,000. A total of five Future Design discussion exercises (workshops) involving Suita City Water Works Bureau staff were held: Session 1 (August 2, 2022), Session 2 (August 18, 2022), Session 3 (September 1, 2022), Session 4 (September 15, 2022), and Session 5 (September 26, 2022). Each session lasted approximately two and a half hours.

A total of 15 city employees (10 men and 5 women) participated in the discussions. Of these, 7 were in their 20 s, 5 in their 30 s, and 3 in their 40 s. To ensure some diversity and balance, three groups of five were formed (A, B, and C). The members of the groups remained unchanged throughout the discussion sessions. In addition to the group members, one Water Works Bureau staff member served as a facilitator in each group. All discussions were recorded, but the facilitators also wrote down important discussion points on paper. Table 1 summarizes the workshop settings.

In line with previous studies and research findings in Future Design (Hara et al., 2021), which used the method to shift the perspective from the current generation to the IFGs within individuals, we designed the discussion content and steps with the aim of generating “futurability.” The authors (researchers) and management of the Water Works Bureau (facilitators) made extensive preparations for the workshops in advance, while the secretariat of the Water Works Bureau took the lead in facilitating the workshop, using a facilitator’s notebook created beforehand.

2.3. Workshop design

Fig. 1 shows the framework and flow of the workshop. Table 2 shows the contents of all five discussions. In terms of the overall design, in Session 1, participants discussed their future vision of Suita City and its water supply system from the perspective of the current generations, and proposed measures for the next long-term water supply plan for 2030 and beyond. Specifically, they discussed

Table 1
Workshop settings.

Item	Content
Schedule	Session 1 (August 2, 2022); Session 2 (August 18, 2022); Session 3 (September 1, 2022); Session 4 (September 15, 2022); Session 5 (September 26, 2022)
No. of sessions	5 sessions in total
WS time	Approx. 2 and a half hours/session
Nos. of people and groups	5 people × 3 groups (A, B, C)
Ages	20 s (7persons), 30 s(5persons), 40 s (3persons)

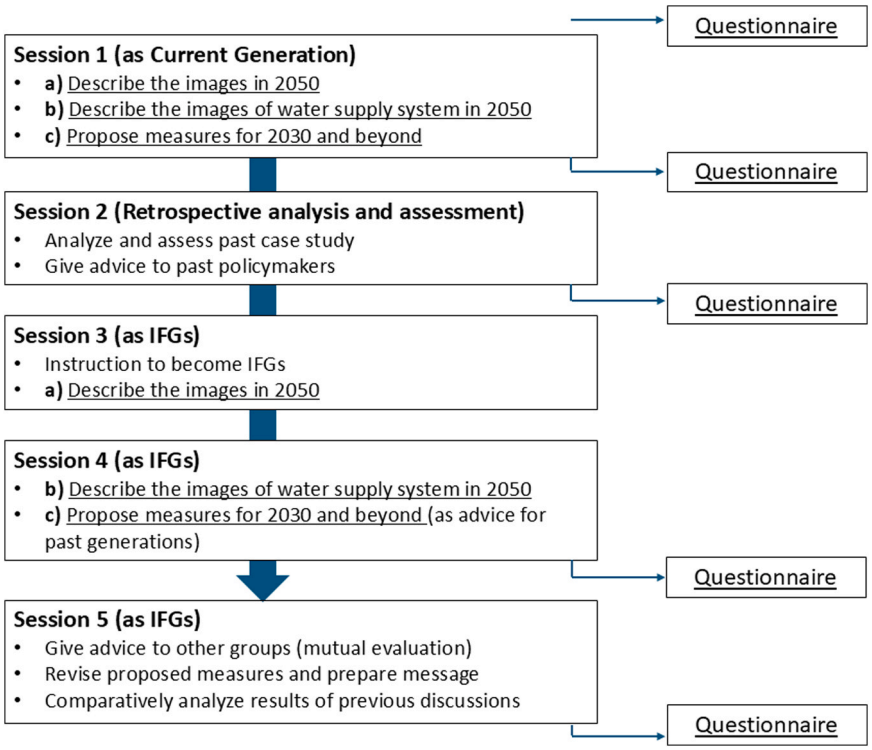

Fig. 1. Framework and flow of workshop.

Table 2
Flow and contents of workshop.

Session and perspective	Discussion contents
Session 1 As current generations	**Describe the society and water supply in 2050 and propose and select measures** • Task 1: Describe the images of Suita City in 2050 • Task 2: Describe the images of water supply system of Suita City in 2050 • Task 3: Propose issues to consider and measures to take for the next long-term plan for 2030 and beyond
Session 2 Retrospective analysis and assessment of past policies	**Analyze, evaluate, and give advice on case studies of 30 years ago** • Explanation and information of past case study • Task 1: Analyze and comparatively assess a past case study • Task 2: Give advice on past policies to past policymakers
Session 3 As IFGs	**Describe the society of 2050 as IFGs living in 2050** • Explanation and instruction of Future Design • Task 1: Describe the images (visions) of Suita City in 2050
Session 4 As IFGs	**Describe the water supply situation in 2050, and propose and select measures (advice for past generations)** • Task 1: Review of previous discussions • Task 2: Describe the images of water supply system of Suita City in 2050 • Task 3: Propose issues to consider and measures to take for next long-term plan for 2030 and beyond (advice for past generations)
Session 5 As IFGs	**Mutual evaluation and advice sharing between groups and discussion of final proposal** • Task 1: Give advice to other groups (mutual evaluation) • Task 2: Revise proposed measures and prepare message to Water Works Bureau staff of 2022 • Task 3: Compare and analyze results of previous discussions

"a) A vision of Suita City in 2050," "b) The water supply situation in Suita City in 2050," and "c) Proposed issues to consider and measures to take for the next long-term plan for 2030 and beyond." Session 2 was a retrospective assessment and analysis of past water supply policy case studies (hereinafter "past analysis"). Previous research (e.g., Nakagawa et al., 2019) has shown that viewing and analyzing past decisions from the perspective of future generations can lead to the generation of futurability in individuals. Based on

these findings, Session 2 was intended as a preparation for the discussion as an imaginary future generation after Session 3. In Sessions 3 and 4, the perspective of imaginary future generations (IFGs) in 2050 was applied when examining the same three questions as in Session 1 (current generation perspective). In Session 5, maintaining the IFG perspective, the groups shared their proposals, and evaluated and offered advice to each other. Then based on the advice from other groups, each group formulated a final draft of its "Proposed issues to consider and measures to take for the next long-term plan for 2030 and beyond."

To make it possible to compare discussion results and analyze the effectiveness of adopting IFGs at these workshops, we made the discussion contents from the current generation perspective (Session 1) and from the IFG perspective (Sessions 3 and 4) identical. Since retrospective assessment of past case studies has been shown to be effective in enhancing "futurability," a past case study was presented for analysis in Session 2, just before the application of the IFG perspective. The details of each discussion session are outlined below.

Session 1

In Session 1, the participants discussed their future vision of Suita City in 2050 (vision of society) and an ideal water supply system for Suita City in 2050, from the perspective of current generations. They also proposed issues to consider and measures to take for the next long-term water supply plan, as well as advice for this purpose.

In Task (1), the participants described and defined their vision of what Suita City will become by 2050. Using a distributed worksheet containing the timeline, they examined possible social transformations up to 2050, considering a series of social realities and policies (e.g., water supply policy, carbon neutrality, SDGs) that may occur and have an impact on lifestyle, social values, urban infrastructure and industry, etc. Finally, after the participants described their vision of what Suita City would become in 2050 as a result of this social transformation, in terms of lifestyle, values, urban infrastructure, industry, etc., they formulated their vision in writing.

In Task (2), they discussed how the water supply system would be positioned in the context of the Suita City society of 2050 envisioned in Task (1). This included consideration about the kind of water supply services provided. Next, they broadly examined their vision of an ideal water supply system in 2050 with reference to a list of presented keywords: risk management (disaster countermeasures), water sources, optimal facility location, distribution reservoir capacity, water purification, government buildings, wide-area collaboration, environmental impact reduction, DX (digital transformation) and ICT (information and communications technology), smart meters, and citizen services. (Participants were free to also use any other keywords.) Finally, summarizing their discussion, they formulated their vision of the water supply situation in Suita City in 2050 in writing.

In Task (3), based on the results of the discussions in Tasks (1) and (2), the participants proposed the issues that the Water Works Bureau needs to consider and the measures they need to take for their next long-term water supply plan (for 2030 and beyond). Firstly, they assessed their vision of the ideal water supply situation in 2050 from Task (2), asking themselves if it was really ideal or there were issues to address or improvements to make. Next, based on the results of this assessment, the participants formulated a proposal of the issues and measures that the Water Works Bureau needs to consider. This proposal was what they judged to be necessary for realizing the next long-term water supply plan. Finally, from all their specific proposals, the participants selected the three essential issues and measures they considered most important for the next long-term plan, giving reasons for their choices.

Session 2

In Session 2, the discussion centered on the analysis and comparative assessment of a past case study of water supply policy from about 30 years ago, and giving advice to the people in charge of those past policies and measures. The main objective of this session is to allow participants to obtain the perspective of future generations compared to the generation at the time of the case study (Nakagawa et al., 2019) and to gain insights into the time dimension by learning about social change in the past (Hara et al., 2019). This step is intended to be a preparation for becoming IFGs in Session 3. Firstly, to provide some background on decision-making processes at the time and explaining relevant data, three past case studies of water supply administration were shared and discussed. The three case studies were 1) Introduction of an advanced water purification system at the Izumi Water Treatment Plant, 2) construction of the Minami Suita Park Reservoir, and 3) a pipe rehabilitation project (cleaning). All of these initiatives were past turning points in the water supply administration of Suita City. Table 3 briefly explains the history of each case study.

In Task (1), each group selected one of the three case studies and examined the background information on the measures and

Table 3
History of each case study used in Session 2.

Case study	History
Case study 1)	About 30 years ago, the deterioration of the quality of the water in Lake Biwa and Yodo River was a problem, and there was a need to remove moldy odors and chemical substances such as trihalomethane. Citizens demanded the need for good-tasting water at that time. After confirming that it was possible to significantly reduce mold odor and trihalomethane in the advanced water purification treatment experiments conducted from 1991 to 1993, the supply of tap water with advanced water purification treatment began in June 1997.
Case study 2)	According to the water demand forecast by the Suita City Water Works Bureau about 30 years ago, the water supply population and water volume were still expected to increase due to large-scale development and the spread of sewage systems. Since it was necessary to secure a distribution reservoir with sufficient capacity for stable water supply, a plan to construct a new reservoir in Minami Suita Park was considered. However, the plan was not realized due to the low water demand and the park's location on a lowland, which made pumping inefficient.
Case study 3)	About 30 years ago, many of the old water pipes in use at that time had rusted bumps blocking most of their cross-sections, and clogging inside the pipes caused poor water flow, which interfered with daily life and firefighting. In the summer, the amount of water used increases dramatically, causing the rust bumps to peel off and causing red water. The Water Works Bureau removed the rust bumps and applied a resin coating as part of the pipe rehabilitation work to restore the functionality of the pipes. In 2001, in place of the pipe rehabilitation work, the Water Works Bureau began replacing irregularly shaped pipes, such as curved pipes that were clogged severely.

initiatives taken at the time. In particular, they analyzed "social trends and issues, and policy needs of the time, as well as the future risks and technological trends that the people in charge would have considered" in terms of their impact on the policy decision-making that was conducted. Next, comparing "then" (when the case study occurred) and "now," the groups identified what had changed (differences) and what had not changed (commonalities) in relation to water supply administration in terms of social trends and issues, policy needs, future risks and technological trends, etc.

Then in Task (2), based on the results of discussion in Task (1), the groups worked on formulating advice to give to the past water officials (at the time of the case studies).

Session 3

In Session 3, all participants assumed the perspective of imaginary future generations (IFGs) living in 2050, to discuss their images (visions) of Suita City in 2050 from this viewpoint (as someone living in 2050).

At the beginning, the authors explained the concept of Future Design and gave instructions on how to adopt the perspective of IFGs (Saijo, 2020; Hara et al., 2019). All participants were asked to imagine themselves time-traveling approximately 30 years into the future to the year 2050 while remaining the same age as now, and living in that future world of 2050. As a condition for maintaining the IFG perspective, the participants were asked to speak in the present tense when talking about things happening in 2050 and in the past tense when talking about things before that time.

After a short "ice breaker" period to get used to thinking from the perspective of a future generation, the groups began their tasks. Two types of icebreakers were used here. One is to share with the group members how they live as people living in the year 2050. The second was to share with the members the environmental situation and disaster conditions in the "present" year 2050 and to send a message to the past generation of about 30 years ago. These icebreakers allowed the participants to get used to the perspective of IFGs. In Task (1), they described and defined the situation of Suita City in 2050. Firstly, they discussed and shared their views about the lifestyles, livelihoods, values, urban infrastructure, and industry of 2050 within the group. Next, they reviewed the historical development leading to these current realities in 2050. Using distributed worksheets, the participants created a timeline of past development up to the year 2050, showing social events and policies (e.g., water supply policy, carbon neutrality, SDGs) and their impacts on society (e.g., lifestyles, social values, urban infrastructure, industry). They then retrospectively analyzed how social changes had occurred. Finally, they revised and reconfirmed their images of Suita City in 2050 based on the analysis of past transformation and defined them in writing.

When participants seemed to return to the perspective of the current generation during the discussion (e.g. when participants thought and talked predictively about society in 2050), the facilitator reminded them that they were living in the world of 2050 in order to maintain the IFG perspective

Session 4

Maintaining the perspective of IFGs, discussion in Session 4 focused on formulating images of the water supply situation in Suita City in 2050, and on providing advice to the Water Works Bureau staff of 2022 on the issues to consider and measures to take for realizing their next long-term water supply plan.

After reviewing their discussions from Session 3, in Task (2) the participants described their images (visions)of the Suita City water supply situation as of 2050. Firstly, they examined the positioning of the water supply situation in the context of the images of Suita City in 2050 they defined in Task (1), as well as the services provided by the Water Works Bureau. Next, they described their images of the water supply system of 2050. The groups were presented with the following keywords associated with water supply infrastructure that were used by the Water Works Bureau 30 years earlier. They could refer to these keywords (if still relevant in 2050) to broaden their assessment: Risk management (disaster countermeasures), water sources, optimal facility location, distribution reservoir capacity, water purification government buildings, wide-area collaboration, environmental impact reduction, DX (digital transformation) and ICT (information and communications technology), smart meters, and citizen services. Finally, they integrated their discussions and defined the water supply situation in Suita City in 2050 in writing.

In Task (3), the groups worked to develop proposals and advice from their future perspective as IFGs to offer to the Water Works Bureau on issues to consider and measures to take for the next long-term plan (for 2030 and beyond), which the bureau was working on in 2022. First, they evaluated whether the 2050 water supply situation depicted in Task (2) was really ideal from the viewpoint of the Water Works Bureau staff of 2050, or whether there were issues or possible improvements. Next, based on this assessment, the groups formulated advice for the staff of the past Water Works Bureau in 2022 from the standpoint of the future generations of 2050 on issues to consider and measures to take. Lastly, the groups selected the three most important measures from their proposals and advice they considered most important, giving reasons for their choices.

Session 5

In Session 5, maintaining their IFG perspective, each of the groups offered comments and advice on the proposals of the other groups (i.e., mutual evaluation). Finally, the participants discussed the final proposals and conducted a review of the whole workshop.

In Task (1), each group in turn presented its (I) current situation of Suita City and its water supply situation in 2050, and (II) advice and proposals for policies and measures for the next long-term plan (for 2030 and beyond) with three selected options. After their presentation, they received advice from the other two groups. The advice was focused mainly on two questions: Does this measure lead to a good water supply system for the city in 2050? Does this measure benefit the citizens of Suita City in 2050? This process was repeated for each of groups A to C.

In Task (2), the participants created a final draft of advice on policies and measures for Water Works Bureau staff in the year 2022 based on the feedback from the other groups in Task (1). Finally, from the IFG perspective in 2050, the groups prepared a written message to the Water Works Bureau staff of 2022. In Task (3), the groups reviewed all their discussions since Session 1.

2.4. Text mining analysis

On the two themes "Images of Suita City in 2050" and "Suita City's water supply situation in 2050," audio recordings of discussions from the perspectives of current generations (session 1) and IFGs (sessions 3 and 4) were converted from speech to text. The text was then used for text mining analysis to compare and analyze the contents and characteristics of the discussions for each. Text mining is an analysis method that extracts useful information from text by splitting up sentences into words or terms and analyzing their frequencies and correlations (Feldman and Sanger, 2007). We used text mining to complement the comparative analysis to clarify the characteristics of the discussion patterns of IFGs.

For this study, we used "AI Text Mining" (https://textmining.userlocal.jp/), a text mining tool developed by User Local, Inc., to visualize the contents of discussions by focusing on the degree of importance of words and their "co-occurrence," that is, the relationship between words that appear in the same sentence. We used two basic approaches to text mining. The first is a numerical comparison based on word importance and co-occurrence of single words. The second is comparison based on co-occurrence networks that illustrate the co-occurrence relationships of terms.

2.5. Questionnaire analysis

To assess the impact of the treatments applied at each session on the perceptions of discussion participants and their prioritization of policy decision criteria, we administered questionnaires (Appendix 1): before the start of the workshop (pre-session), and after the end of each of Session 1 (current generation perspective), Session 2 (past analysis), Session 4 (IFG perspective), and Session 5 (IFG perspective). These questionnaires were intended to verify the impact and effectiveness of the different treatments applied at each session, that is, before discussion (no treatments), after discussion from the current generation perspective (Session 1), after past analysis (Session 2), after discussion from the IFGs perspective (Session 4), and after sharing of advice from the IFGs perspective (Session 5). The whole questionnaire consisted of four main questions, but our analysis focused on Question 1 (a, b, and c), which relates directly to the purpose and theme of this study.

Question 1 asks about the evaluation criteria used when considering policies related to water supply. In water supply administration, policies are examined according to various criteria, such as whether water supply safety can be ensured and whether water supply to the city can be reliably delivered (Appendix A). In Q1-a, we presented participants with the following eight policy criteria related to water supply administration, asking them to rate the importance of each on a scale of 1–5. These criteria were selected as indicators used in making policy decisions based on interviews with Suita City Water Works Bureau staff.

1) Is it consistent with the direction/vision of the nation (i.e., responsible Ministries) and of Osaka Prefecture, etc.?
2) Will it lead to solutions to issues in Suita City (water utilities)? (Is it a measure that takes circumstances into account?)
3) Can it secure the safety of the water supply?
4) Can it secure the stable supply of water to the municipal area?
5) Will it be understood by citizens?
6) Will it lead to improvements in services for citizens?
7) Is it highly cost-effective?
8) Status of and trends in initiatives by other entities

In Q1-b, the participants were asked to rank these eight criteria. They had to select the four most important criteria and rank them in order of importance. In Q1-c, the participants were asked to rate the importance of the top four criteria they selected in Q1-b by

Table 4
Images of Suita City in 2050.

	Current generations	IFGs
Group A	In Suita City in 2050, most people will lead a healthy, long working life, but life will be difficult (high taxes). There will be advanced hardware and software. The population of Suita City will not decline.	Suita City in 2050 has been greatly transformed as a result of SDGs^{+} introduced in 2030. Energy self-sufficiency is the norm, all means of transportation are electric, and virtual business is mainstream.
Group B	Suita City in 2050 will have highly developed transportation and leisure facilities. With advances in IoT, most services will be available at home. People will be able to produce their own electricity and water at home. Leisure industries will grow in the north of the city; medical industries will grow in the south of the city. The development of Minami Suita will be particularly remarkable. In 2040, a Nankai Trough earthquake will hit the city, but thanks to its strong infrastructure, the city will survive.	With AI and robotics, most people have little need or opportunities to go out. Everyone understands that self-sufficiency and CO_2 reduction are important. Urban infrastructure is leaner, and home delivery and renewable energy are growing businesses.
Group C	Due to population decline, drones, robots, etc., will play a big role in the Suita City of 2050. There will be changes in living spaces in response to the environment, due to rising temperatures, and working hours will be much lower. These changes will not just affect Suita City itself; even the concept of city governance and administration will probably change significantly.	Drones, robots, and 3D printers are changing the way people work, and a four-day work week is normal. Due to past wars and disasters, there are many underground shelters and disaster relief robots.Production of household drinking water and the diffusion of domestic water recycling systems have improved disaster recovery measures.

assigning a score out of 20 points to each criterion. Since Q1-b and Q1-c asked about the relative importance of the eight criteria, looking at the changes in the responses allowed us to interpret the effectiveness of the treatments in each workshop session.

3. Results

In this section, we present and compare the discussion results from the perspectives of the current generation and IFGs on three items (see Fig. 1): a) images of Suita City in 2050 (Section 3.1.1), b) water supply situation of Suita City in 2050 (Section 3.1.2), and c) proposals for the next long-term plan for 2030 and beyond (Section 3.1.3). Based on the comparative analysis along with text mining analysis, we discuss the characteristics of discussion and decision-making from the perspective of IFGs. We also present the results of the questionnaire survey and analyze the effects of treatments, such as the introduction of IFGs, on participants' decision criteria (Section 3.2). These results are synthesized to argue the implications of the introduction of IFGs for the policy discussion on the management of sustainable water supply

3.1. Discussion results

3.1.1. Images of Suita City in 2050

Table 4 shows the description of the images of Suita City in 2050 defined by each group from the perspective of current generations and separately from that of imaginary future generations (IFGs). The visions of the future society defined from the standpoints of current and future generations are clearly different between groups. For example, the members of Group C, from the perspective of IFGs, envisioned the society in 2050 in which there are many underground shelters and disaster relief robots because of the strong perception of disasters that occurred before 2050. They also presented the image of a society in which the production of drinking water for households and the diffusion of domestic water recycling systems have improved disaster recovery measures. However, such disaster-related items were not presented in the discussion from the perspective of the current generation. For all groups, some differences were observed in the images of society in 2050 between discussions from the current generation and IFG perspectives. (See Table 4).

Next, to confirm the characteristics of the discussions from the different perspectives in more detail, we present the results of text mining of relevant discussions. For each group's discussions, we identified the top five high-scoring nouns, giving them scores. The results are shown in Table 5. Here, let us focus first on the high-scoring nouns in the discussions from the current generation viewpoint. In both Groups B and C, "population decline" was the high-scoring noun, whereas in Group A, "extension of retirement age" was a high-scoring noun. We can infer from this that all the groups discussed population decline and aging. In Group A, "telework" also ranked high, broadly suggesting that discussions from the perspective of current generations are focused on current social realities and challenges. Interestingly, such nouns are not found in discussions from the IFG perspective. Next, let us focus on the high-scoring nouns in discussions from the IFG perspective. In Group A, nouns such as "waste" and "carbon neutrality" were prominent, whereas in Groups B and C, "CO_2" and "food loss," respectively, were notable. In contrast, high-scoring nouns related to specific environmental problems did not appear in discussions from the current generation perspective. In discussions from an IFG perspective, the importance of nouns reflecting environmental awareness increased, suggesting that the future perspective tends to make people envision the future more concretely. Conversely, in discussions from the current generation perspective, people tend to develop arguments based on the assumption of current realities, envisioning the future as an extension of the present.

Appendix 2 (a) shows a numerical comparison of three things: nouns that appear in only in either current or future generation discussions, co-occurrence networks, and terms that make up the co-occurrence network that contains the top-scoring noun. Let us focus on the top-scoring nouns and the terms they co-occur with. In the current generation discussion of Group A, there was no co-

Table 5
Nouns with the highest scores (Discussion on the images of Suita City in 2050).

	Current generations		IFGs	
	Nouns	**Score**	**Nouns**	**Score**
Group A	ICT (information and communications technology)	122.14	SDGs	266.28
	Telework	65.98	Piece-work system	61.38
	City bus	50.78	VR	51.53
	Extension of retirement age	49.84	Waste	38.66
	SDGs	49.84	Carbon neutrality	38.58
Group B	Population decline	36.61	CO_2	100.96
	Toughness	33.29	Underground water	50.03
	Infrastructure	30.26	Society	49.84
	SDGs	27.69	Infectious disease	33.19
	Extreme weather	25.11	Self-sufficiency	28.01
Group C	SDGs	61.38	Domestic water	124.17
	Population decline	55.21	3D printers	109.67
	Robots	51.69	Shelter	68.69
	45°C	49.02	Water treatment plant	61.38
	*NATS	38.58	Food loss	61.38

*NATS: Inter-city cooperation (N = Nishinomiya city, A=Amagasaki city, T = Toyonaka city, S=Suita city)

occurrence network that contained the top-scoring noun. This indicates that not many topics were developed from this top-scoring noun, "ICT" (information and communications technology). For this reason, the co-occurrence network containing the No. 2-ranked word, "telework," is investigated. There was discussion based on the assumption that as the number of jobs and people who can telework grows, making telework more common, the population of Suita City will decrease. In the IFG discussion, the terms "plus" and "results" co-occurred around the top-scoring noun, "SDGs." Specifically, the discussed postulated that as a result of the failure to achieve the current SDGs, new enhanced goals called "SDGs+ (plus)" would be formulated in the future. This is an example of how an IFG perspective helps to look at the results of current initiatives and then depict a future based on projecting the development of that initiative into the future.

In Group B's discussion from a current generation perspective, the top-scoring noun, "population decline," led to "AI," thereby forming a co-occurrence network. More specifically, the group alluded to not only the advancement of AI technology as a result of population decline, but also the emergence of greater regional differences and the streamlining of cities. On the other hand, in the group's IFG discussions, we could see a co-occurrence of "emissions" and "reduction" around the noun "CO_2." Specifically, the discussion imagined that an announcement about progress in achieving the SDGs prompted the government to start focusing more seriously on cutting CO_2 emissions by imposing taxes on emissions of CO_2, leading to a society in which nearly all energy is emissions-free. We could say that, like Group A, after foreseeing the results of current efforts, Group B envisioned a more progressive future.

In the discussions of Group C from the current generation perspective, no co-occurrence networks containing the top-scoring noun were found. Since the top-scoring noun was "SDGs," we can infer that little or no discussion was developed on the topic of SDGs. For this reason, the co-occurrence network containing the No. 2-ranked word, "population decline," is investigated. Specifically, there was discussion about population decline leading to wider disparities between regions and accelerated development of robotics, resulting in declining employment. Group C also predicted changes in working hours due to the growing number of elderly people. As for the group's discussions from the IFG perspective, there is a large co-occurrence network around the top-scoring noun, "domestic water." Specifically, the discussion anticipated that the concept of food loss would disappear in the future, and that household systems for recycling domestic water would be developed. It was also assumed that systems for producing potable water from air at home would become widespread. While discussions from the current generation perspective assumed that current social issues will persist, discussion from the IFG perspective predicted that the current social concern about food loss would disappear before 2050. It is also evident that this future-based discussion yields a more concrete vision of life in the future. The results of these co-occurrence network analyses are also reflected in the descriptive images of society in 2050 described in Table 4.

We argue that discussion from the current generation perspective tends to imagine the future based on current social conditions, such as population decline and aging, and the growing practice of telework due to the COVID-19 pandemic. In contrast, discussion from an IFG perspective tends to depict a society of the future more concretely and extends people's viewpoints to the level of individual household lifestyles, focusing on domestic water, for example.

3.1.2. Water supply situation of Suita City in 2050

Here, we present the results of discussions on the images of water supply in Suita City in the year 2050. Table 6 shows that as in the

Table 6
Suita City's water supply situation in 2050.

	Current generations	IFGs
Group A	The municipality will work hard in collaboration with Hokusetsu. Facilities will be optimized and upgraded, and there will be less need for employees. The cost of living will be higher, but water rates will not rise because the costs of assets and personnel will be lower (services will be improved).	In 2050, water supply in Suita City is privately managed in collaboration with Hokusetsu. Potable water supply is the main service. Citizen services have improved and various procedures are simpler, thanks to the universal use of the My Number system and the installation of smart meters in all households. Facilities have been reviewed (downsized), so they are now more efficient, due to lower demand for water. They are also more earthquake-resistant now.
Group B	Suita City's water supply in 2050 will be more efficient thanks to advances in ICT, which will allow a more diverse payment system. Citizen services such as water quality testing will also be different. Required employee skills will also be more diverse. Leakage investigation technology will be more advanced, and pipeline maintenance and upgrade capabilities will be better. Pipeline renewal and wide-area cooperation will advance, and the city's water supply system will be highly disaster-resistant.	Suita City's water supply in 2050 will serve largely as a make-up water supply service. Services will include maintenance for private water purification facilities and water supply to hospitals, commercial facilities, and other large water consumers. The only facility is the Katayama Water Treatment Plant, which can be conveniently operated and monitored remotely.
Group C	Although fees are expected to increase due to population decline and lower domestic water use, the increase will be minimal, thanks to wide-area collaboration, digital transformation (DX), and ICT (robotics). Public acceptance will be achieved through selectable rate plans and services unique to Suita City, such as a drone watering service.	Suita City Water Works Bureau is now a wide-area corporation. The Katayama Water Treatment Plant, which is one of its bases, plays an active role in disaster management. Disaster-resistance is very high. There was virtually no damage when a massive earthquake struck, thanks to the earthquake-proofing of pipelines. Drones and robots are actively used for emergency water supply and pipeline repairs. Suita City offers its own unique rate plans (e.g., the Disaster Emergency Water Supply Plan). The site of the former Izumi Water Treatment Plant has been transformed into the "Suisui Water Park," which is used for PR purposes.

case of their vision of society (Suita City) in 2050, there is also a marked difference in the images of water supply of the city in 2050 between discussions from the current generation and IFG perspectives for all three groups. For example, when discussing the current generation's perspective, Group B members envisioned the water supply situation in 2050 as an extension of the present, including improved efficiency and a diverse payment system. On the other hand, when they discussed from the IFGs' perspective, they portrayed a completely new situation different from the status quo. For example, they envisioned Suita City's water supply in 2050 largely as a supplemental water supply service, including the maintenance of private water purification plants and the supply of water to hospitals, commercial facilities, and other large water consumers (See Table 6).

Table 7 shows the results of the text mining analysis of relevant discussions. Further, based on Appendix 2(b), we also examined co-occurrence networks and summarized discussion content containing the top-scoring nouns, which tend to be the most revealing about discussion characteristics.

In the discussion of Group A from the current generation perspective (Session 1), the top-scoring noun "Hokusetsu (i.e., Name of area spanning multiple municipalities, including Suita City, located in the northern part of Osaka)" co-occurred with "collaboration" and "strong," corresponding to strengthening of collaboration with Hokusetsu and the formation of a water supply corporation. In the discussion from an IFG perspective (Session 4), the top-scoring noun was "smart meters," which were predicted in the future vision to be "installed" in all "households," leading to a loss of jobs, but enabling automatic water shut-off.

In discussions of Group B from the current generation perspective, the top-scoring noun, "ICT" (information and communications technology) co-occurs with "technology" and forms a co-occurrence network. There was a discussion about advances in technology achieved through ICT. On the other hand, in discussions from the IFGs perspective, the use of "underground water," the top-scoring noun, was discussed in detail. Of particular note is the idea that the use of underground water for personal use is starting to become widespread.

In discussions of Group C from the current generation perspective, the co-occurrence networks that contain the top-scoring noun, "ICT," consisted of 29 terms, a remarkably high number, suggesting in-depth discussions related to the top-scoring nouns. As in the case of Group B, the use of ICT and DX (digital transformation) has reduced leaks and increased efficiency, thereby limiting the increase in water rates. From the perspective of IFGs, the highest scoring noun, "water supply business," co-occurs with "wide area," "business entity," and "Katayama Water Treatment Plant." This corresponds to a future vision in which Suita City's water supply business is managed by a wide-area corporation, with the Katayama Water Treatment Plant operating as one of the corporation's bases. Again, the results of these co-occurrence network analyses are reflected in the descriptive images of water supply in 2050 shown in Table 6.

Looking at the results as a whole, it is evident that discussions from the IFG perspective tended to be closely concerned with the details of day-to-day life. These discussions were also held on points that are not necessarily obvious extensions of currently envisioned water supply planning. For example, rather than the municipal water supply administration handling everything, these discussions tended to feature more concrete descriptions of how water supply services are used by individual households, with mention of changes in water supply services enabled by the introduction of smart meters and the promotion of underground water use at the individual level. It is also clear that new ways of running water supply services, such as wide-area collaboration, were flexibly examined. In general, the discussions reveal that the state of water supply administration was reviewed from the viewpoint of the lifestyles of Suita City residents.

3.1.3. Proposals for next long-term plan for 2030 and beyond

Table 8 shows three most important measures selected by each group for the next long-term plan for 2030 and beyond from each perspective. It is evident that the proposals of each of the three groups changed significantly between their discussions from the current generation perspective (Session 1) and their discussions from the IFG perspective (Session 4). In the discussions of Group A from the IFGs perspective, an awareness of sustainability arises, leading to a proposal that envisions cooperation with the Hokusetsu district. We can also detect a recognition of the need for the government to grasp the needs of citizens and create a system that responds promptly

Table 7
Nouns with the highest scores (Discussion on water supply situation in Suita City in 2050).

	Current generations		IFGs	
	Noun	**Score**	**Noun**	**Score**
Group A	*Hokusetsu*	119.07	Smart meters	334.77
	Earthquake-resistance	101.11	Potable water	97.33
	Water rates	73.17	*Hokusetsu*	81.66
	Water supply	66.85	Earthquake-resistance	53.56
	Business entity	61.38	Simplification	49.84
Group B	ICT	85.16	Underground water	133.89
	Pipelines	61.38	*Katayama*	80.61
	Water supply business	61.38	Water supply	70.65
	Smart meters	49.84	Government buildings	27.86
	Water supply	48.71	Water treatment plant	27.69
Group C	ICT	186.31	Water supply business	212.66
	Water rates	122.14	*Katayama* Water Treatment Plant	122.14
	Water leakage	112.18	Disaster event	118.73
	DX (digital transformation)	100.87	Earthquake-resistance	111.03
	Meter inspection	98.98	Pipelines	109.67

Table 8
Proposed measures for next long-term plan (reasons for proposals in italics).

	Current generations	IFGs
Group A	• **Review personnel structure** *It is necessary for collaboration with Hokusetsu and adoption of leading-edge technology.* • **Improve citizen services** *If the number of citizens increases or remains unchanged, revenue will increase and services will improve.* • **Cost** *Introduction of leading-edge technology and maintenance are expensive.*	• **Take leadership in promoting collaboration with Hokusetsu (bulk ordering, facility sharing)** *For sustainable management.* • **Promote electronic and online technologies (install smart meters in all households and cut service costs by using apps for electronic payments and procedures)** *It is necessary to respond quickly to the demands of the world, and to address the needs of citizens.* • **Improve digital technology skills of staff (technical training, systems development)** *It is necessary to adapt to the demand for electronic procedures. Don't fall behind young people!*
Group B	• **Strengthen regional collaboration** *This is necessary for disaster preparedness and to address declining revenue from water rates.* • **Train personnel and preserve skills** *The needs of citizens are increasingly complex, and technology is increasingly sophisticated (advances in ICT and DX)* • **Publicity and public hearings for citizens** *Disaster preparedness, revival of city water, optimization of rate structure*	• **The pace of seismic retrofitting is slow, so step up the pace!** *(If the pace is not increased) Safety and security will decline!* • **Increase efficiency of facilities and services** *Otherwise, people may move away from city water due to rate increases.* • **Improve publicity and public hearings (multi-directional communication)** *(If publicity and public hearing are not improved) The level of citizen satisfaction will drop!*
Group C	• **Visualize population decline, water use reduction, and natural disaster countermeasures with numerical data** • **Visualize the impacts of DX, ICT, and wide-area collaboration (cost reduction) with numerical data** • **Survey citizens for opinions on unique services** *It takes time to obtain the understanding of citizens.* *These are issues that need to be addressed urgently.*	• **Clearly define response to deteriorated pipelines, trial use of drones and robots** *This is based on the experience of the Great Kansai Earthquake of 2035.* • **Try to fill in the gaps in exchanges with other cities and business entities** *More efficient management could have been achieved if wide-area collaboration had been promoted sooner.* • **Collect public feedback about citizen services (e.g., rate plans) as soon as possible (promote publicity too)** *Population decline in Suita City has created a difficult business environment.*

to those needs. The proposal of Group B from the perspective of IFGs was based on an awareness of the need to step up the pace of earthquake resistance and increase the efficiency of facilities and operations, seeming to reflect a heightened sense of crisis about the future water supply situation. The group's discussions to envision the water supply situation in 2050, which mention the use of underground water for household use, also indicate a heightened sense of urgency about the delivery of value by the city's water supply administration. This may also be reflected in the measures to "improve the efficiency of facility operation and day-to-day services." Anticipating the occurrence of a massive earthquake in 2035, Group C proposes specific measures "to clearly define measures to deal with deteriorated pipelines and to trial the use of drones and robots." In the discussion of the water supply vision in the previous section, it is possible that the proposal was made as "an effort to fill the gaps in exchanges with other cities and business entities," because it is assumed that the Suita City Water Works Bureau will become part of a wide-area collaboration.

Overall, the results suggest that the adoption of the IFG perspective may have given rise to a sense of crisis and a strong concern

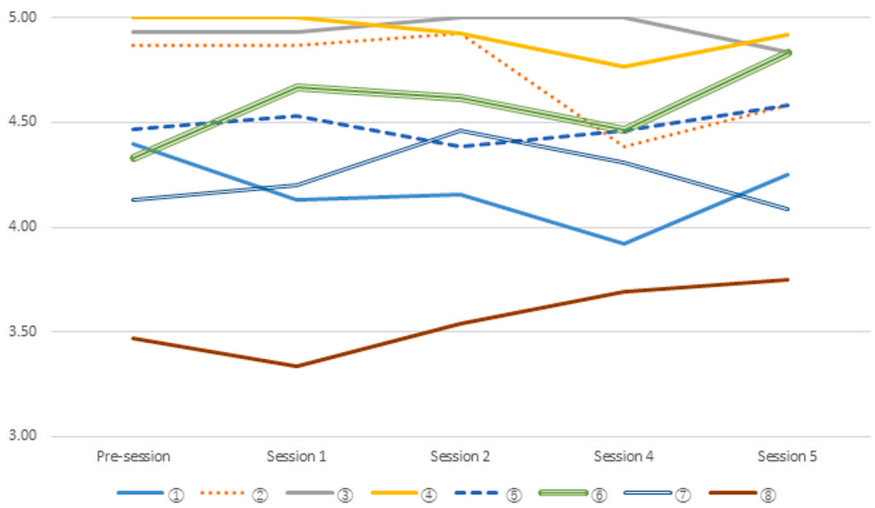

Fig. 2. Answers to question Q1-a.

with sustainability. For example, while some discussions from the current generation perspective assumed that the current generations would be able to deal with disasters and achieve the SDGs, in discussions from the IFG perspective, the sense of crisis about the future grew stronger, resulting in suggestions to step up the pace of measures, respond more quickly to public demand, and so on. It seems very probable that the groups formed a more specific vision of the future situation that was not just an extension of the services and water supply administration currently provided by the Water Works Bureau. Thus, the results show that the adoption of an IFG perspective causes a significant shift in policymaking and policy priorities.

3.2. Questionnaire results

The responses to Questions 1-a, 1-b and 1-c of the questionnaires are given below. Note that the basic data related to Figs. 2–5 is shown in Appendix 3. Fig. 2 shows the results of Question 1-a. The most significant feature about the responses to Q1-a is that after the adoption of the IFG perspective, the importance of criterion (2) "**Will it lead to solutions to issues in Suita City (water utilities)?**" dropped, whereas the importance of criterion (8) "**Status of and trends in initiatives by other entities**" rose. Both criteria are related to the vision of Suita City in 2050 and to discussion about the ideal water supply situation in 2050. From the perspective of IFGs, lifestyle changes, such as the use of domestic water for households in 2050, were discussed. Therefore, the drop in importance of (2) may relate to the fact that much of the IFGs-based discussion focused on aspects of water use and management at the household level, rather than assuming that everything is addressed by the water supply administration. On the other hand, discussion from the IFG perspective positioned Suita City's water supply in the context of wide-area collaboration, which would explain the increase in importance of criterion (8). In this discussion, the city's water supply administration seems to be viewed objectively from a bird's eye perspective.

Note that discussion in Session 5 (mutual evaluation between groups) gave rise to new changes in the perceptions of participants. In the case of several criteria, there was even a reversal in the direction of numerical scores between Sessions 4 and 5.

Next, for Q1-b, the participants were asked to select the four most important decision criteria from the list of eight. Given that each participant had four votes, Fig. 3 show how many of the total votes each criterion received from all participants, with percentages. To rank importance, respondents also awarded scores of 4 points for No. 1 (most important), 3 points for No. 2, 2 points for No. 3, and 1 point for No. 4 (i.e., fourth most important) to their four most important criteria. The total score of each criterion and corresponding percentage of total points received are shown in Fig. 4.

From the viewpoint of percentage votes (Fig. 3), it is evident that the importance of criteria (2) and (3) "**Can it secure the safety of the water supply?**" declined over the course of the discussion. The reason for this in the case of (2) is probably the same one already mentioned above (i.e., expansion of water use and management at the household level from the perspective of IFGs), and that for (3) may similarly be related to the fact that discussion from the perspective of IFGs assumed that the city's water supply administration would not provide all water services, imagining instead a diverse range of water use by individual households. While safety and supply stability are high priorities under the current water supply administration, if private water use and management by individual households become mainstream, safety assurance may become a lower priority from the standpoint of the city's water supply administration. On the other hand, the importance of criterion (7) "**Is it highly cost-effective?**" increased over the course of the discussion. Increasing the efficiency of facilities and operations (Group B) and sustainable management (Group A) were featured in the proposed measures for the next long-term plan (see Table 8), so there seems to have been a strong sense that increasing cost-effectiveness was important.

In terms of percentage scores (Fig. 4), the importance of criteria (3) and (4) "**Can it secure the stable supply of water to the municipal area?**" declined in discussions from the IFG perspective, whereas that of criteria (6) "**Will it lead to improvements in**

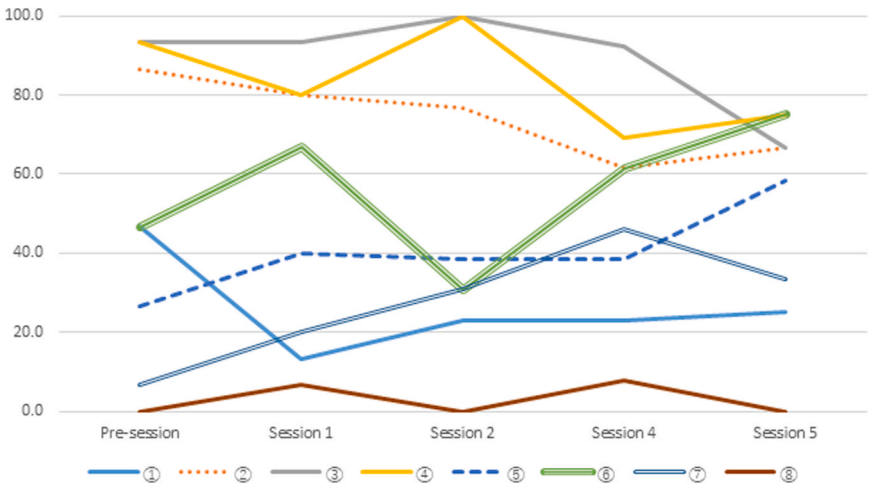

Fig. 3. Answers to question Q1-b (percentage of votes).

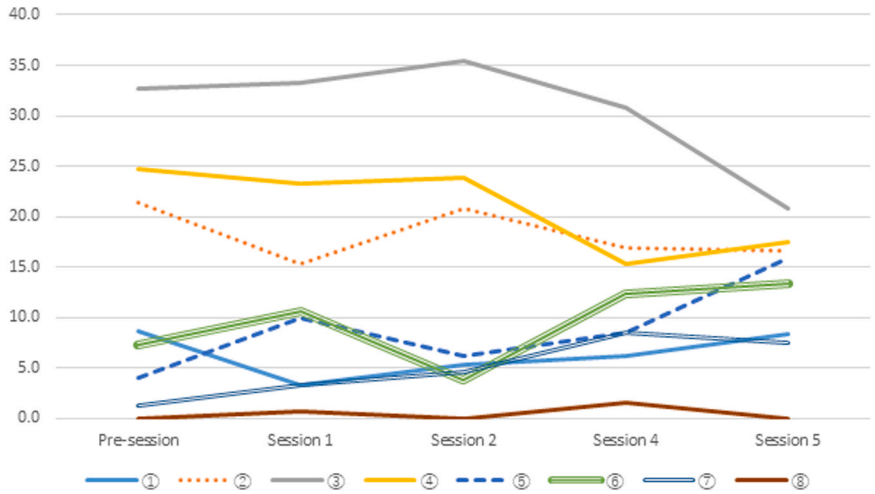

Fig. 4. Answers to question Q1-b (percentage of scores).

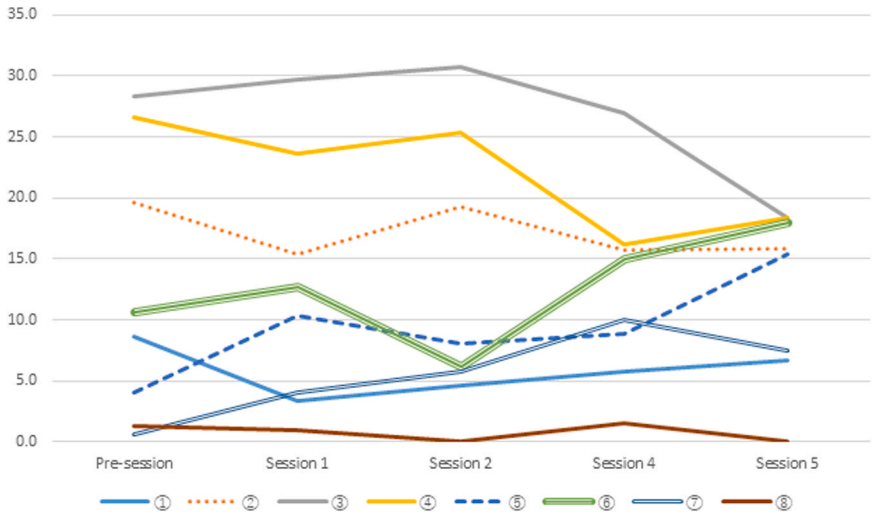

Fig. 5. Answers to question Q1-c.

services for citizens?" and (7) rose. As mentioned above, these results also probably linked to the observed changes in discussion contents between current generation and future generation perspectives. For example, we can hypothesize that the increase in criterion (6) is related to the assumption from the perspective of IFGs that water use and services as well as management should be expanded at the household level, rather than the case where everything is managed by the water supply administration.

Finally, the results of responses to Q1-c are shown in Fig. 5. The most obvious features are the decline in importance of criteria (3) and (4) and rise in importance of criteria (6) and (7). As with criterion (3), the trend of criterion (4) relates to the way the respondents envisioned Suita City (society) and its water supply situation in 2050 from the IFGs perspective. Since the use of water services managed at the individual household level increases, the necessity for the Water Works Bureau to ensure the reliability of water supplies decreases. In this way, it is clear that adopting an IFG perspective changes the perception of the measures that need to be taken in the future and the priorities of policy criteria, because the essential issues and state of society are not seen simply as extensions or extrapolations of present realities.

4. Discussion

4.1. Findings and insights

Here, we summarize the study results reported above. First, it is clear that adopting the perspective of IFGs significantly changed the contents of the discussions from that based on a current generation perspective in terms of the future visions of Suita City in 2050

and an ideal water supply service, as well as the issues to consider and measures to take for the next long-term plan. Most notably, in discussions from the IFG perspective, participants tended to think about how water services should be used in relation to the lifestyles of individual households and to sustainable management. This suggests that by considering issues from the perspective of future generations, officials may have developed a concern and empathy for households, the users of the water supply, that goes beyond mere policy discussions. Previous studies show that experiencing the perspective of IFGs can help increase empathy for others (Hara et al., 2021). However, the fact that policymakers may have created a deeper sense of empathy for residents' lifestyles would be a new finding as an effect of Future Design.

Further, a strong sense of crisis about the future of water services was also expressed. The participants were also able to flexibly envision efficient management policies, including wide-area collaboration, as opposed to imagining the future of the water supply business merely as extensions of the current system and structure. These trends in thinking and decision-making from the perspective of IFGs are consistent with the findings of earlier studies on Future Design (Nishimura et al., 2020; Hara et al.,2023a). Previous studies show that experiencing IFGs could allow individuals to increase their sense of risk about the future (Hara et al., 2023b). Making decisions and proposing ideas as IFGs tends to be more innovative compared to those from the perspective of the current generation. It is evident that generating "futurability" enables participants to have a larger, bird's-eye view of issues, and to discuss the future social conditions more concretely. Specifically, the findings of this study indicate that the adoption of the perspective of IFGs influences decision-making processes and criteria in policy discussions among employees of a municipal water supply department engaged in water supply administration, and that the use of IFGs is effective in promoting thinking and discussion of sustainability from a long-term perspective.

The results of our questionnaire analysis also showed that when an IFG perspective is adopted, the priority and importance of policy decision criteria change in accordance with depictions of a future society and the ideal state of its water supply system. These results indicate that applying the mechanism of IFGs enables a resetting of policy decision criteria and reviewing of water supply policies from long-term and sustainability viewpoints, as opposed to viewing future policies as extensions of existing policy. At the same time, the IFGs method also promotes discussion that is more focused on essential issues and countermeasures. The maintenance and management of water supply infrastructure constitute one of Japan's most pressing issues, but this problem is a difficult one that needs to be considered from a variety of viewpoints. This study demonstrated that the IFGs method can be adopted as a treatment to enable more effective and flexible formulation of policy related to sustainable water supply infrastructure.

The results of this study also suggest that discussion from the perspective of IFGs helps to expand the thinking of administrative officers beyond the confines of their current water supply-related administrative responsibilities to take into consideration the lifestyles of future Suita City residents and the way water is used in individual households, reflecting a heightened awareness of the viewpoints of water users. This points to the potential for joint investigations of future water use and services by various stakeholders, including citizens and government representatives. We argue that the flexible policy formulation made possible by the adoption of IFGs could provide a clue to the management of sustainable water supply, which is likely to become increasingly difficult in the coming years in Japan. This finding also has implications for other countries in a similar situation as Japan.

To further analyze the effectiveness and potential of Future Design for water supply policymaking, it will be necessary to conduct more discussion experiments with the broader participation of citizens and other stakeholders over the coming years.

In terms of contributions to the Future Design research area, we highlight the following two points. First, IFGs have been newly introduced into water infrastructure maintenance and management policy and planning, and their effectiveness has been clarified. Existing studies on water supply maintenance and water resource management have presented approaches such as increasing water tariffs (Zetland and Gasson, 2013; Barberán et al., 2022). Other methods such as environmental and sustainability assessment methods (Balkema et al., 2002; Boldrin et al., 2025), decision support tools (Makropoulos et al., 2008; Padula et al., 2013), participatory planning (Hassenforder et al., 2016; Neverre. 2024) and scenario analysis (Momeni, et al., 2021) have also been widely discussed in the context of water management and planning. However, these are all based on the perspective of the current generation and do not explicitly address intergenerational conflicts of interest. By incorporating IFGs, this study weighs the interests of future generations and allows for more flexible policy design based on the risk awareness and perception of water users. In other words, the introduction of IFGs has implications for flexible policy design to ensure sustainability.

Secondly, the results show that the perspective of policy makers can be broadened to include water users, making them more inclusive. This is thought to be an effect of the activation of futurability. The following effects related to the activation of futurability have been shown in the past: increased creativity, creation of an overarching perspective of both current and future generations, increased perception of common goals considered desirable for society, increased perception of future risks, and incentives for societal transformation (Nishimura et al., 2020; Hara et al., 2023b; Hara et al., 2021, Hara et al., 2019; Saijo, 2020; Uwasu et al., 2020). However, the effects on increasing inclusiveness have not been reported. Therefore, this finding will add an important insight to the knowledge in the field of Future Design.

4.2. Implications of the retrospective analysis (Session 2)

Here we discuss the possible impact of the retrospective analysis conducted in session 2. The results of the discussion suggest that the session was particularly effective in three ways: Firstly, by undertaking a comparative analysis of the past and the present (i.e., Task (1) in Session 2), participants were able to understand both what had changed and what had not changed over this period. It was suggested that this led to the development of an awareness of the time dimension. For example, the three groups identified the following items on the worksheets as having changed "the need to develop water sources", "tap water is no longer expensive", "the time has come to buy water", "the need for earthquake resistance has emerged", "the demand for water has decreased" and "awareness

of water conservation has increased". On the other hand, the following were presented as unchanged: "citizens want safety and good taste", "increased personal satisfaction", and "strong awareness of environmental issues (e.g. SDGs)". These discussions suggested an increased awareness of time dimensions, and these attitudes should be useful in gaining perspective on IFGs.

Secondly, the work on formulating advice to the past water officials (i.e., Task (2) in Session 2) suggested that the participants developed a perspective as a future generation through the process of sending messages to decision makers involved in past cases. The messages on the worksheet included "I wish they had kept a record of the verification process", "be aware of earthquake resistance so that they can respond in case of disaster", "promote the safety of tap water and prevent people from leaving the water supply", "maintain good communication with citizens", "it would have been better to renew the pipe line instead of rehabilitating it", "pass on the knowledge you have gained in the course of your work", and "the decision not to build the facility has now become useful". These statements suggest that these proposals have led to a re-examination of the decisions taken at the time from the perspective of future generations.

The third point is the possibility that what was discussed in Session 2 may have had some influence on subsequent discussions and decisions as IFGs. For example, Group B brought up messages (advice) for the past, such as be aware of earthquake resistance so that they can respond in case of disaster" and "maintain good communication with citizens" as presented above. These perspectives may have influenced the consideration of the image of water supply in 2050 as an IFG (see Table 6). They may also have influenced the selection of proposed measures (see Table 8). For example, the first and third ranked measures in Group B were also related to the above messages.

The above suggests that the work and treatments of Session 2 are also important in discussions and decision making as IFGs. More specifically, the discussion content and perceptions created in Session 2 would have influenced the creation of the images of water supply in 2050 (Table 6) and the proposed measures (Table 8) as an IFG. It is therefore suggested that ideas with increased risk perception and inclusiveness, which are the main characteristics of the discussions of IFGs in the practice, can to some extent be traced back to the discussion in Session 2.

5. Conclusions

In this study, we analyzed the effectiveness of applying the treatment of "imaginary future generations" (IFGs) in a deliberation experiment focused on envisioning future water supply services and policies with the participation of employees of the Suita City Water Works Bureau. The results show that the adoption of an IFG perspective leads to a qualitatively large change in depicted visions of the city and its water supply system in 2050 compared to similar discussions from the perspective of current generations. The most notable features of the IFGs treatment are as follows: (1) it stimulates awareness of water supply use and services at the household level by citizens; (2) it stimulates the proposal of new policies and systems that are radically different from existing ones, with a stronger focus on sustainable management and efficient business operation; and (3) it stimulates the proposal of measures based on a sense of crisis about the future, taking into account earthquakes and other future risks.

The results of a questionnaire analysis also showed that switching discussion to the perspective of IFGs precipitated a change in policy decision criteria related to the transfer of water supply administration, and that this change was linked to how the future of the city and an ideal water supply system for the city are envisioned. These findings suggest that the adoption of IFGs as a discussion treatment influences how water supply services are viewed, enabling policy discussions to be conducted from various perspectives.

As a future research challenge, it is necessary to verify the effectiveness in more detail by accumulating cases of discussion experiments involving a wider variety of other stakeholders, not just water supply department staff. This study examines the effects of implementing Future Design in the context of Japan, which is facing issues of sustainable maintenance of water supply infrastructure under a declining population. Conversely, further research is needed to determine what effect Future Design can have when considering sustainable maintenance of water supply infrastructure under different social conditions and contexts, such as population growth and the size of the target communities. In addition, further research is needed to examine the effects of IFGs under different conditions and constraints, such as specified maintenance costs.

The maintenance and management of water supply infrastructure constitute a long-term challenge that needs to be discussed from the viewpoint of sustainability, taking into consideration the perspective of future generations. The findings of this study indicate that generating "futurability" using the method of IFGs can help administrative officials discuss long-term issues in more detail and from a more sustainability-focused perspective, as opposed to merely extrapolating current issues into the future. As future work, we need to assemble more case studies, in order to pioneer a social technology that includes the mechanism of IFGs as a new decision-making method for water supply maintenance and management issues.

CRediT authorship contribution statement

Hara Keishiro: Writing – review & editing, Writing – original draft, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Ikenaga Taiga:** Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Arai Takanobu:** Investigation, Formal analysis. **Fuchigami Yukari:** Supervision, Investigation, 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.2025.103618.

Data availability

Data will be made available on request.

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