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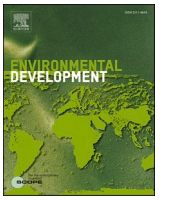

A Delphi-based methodology for participatory adaptation pathways building with local stakeholders: Methodological considerations and an illustrative application in peri-urban India

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ABSTRACT

Adaptation pathways is a planning approach used to design flexible, long-term strategies for dealing with future uncertainty. However, emphasis on how to discuss pathways elements with stakeholders during the pathways building process is under-represented in the existing pathways literature. This paper presents a participatory methodology for building normative adaptation pathways with local stakeholders. Iterative discussions are facilitated using a Delphi study that is designed to explicitly consider institutional, and multi-actor dimensions in the formulation of future adaptive strategies. This leads to adaptation pathways that are more inclusive of local needs. This paper describes the steps for iteratively designing adaptation pathways in a multi-actor setting through a Delphi study.

A pilot application of this Delphi-based adaptation pathway approach is illustrated with local actors in peri-urban Kolkata (India) for future water management. It demonstrates how this methodology offers a structured way to introduce pathways thinking to local stakeholders and helps build consensus about future preferences and adaptation options. Moreover, it stimulates discussions about normative differences across and within stakeholder groups through the underlying values that define future pathways as well as the institutional adjustments needed to successfully activate adaptations strategies over time. Future work may be directed towards to strengthening discussions around uncertainty, connecting pathways to a broader set of future scenarios, and comparing this facilitation method against other existing ones.

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1. Introduction

Local and regional solutions for sustainable development and climate change adaptation are needed in the fast-growing agglomerations of the Global South. Urbanization processes in these contexts offer a unique window of opportunity as it reflects a spatial transformation on the planetary scale. By 2050, there will be an additional 2.3 billion urban dwellers worldwide – most of them in the Global South: 900 m in Africa, 1.1 bn in Asia and 145 m in Latin America (UN, 2018). This urbanization differs from the urbanization experienced in the Global North regarding the speed of growth, the administrative fragmentation within urban agglomerations, and the dominance of informality (Roy, 2009). These challenges require new responses for planning and policy making. First, in the context of this specific urbanization pathway and in view of the multiple crises, including climate change, planning requires a long-term perspective of emerging drivers of change and potential vulnerabilities. These need to be combined with instruments for short term actions and – most important – the flexibility to adapt plans to different scenarios. Second, local, regional, and national planning needs to be more inclusive, as sustainable development is ultimately only achievable through the coordinated action of different actors. Plans must be context appropriate in terms of socio-ecologic, institutional and economic conditions and satisfy the unique needs of the people who reside in the planning areas.

Adaptation pathways approaches support a shift in planning from either exclusively short-term planning or long-term master planning, towards a flexible, long-term adaptation process with multiple strategic possibilities (Bosomworth et al., 2015; Haasnoot et al., 2013; Maru et al., 2014; Reeder and Ranger, 2010; Stafford Smith et al., 2011; Werners et al., 2021; Wise et al., 2014). And likewise, a shift from reactive towards more anticipatory decision-making. Adaptation pathways typically comprise different sequences of decisions and continuous learning from system changes over time (Haasnoot et al., 2013; Wise et al., 2014). In this way, the approach prepares actors for future uncertainty and considers possible consequences of decisions over time (Prober et al., 2017).

Adaptation pathways approaches have been applied in a wide variety of planning domains including climate change, natural resource management, rural livelihoods, etc. In the water sector, adaptation pathways can be seen in managing flood risk, coastal salinization issues, freshwater supply, climate change, etc. in various geographic contexts and at various scales (see Haasnoot et al., 2013; Manocha and Babovic, 2017). Adaptation pathways are used in urban planning (Kingsborough et al., 2016; Mendizabal et al., 2018; Rosenzweig and Solecki, 2014), in the Global South (Butler et al., 2016; Hossain et al., 2018; Vervoort et al., 2014), with local stakeholders (Barnett et al., 2014; Maru et al., 2014), and in ambiguous contexts with conflicting views (Bosomworth and Gaillard, 2019; Pandey et al., 2021). These applications highlight the approach's potential and relevance for planning sustainable urban futures.

Yet, there are several areas where the pathways approach can be developed further, namely a) in terms of the structuring of processes to facilitate participatory and multi-stakeholder-oriented pathways (Bosomworth and Gaillard, 2019) especially in local-level planning efforts (Barnett et al., 2014; Maru et al., 2014) and b) in the incorporation of multi-actor and institutional elements within adaptation pathways (Butler et al., 2015; Lavorel et al., 2019; Prober et al., 2017). Therefore, this paper describes the design, application, and evaluation of a methodology for developing normative adaptation pathways in a participatory and –due to the COVID-19 pandemic – remote way with local actors by applying a Delphi-type research design. This was done in the framework of the multi- and transdisciplinary research project "H_2O – Transformation to Sustainability", in which we worked with peri-urban communities in the megaurban agglomerations of Pune, Hyderabad and Kolkata cities in India. In this paper, we focus on adaptation pathways developed for Hadia village, situated in peri-urban Kolkata. This illustrative case demonstrates the method's applicability for participative research at the local level.

This paper is structured as follows. Section 2 reviews earlier approaches of building adaptation pathways with local actors from the adaptation pathways literature . Section 3 describes the steps in our Delphi-based adaptation pathways approach. Section 4 illustrates its application in peri-urban Kolkata (India) and presents the evaluation results. Section 5 discusses strengths and limitations of this method before concluding the main insights and directions for further work on this topic in section 6.

2. Adaptation pathways for long-term adaptive planning

2.1. Adaptation pathways and their application

Adaptation pathways is an approach to explore decision-making under uncertainty. It represents a planning paradigm rooted in the field of adaptive planning. Pathways thinking is also associated with theory of change (via impact pathways) or pathways to sustainability literature (Haasnoot et al., 2013; Werners et al., 2021). At its core, adaptation pathways consists of a series of actions sequenced over time to achieve desired goals under uncertainty (Werners et al., 2021). It incorporates flexibility into long-term planning by creating options for adapting to changing system conditions over time. By exploring near-term actions while keeping the possibility to modify, extend, or alter responses as the future unfolds guides long-term decision-making in a dynamic way (Haasnoot et al., 2013). Their methodological development have been guided by a variety of frameworks (see for e.g. Maru et al., 2014 and Gorddard et al., 2016) and analytical methods including causal diagrams, multi-criteria decision analysis, GIS, real options analysis, exploratory models, and risk analysis (Bosomworth and Gaillard, 2019; Fazey et al., 2016; Lawrence and Haasnoot, 2017; Moallemi and Malekpour, 2018; Ryan et al., 2022).

The basic steps in developing adaptation pathways are outlined in several studies (Bosomworth and Gaillard, 2019; Butler et al., 2016; Coulter, 2019; Dunlop et al., 2016; Haasnoot et al., 2013). Adaptation pathways can be classified into three major clusters as described in Werners et al. (2021): (i) static approaches derive pathways from a well-defined objective, (ii) dynamic approaches explore directions for change and transformation more broadly. The latter applies more explorative forecasting methods whereas the former's back casting methods are more normatively aimed at developing pathways for reaching a specific future (Bizikova et al.,

2015). (iii) In the climate change domain, pathways are threshold oriented, multi-stakeholder oriented, or transformation oriented. These clusters are complementary and partly overlapping. Yet, they point to different purposes of pathways planning. Performance threshold-oriented pathways extend the expert toolkit of policy analysts to also consider pathway effects and uncertainties, in discussing the performance of different strategies – using simulation models, optimization techniques and multi-criteria assessments – with Dynamic Adaptive Pathways Planning (Haasnoot et al., 2013) as one of its hallmark approaches. Multi-stakeholder-oriented approaches primarily use pathways as means to engage stakeholders in strategic discussions, dealing with ambiguity and participatory planning (Bosomworth and Gaillard, 2019). Transformative approaches aim to realize a transformation in society by addressing underlying values. Newer approaches combine elements of these three types such as the analytical strengths of the performance-threshold approaches, and the process and consensus-building benefits of participatory multi-stakeholder-oriented approaches (e.g. Barnett et al., 2014; Bhave et al., 2018; Maru et al., 2014).

2.2. Knowledge gaps in the adaptation pathways literature

A review of existing adaptation pathways literature highlights a number of areas where further research is warranted: (i) only a small number of applications fully engages with local level stakeholders throughout the pathways building process (Barnett et al., 2014; Maru et al., 2014). In some cases, representative stakeholders (e.g. researchers) are engaged but not the users themselves (Bhave et al., 2018) or local stakeholders are engaged to validate pathways developed by researchers using previously generated inputs (Lavorel et al., 2019). A review by Bosomworth and Gaillard (2019) find few participatory pathways applications at the local while at the same time highlighting specific conditions and needs at this planning level. Technical skills and financial resources are limited and there is a larger need for consensus to implement local plans (Barnett et al., 2014). Moreover, local communities may be detached from decision-making arenas, limiting their capacity to act. At the same time external influences produce sources of vulnerability and resilience from outside (Maru et al., 2014). Recent studies from NZ featuring long-term adaptive planning with local, indigenous communities (see Ryan et al., 2022; Schneider et al., 2020) illustrate the importance of incorporating marginalized voices, yet they reflect collaborative planning efforts initiated by government. Further research is needed to understand the potential of adaptation pathways in supporting local communities when windows of opportunity for bottom up planning is lacking (Maru et al., 2014).

(ii) Furthermore, even at the local level, long-term planning interests may not be aligned. Actors may disagree on the specific goals and objectives or the problem framing the knowledge base and may have different underlying values (Bosomworth and Gaillard, 2019; Hermans et al., 2017; Kwakkel et al., 2016). In the context of climate change, local consensus is challenged by varying awareness about climate risks, preferences for addressing them, attachments to place and ideas about the future (Barnett et al., 2014). It is unclear whether adaptation pathways can be used to bridge diverging interests. Moreover, a better understanding is needed of how to design pathways that reflects the collective needs while also highlighting key areas of divergence. Pandey et al. (2021) designed pathways from different stakeholders perspective to support climate-resilience development, however, their study does not offer tools to thereafter integrate the different priorities and pathways. This points to the under-explored value of pathways approaches in ambiguous contexts with diverse or conflicting goals, means, values etc. (Bosomworth and Gaillard, 2019).

(iii) In most cases, stakeholder engagement is largely undertaken through face-to-face workshops, sometimes in combination with in-depth interviews, focus group discussions, serious games, and ethnographic methods (Bosomworth et al., 2015; Bosomworth and Gaillard, 2019; Câmpeanu and Fazey, 2014; Lawrence et al., 2019). Although workshops are an obvious medium for conducting participatory processes and offer benefits such as co-design, joint learning, and consensus-building, they also have several limitations. Getting stakeholders physically together in one room at the same time may be practically infeasible (especially when working with vulnerable stakeholder groups struggling with securing a days' income or as dictated by events like the Covid-19 pandemic). Likewise, there is a risk of participation fatigue and power imbalances which can hinder discussions on an eye-to-eye level. Reducing the reliance on traditional processes help overcome these issues and enable us to explore adaptation pathways' potential in new contexts or stakeholder groups. Bosomworth and Gaillard (2019) highlight a need for greater consideration of representation and procedural equity in the design, use, and efficacy of adaptive planning processes. Developing alternatives to workshops requires an even more structured approach, ensuring that benefits of participation are not compromised. A deeper understanding of the facilitation process to introduce pathways concepts and meaningfully discuss them during the pathways building process is needed.

(iv) Finally, greater consideration of decision-making aspects when formulating adaptation pathways with local stakeholders should be explored. First, the underlying values of local stakeholders offers insight into why certain future scenarios and pathways are more preferrable than others. Few studies (see Maru et al., 2014; Ryan et al., 2022) describe how to illicit these values and use them during the pathways building process. Second, the institutions, as societal *rules*, that enable and constrain adaptation to system changes must also be considered when designing pathways. Local adaptation barriers can stem from the underlying institutional context and are important to address (Butler et al., 2015; Bosomworth and Gaillard, 2019). Future adaptation may also require institutional change. Local stakeholders need to consider the thresholds beyond which existing institutions are ineffective and how they can shape the institutional landscape to achieve a particular pathway (Fletcher et al., 2013; Haasnoot et al., 2018). Studies incorporate this institutional context in different ways (Barnett et al., 2014; Butler et al., 2015; Lavorel et al., 2019; Lawrence et al., 2018; Prober et al., 2017). In other words, it is unclear where in the pathways building process, institutional dimensions should be addressed by local stakeholders. Third, the multi-actor dimensions within adaptation pathways are also relevant. Adaptation problems are typically collective action problems (Bisaro and Hinkel, 2016). Different actors will influence the success of adaptation strategies. Exploring future sustainable trajectories requires explicitly discussing the roles of actors over time. There is a need to focus on how to meaningfully incorporate these values, multi-actor and institutional dimensions when building normative adaptation pathways with stakeholders.

Based on these research gaps, we focus our study on the design, application, and evaluation of a participatory methodology for building normative adaptation pathways with local actors that incorporates multi-actor and institutional elements into pathways design.

3. A participatory approach for building adaptation pathways using the Delphi method

Our pathways building approach seeks to promote collaborative learning, strengthen adaptive capacity and planning, and uses participatory methods to engage multiple actors. It focuses on the interests of different stakeholders as well as social and institutional features of the system in question (Werners et al., 2021). We explore the back-casting method for designing adaptation pathways given it's normative focus. The approach is designed to be used as a planning support tool for local actors from contexts undergoing transformations. It uses a consensus-based approach to help converge local action in a coordinated way. Consensus about the adaptation problem, objectives, and future uncertainty are a precondition for successfully designing adaptation pathways (Zandvoort et al., 2017). To do this, we will structure a joint exploration of adaptive strategies needed to achieve a shared future objective. The lacunae described in section 2 are addressed by further elaborating how to structure pathways building with local actors while engaging them in a deeper reflection of their decision making context.

3.1. Basic steps in constructing adaptation pathways

The literature broadly outlines the key stages common in nearly all adaptation pathways approaches with minor variations in the sequence of these steps (Bhave et al., 2018; Bosomworth et al., 2018; Bosomworth and Gaillard, 2019; Butler et al., 2016; Coulter, 2019; Haasnoot et al., 2013). The steps include: understanding the current situation, defining the goals and objectives, analyzing possible futures, sequencing actions in the pathway, and evaluating the different pathways (Fig. 1).

There are multiple ways to represent adaptation pathways. A visual representation of adaptation pathways is useful for communicating results of the entire pathways building (Werners et al., 2021). Commonly used schematics are referred to as route maps, subway maps, or train-line diagrams (Butler et al., 2016; Haasnoot et al., 2013; Zandvoort et al., 2017).

Formulating adaptation pathways furthermore involves (i) defining the system's boundaries and specifying important system factors, wherein (ii) the system represents a part of reality that is being studied regarding a (future) problem; (iii) the elements that determine a system's outcome, and which can be influenced by means and external factors (Enserink et al., 2022); (iv) system actors and institutional context define the scope for adaptation pathways; (v) *drivers* represent external and internal forces altering the system and determine which pathways can be pursued.

The *baseline* represents the problem in its current state. Future visions are based on the actors' value systems. These *values* represent normative beliefs about what actors consider 'good' and what matters in a given system or situation. Values are fairly abstract notions, generally expressed through objectives (Hermans et al., 2017). As this methodology explores normative aspects of adaptation pathways, identifying the shared values of different actors is key to the subsequent stages of the pathways building process.

Based on these values, participants explore future *scenarios* for a given context. A scenario describes a course of events towards a future state of the system (Marchau et al., 2019). These normative sketches capture the participants' ideal to worst-case futures (Enserink et al., 2022). Thereafter, participants rank the scenarios to identify a collectively preferred future.

Pathways consist of a sequence of actions from the present to the different futures (Haasnoot et al., 2013). They indicate, along a timescale, the future planning suited for a given problem context. Shifting between the different pathways is related to: i) *signals* and *triggers* that reflect observed changes in the system and are used to monitor the performance of a pathway over time. Signals can come from a variety of information sources that allow actors to reflect on their current actions as pathways evolve over time. Triggers are reached when signals indicate that a threshold for a particular pathway may be approaching. If indeed the signals about triggers are correct, it means that *transfer stations* and *decision nodes* are being reached, thus 'triggering' a possible adaptation of the strategy to avoid unacceptable outcomes (Marchau et al., 2019). (ii) T*ransfer stations* represent the point where actors shift from one pathway to an alternate pathway. (iii) D*ecision nodes* are points where actors prepare for the appropriate transfer to a new course of action. Signals are therefore observed before a decision node (Haasnoot et al., 2013; Hermans et al., 2017). Institutional elements in our approach shape decision nodes where actors consider formal and informal rules to carry out their intended actions. They represent strategic or institutional turning points in the pathway. *Tipping points* are the system's thresholds at which adaptation is no longer effective (Barnett et al., 2014; Bosomworth et al., 2015). Pathways are assessed along different time horizons and scenarios with the help of *scorecards*

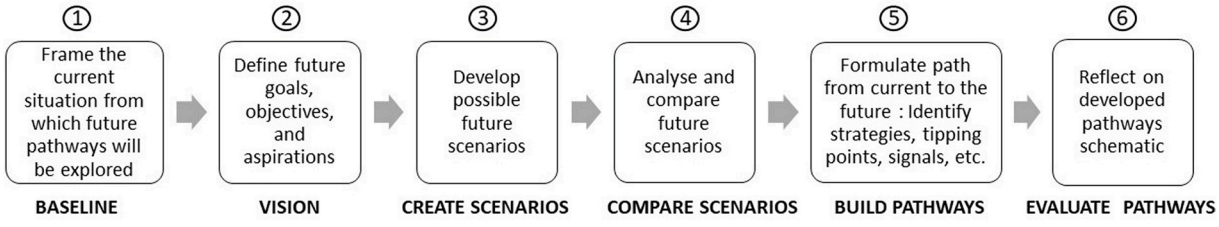

Fig. 1. Overview of the key steps in building adaptation pathways.

(Haasnoot et al., 2013; Zandvoort et al., 2017).

3.2. Facilitating multi-stakeholder discussions using the Delphi method

The Delphi method was developed at the RAND Corporation to forecast change in the field of technological development, especially in the military sector (Davidson, 2013; Day and Bobeva, 2005; Grime and Wright, 2019). It aims at building consensus in a group of experts on future developments. The first Delphi type studies relied on a set of questions, which was repeatedly asked to the same groups of experts individually. Originally questionnaires were used, today also qualitative approaches or even a combination of quantitative and qualitative methods are well accepted (Tapio et al., 2011). The results were summarized for participants after each round. The experts could then rethink their own standpoint and alter it in the next round. The final outcomes of the process are either mutual consensus or stable multiple opinions (Rowe et al., 1991).

Unlike other consensus seeking methods (Day and Bobeva, 2005), the strong structuration is a strength despite ranking low on communication intensity. It can be found in situations where there is limited problem understanding, when there are multiple viewpoints and opinions, when group dynamics is a deterrent to face to face interactions (due to sensitivity of the topics or power differences), and finally, when precise analytical methods or data for forecasting, modelling are unavailable (Davidson, 2013; Day and Bobeva, 2005; Grime and Wright, 2019). Anonymity allows for an unprejudiced consensus building/dialogue (Davidson, 2013). This can help ensure meaningful participation of different social groups. In workshops, hierarchies and pre-existing conflicts may hinder or influence the communication.

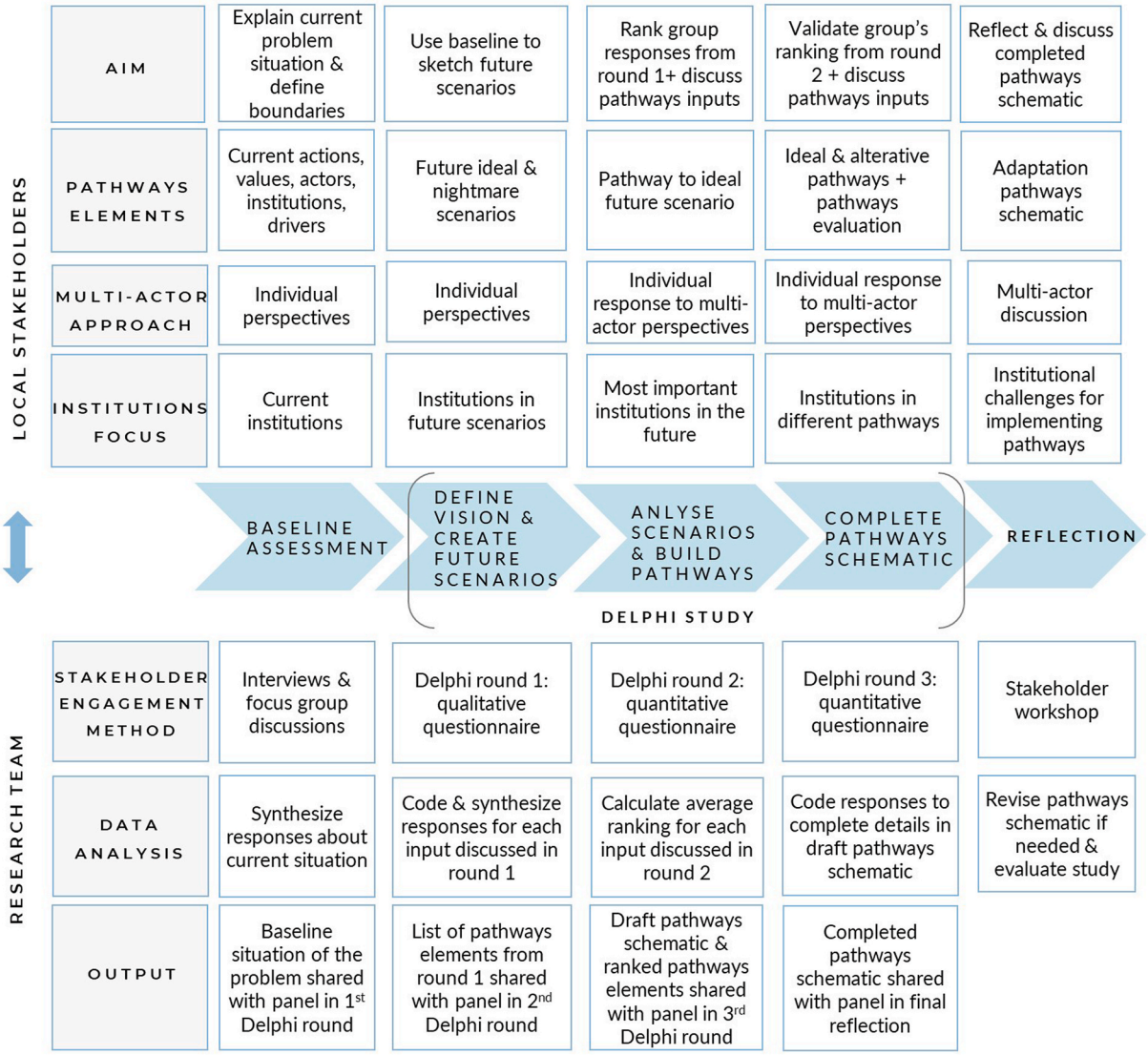

Fig. 2. Schematic of Delphi-based adaptation pathways methodology.

From the traditional forecasting purpose, other uses of Delphi type studies include building, exploring, testing or evaluating (see examples in Day and Bobeva, 2005). Several modifications from the original approach described above can be found in various domains (see Davidson, 2013; Day and Bobeva, 2005) and these are combined with other futuring methodologies such as scenario planning (Grime and Wright, 2019).

Three distinct features of the Delphi method guide our methodological choice: (a) Delphi was purposely developed to gain information about the future under conditions of uncertainty, (b) Delphi originally was designed for collecting data without physical interaction, (c) Delphi is a multi-staged process, in which inputs from earlier rounds are fed back to participants.

3.3. A Delphi-based method for co-designing adaptation pathways

Our Delphi based pathways methodology consists of (i) a baseline assessment and set-up of a stakeholder panel (ii) three Delphi rounds and (iii) a concluding session with stakeholders (Fig. 2).

Baseline assessment & setting up a Delphi panel: A fact-finding or baseline assessment (step 1, Fig. 1) is undertaken through interviews and/or focus group discussions with local stakeholders. The aim is to extract multiple perspectives about how the problem is currently experienced by the actors in their day to day or professional lives. The problem boundaries are jointly defined by the research and decision support needs of the actors. Photographic or video evidence can help visualize this baseline situation. This is used to construct a brief narrative-style summary of the baseline in preparation for the Delphi study that follows.

A panel of local stakeholders are invited to participate in the subsequent steps of the pathways building process (via a Delphi type study). It is recommended to include heterogenous members with appropriate domain knowledge on the topic (purposive sampling) (Day and Bobeva, 2005; Grime and Wright, 2019). The panel's composition remains constant during the entire Delphi study. A description of the baseline situation is presented to panel members in preparation for round 1. The medium for presenting the baseline can vary, however, including the information necessary to answer the first round of questions about the pathways elements is essential.

Delphi rounds: In round 1, a semi-structured qualitative interview is conducted, while rounds 2 and 3 are conducted via quantitative questionnaires. Unlike in a "classical" Delphi-type study here, different questions are posed in each round directed towards an evolving product as an outcome.

In round 1, the discussions focus on how the problem or context will develop in the future, reflecting the goal and objective setting stage. The timeframe depends on what is relevant for the concrete problem. For e.g., for climate change planning a 50–100 year timeframe is appropriate, whereas for eco-restoration projects a 15 year timeframe may be more suitable.

Each panel member describes the situation in n years for 3 scenarios: the business as usual scenario, the ideal scenario, and the nightmare scenario. A variety of scenarios reflect not only the different perspectives solicited during the pathways exercise but also potential positive and negative development outcomes. The qualitative approach, reveals the panel members' explanations and reasons behind each scenario and eventually, each panel member's values. The interviews further address the drivers, the actions by different actors, and the rules leading to each of the 3 scenarios.

Inputs for round two are a list of future scenarios, values, drivers, actions, and rules. They are presented (using a suitable medium) to each panel member in preparation for round 2 in which a quantitative standardized questionnaire is used to collect panel members ranking of scenarios, values, actions, institutions, and drivers. Open/narrative and closed questions about the drivers of development include the likelihood of different drivers, importance certain drivers for achieving the ideal scenario and how to respond to the most harmful driver. Further inputs about the preferred actions to transition from the current scenario, the support from various stakeholders for specific transformative actions, challenges in achieving a preferred option and their alternatives are discussed as closed or open qualitative questions. Results of round 2 reflect the group preferences about future scenarios, values, actions in the preferred and alternate pathways, transitioning between pathways, and the likelihood of different drivers.

In round 3, panel members respond to the group's scoring of responses from round 2 and provide the inputs to finalize the pathways diagrams through a series of closed and semi-closed questions. Questions in this round extend to the following topics: value-based scoring of scenarios; timing and impact of different drivers; signals, transfer stations and endpoints for different drivers; sequencing of actions towards the ideal future scenario.

The panelists' scoring of scenarios, values, drivers, and actions are used to build a final version of the pathways, reflecting the group's consensus. It shows a trajectory from the baseline to the future for the business as usual, ideal, and alternative scenarios through a sequence of strategies as well as inputs for shifting between strategies.

Final reflection: The results following round 3 are presented to the panel members during the final session. This includes the presentation and discussion of the final pathways diagrams. Ideally this is done in a group setting with all panel members. A workshop or focus group meeting is a suitable format, however, one-on-one engagement methods may also be considered depending on the context. Discussions may focus on further refinement or evaluation of the pathways (e.g. challenges and trade-offs from pursuing pathways). Practical concerns may also be explored such as how to operationalize the pathways and identify next steps. This is also the stage for evaluating the entire pathways intervention.

4. Pathways for sustainable water futures in peri-urban Kolkata

The above Delphi-led pathways approach was implemented as part of the multi-site research project H_2O-T2S (Water Transformations to Sustainability) led by a team of international partners from India, the Netherlands, and Germany. In this paper, we illustrate the implementation in Hadia village, located in peri-urban Kolkata.

The peri-urban village of Hadia is located approximately 10 km to the east of Kolkata (Fig. 3) in the East Kolkata wetlands – a

protected RAMSAR site since 2002 regulated by the East Kolkata Wetland Management Authority (pg. 19, EKWMA and WISA, 2021). Although wetland development is restricted, illegal land conversion is found in some places. A large wastewater canal running through Hadia carries a large share of Kolkata's sewerage through the wetland that provides some level of natural treatment before reaching the delta region of Ganges river (pg. 13, EKWMA and WISA, 2021). Hadia, together with four other neighboring villages is governed by Bamanghata *gram panchayat* (rural self-administration). Hadia is home to approximately 8000 people (1765 households) as per census 2011 (Office of the Registrar General & Census Commissioner, 2011) and is well connected to Kolkata through a highway. Although Hadia largely retains its rural characteristics, largely because of the protected wetland status, it is becoming increasingly threatened by urbanization processes (Mitra and Banerji, 2018). One of the main concerns for local residents in Hadia is water insecurity for livelihoods and domestic uses (Butsch et al., 2021).

4.1. Implementing the pathways building approach in Hadia village

The study was implemented between December 2020 and October 2021 by a research team consisting of an investigator (lead author) who designed the activities and analyzed responses in each round; a study coordinator in Kolkata (Partha Sarathi Banerjee, coauthor) who also translated the materials into Bengali; and two local enumerators who conducted the Delphi rounds over telephone in Bengali. The local team was trained by the investigator through online workshops via Zoom during the study.

During the H_2O-T2S project's first phase, data on the baseline situation was collected during two earlier site visits in March 2019 and Jan–Feb 2020 via key informant interviews, focus group discussions with local stakeholders (community, entrepreneurs, and government departments), guided transect walks and observations in Hadia (see Butsch et al., 2021). Key findings were summarized in a 10 min narrative style video describing the village's current water supply and use and related problems.[1] It was shared with study participants via the messaging application WhatsApp. The baseline assessment highlighted a stark difference between water users for livelihoods and household water. As a result, separate pathways schematics were developed for each sector.

A panel of 20 local participants[2] were identified during the field visits and were invited to participate in the Delphi study. Purposive sampling ensured perspectives represented the main stakeholder groups from the community across sociodemographic groups (gender, caste, income, migrant status and water use sectors) as well as government agencies (across administrative levels and departments),. The panel included 5 livelihood representatives, 6 household water users and 9 government representatives (7 at the *panchayat* level and 2 at the state level).

The discussions in each Delphi round were structured through a questionnaire. As literacy levels varied across panel members, icons and other visual aids were utilized wherever possible. Before each round, each panel member watched a 10–15 min video. The video in the first round provided information on the baseline situation while in rounds 2 and 3 presented summaries of the preceding round. Electronic or hard copies of the translated questionnaire were shared with panel members to aid the telephone-based discussions. A test interview was done before each round and checked by the study coordinator. Responses were documented using written notes or audio recordings and entered into an Excel file for further analysis by the investigator. Quantitative and qualitative analysis was used depending on the question and pathways element. In round 1, we also applied the value analysis method to examine panel members' underlying values when discussing the future (Chapter 4, Hermans and Cunningham, 2018; Keeney, 1996). Any data discrepancies identified during the analysis were clarified with the enumerators or with panel members in the following Delphi round. Table 1 below provides an overview of the structured discussions, timeline, analysis, and outputs from each Delphi round during the pathways building process.

A hybrid workshop was thereafter conducted on October 23rd, 2021 by the project team with the 19 panelists to discuss the final pathways schematics for the livelihood and household water sector. A recap of the study was followed by a presentation and discussion of the final adaptation pathways for Hadia. Break-out discussions explored how pathways help with planning for uncertainty, local agency to implement the pathways, conflicts and trade-offs between pathways for different water users, and identifying next steps for decision-makers. The workshop concluded with an evaluation of the entire study.

4.2. Adaptation pathways for Hadia village

The following are the final adaptation pathways developed by the panel for two water use sectors in Hadia.

4.2.1. Livelihood related adaptation pathways

The livelihood pathways have a time horizon of 15 years (2020–2035) (Fig. 4). The baseline assessment showed that aquaculture was the main source of income for most people given the access to nutrient rich wastewater. Several large fishing ponds were being used for commercial aquaculture by private fishermen and a fishing cooperative. Secondary livelihoods included small-scale agriculture (using groundwater or wastewater), water vending or wage-labor outside the village.

In the business as usual pathway, fishing was expected to continue as is by private fishermen while the fishing cooperative also will develop tourism with government subsidies. Yet this livelihood may not be sustainable long-term as expenses could increase and fish productivity could decline due to water pollution or unplanned construction within the wetland. External drivers like 'urbanization',

[1] All preparatory videos, Delphi questionnaires, and evaluation surveys from peri-urban Kolkata are provided as supplementary materials.

[2] Panelists who participated in all 3 Delphi rounds received a small honorarium of €19 (calculation based on currency exchange rate 1 INR = 0.0125706 on 23-8-2022).

Fig. 3. Map of Kolkata city in India (left); Map of Hadia village in relation to Kolkata city (right). Map layout: authors, Cartography: Martin Gref, Data base: google maps images.

Table 1
Overview of Delphi study used to build adaptation pathways for Hadia village.

Delphi	Objectives	Timeline	Data analysis	Outputs
Round 1	Panelist describe their ideal, nightmare, and business and usual scenarios for Hadia	Dec 29 - Feb 9, 2021	Content analysis of future scenarios. Value analysis method applied to different pathways elements.	List of future scenarios. List of 5–10 most cited values, actions, institutions, and drivers provide a draft pathways schematic
Round 2	Panelist ranks the list for different pathways elements generated from round 1	Mar 7 – Mar 20, 2021	Descriptive statistics to determine average scoring of pathways elements	Group ranking of future scenarios, values, sequence of actions, drivers provided a revised pathways schematic
Round 3	Panelist verify or revise group scoring of pathways elements and provide additional inputs	Jun 11 – Jun 25, 2021	Qualitative and quantitative data analysis of additional inputs	Signals, action sequence, institutions and multi-actor elements, tipping points incorporated into final pathways schematic

unplanned 'wetland development' endangers water-based livelihoods in this pathway. This causes uncertainty regarding the next generation's willingness to continue fishing.

Signals that the fishing sector will be supported could encourage people to shift to the preferred livelihood pathway. In this ideal pathway, a supported fishing sector would be positively shaped by external drivers: supportive 'village development' and a protected 'wetland environment'. A sequence of actions was identified that would sustain traditional fishing. It included financial support, planned development of the fishing industry, managed wastewater and nutrients flow, set up of a wastewater treatment plant and control of wetland pollution in this order. Different actors were considered responsible for implementing these actions, especially the government. In the telephone interviews, "government" was addressed abstractly as the actor responsible for the first three actions without naming specific agencies (for e.g. Department of Fisheries, Irrigation Department). Panel members named citizens, social clubs, panchayat and health workers as the actors responsible for pollution reduction. Panelists differentiated between the type of support needed by different types of fishermen. While subsidies for fishing inputs was needed by both fishing cooperatives and individual fishermen, cooperatives specifically required subsidies for new technologies whereas individuals would benefit more from a guaranteed minimum price for their products. This pathway relied upon improved implementation of existing institutions and better access to government schemes and projects.

Future risks related to this pathway and the 'business as usual pathway' stem from external drivers like 'urbanization', unplanned 'wetland development' and 'climate change', which could negatively impact fishing (Fig. 4). Signals for shifting to the 'alternate livelihood pathway' would be "declining profits" in the 'preferred livelihood pathway' and "the next generation leaving the fishing business" in the 'business as usual pathway'.

In the alternative pathway, people would leave fishing for other livelihoods with factory work, small businesses, and farming mentioned as top three preferred alternatives. The 'unplanned wetland development' driver, might lead to industrial development which could enable people to get factory jobs or work in businesses (e.g. shops and restaurants). Some panel members also explicitly

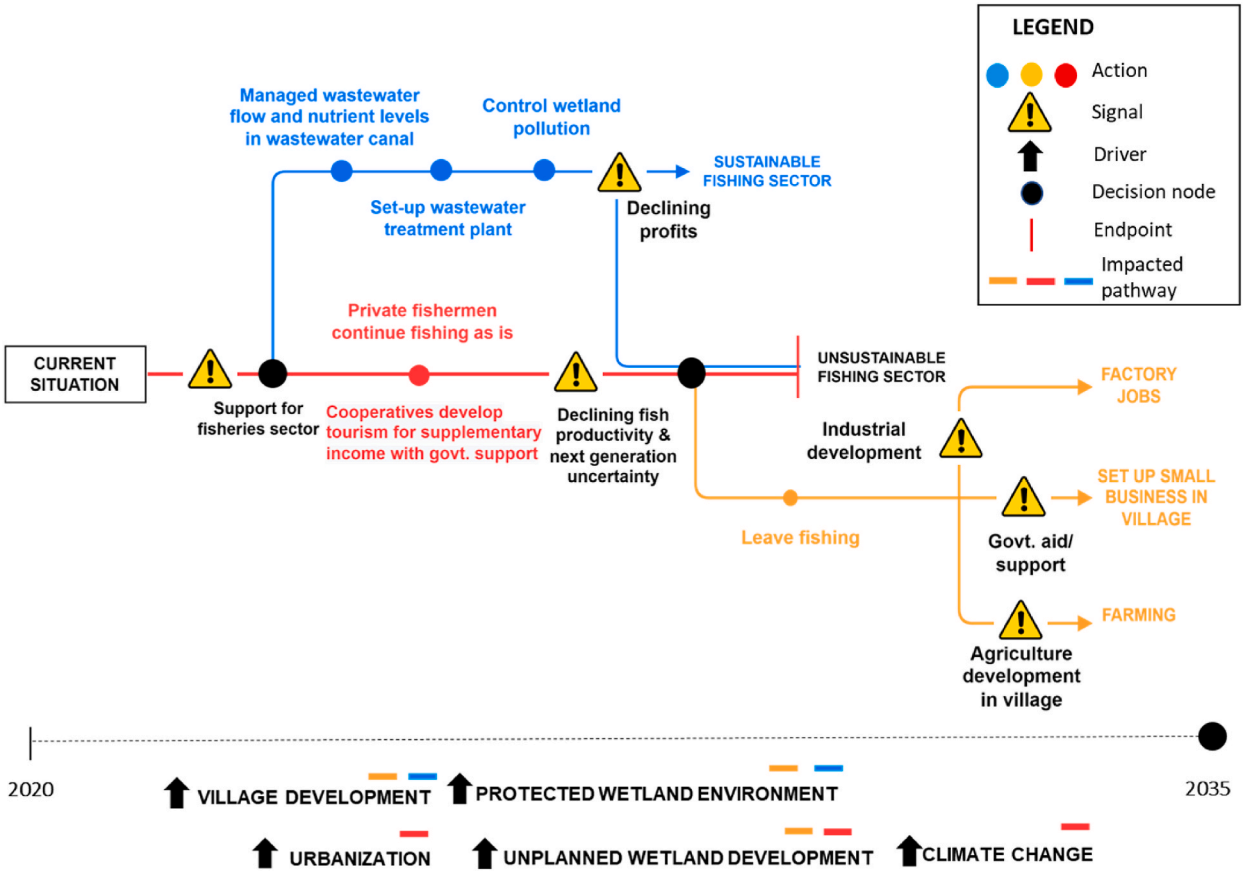

Fig. 4. Future adaptation pathway for livelihoods in Hadia (Red: Business as usual, Blue: Ideal, Orange: Alternate pathways). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

mentioned their preference for planned, non-polluting industrial activities.

The drivers 'village development' and 'protected wetland environment' stimulate locals to set up their own small businesses or work in farming, depending on the enabling conditions provided by government actors. Better access to state government's rural employment schemes was a signal to set up new businesses whereas focused attention on agricultural development by village development authorities would encourage investments in farming.

The ideal and alternative livelihood pathways were scored by the panel in round 3 based on the six different values (Fig. 5). The most commonly selected answer on the satisfaction scale (mode) for each value is shown for the different livelihood pathways in Fig. 5. We note, however, that these results may also be influenced by the varying number of responses for each alternative livelihood scored.

4.2.2. Household water adaptation pathways

Three pathways cover the time period 2020 until 2035 (Fig. 6). According to the baseline assessment groundwater remained the main source of water for drinking and domestic purposes. It was accessed through public handpumps and deep tube wells or privately owned, shared hand pumps or tube wells. Bottled or packaged water from small, privately owned and locally operating reverse osmosis (RO) plants was also used for drinking by wealthier households. This commodification of water is was observed in all of the project's study sites.

In the business-as-usual pathway people continued to rely on the use of handpumps for domestic purposes and packaged water treated through RO until piped supply is installed. At the time of this study, pipelines were being laid but water supply had not yet started. These water supply schemes are part of the West Bengal government's strategy since 2011 to provide safe water supply to rural areas (Public Health Engineering Department, 2018a, 2018b).

The start of the piped supply would be a signal for Hadia residents to shift to their preferred pathway. In this ideal pathway, piped water supply would be used for both drinking and domestic purposes. Several actions were considered necessary for shifting to this pathway in the following order: the local government has to ensure continuation and completion of the pipeline installation. When every household would be connected to the piped network, efforts to prevent water wastage would thereafter be required. External drivers supporting a shift to this pathway were 'village development' (in contrast to 'urbanization') and 'protected wetland environment' rather (in contrast to 'unplanned wetland development'). Unfavorable development related to 'climate change' was also

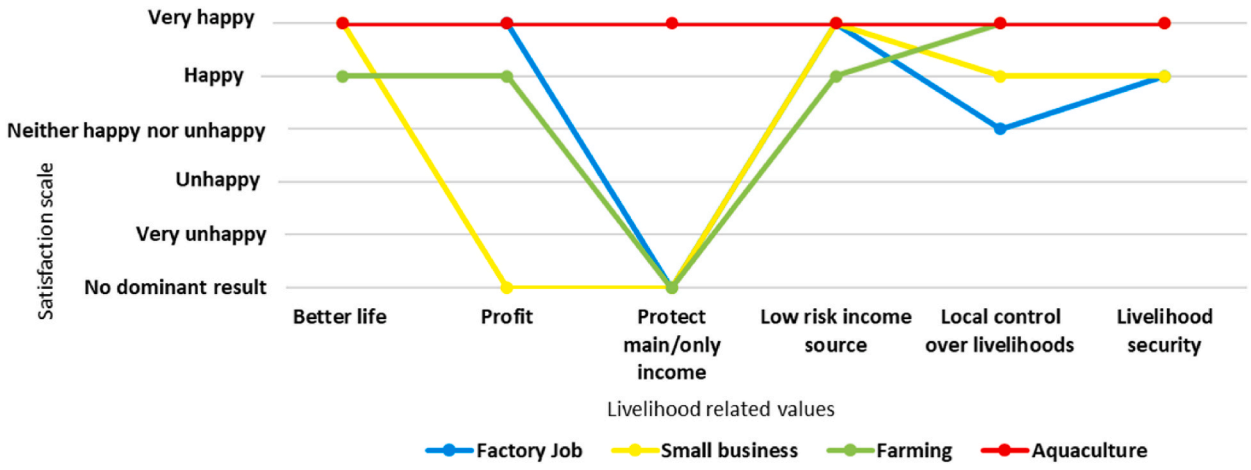

Fig. 5. Scoring of livelihood pathways according to actors' values.

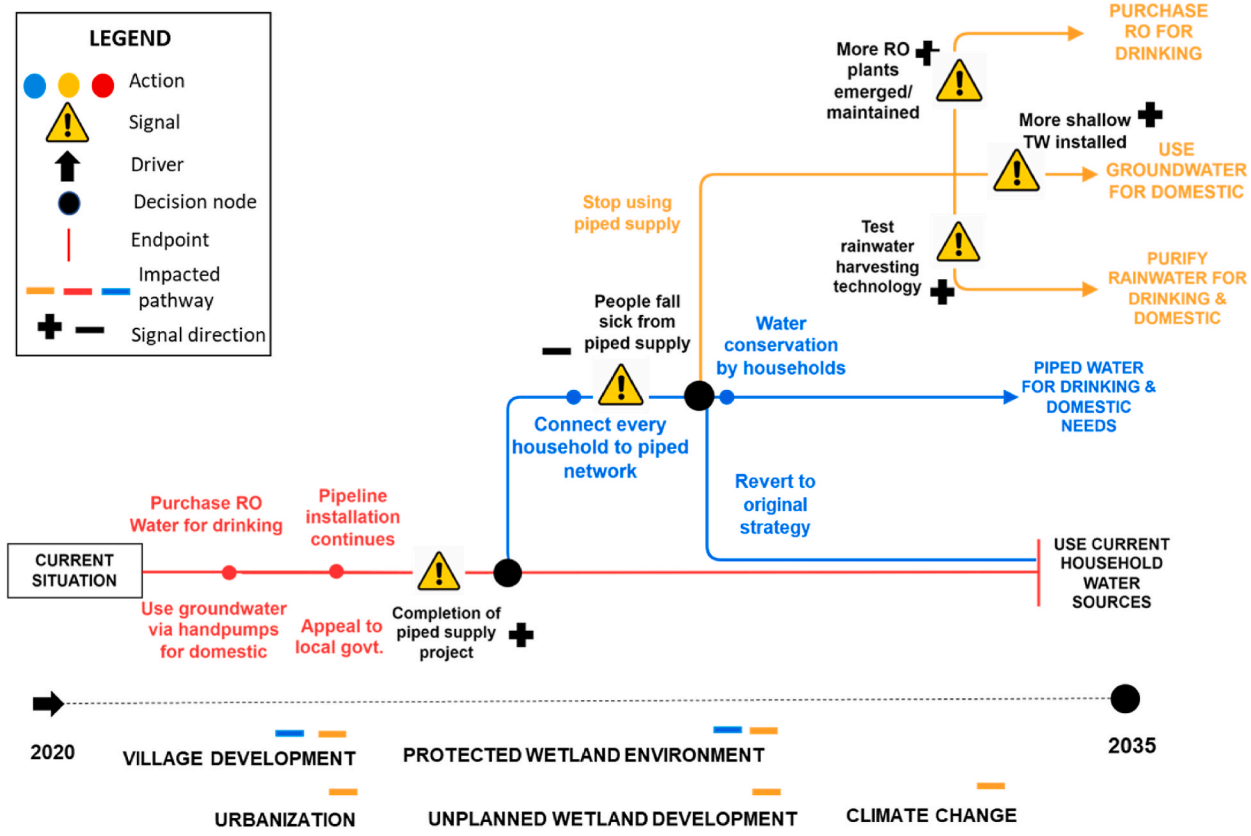

Fig. 6. Future adaptation pathways for household water use in Hadia (Red: Business as usual, Blue: Ideal, Orange: Alternate pathway). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

expected to negatively affect the realization of the ideal pathway.

In the ideal pathway, operation and management of piped water supply remains largely under the control of the public health engineering (PHE) department and local panchayat. Thus, water quality lies outside the sphere of the residents' influence. In the future, if people were to get sick from piped water, this would be a signal to stop using it before a serious health crisis or disease outbreak (tipping point) is reached. In this case households would shift to the alternate pathway or revert back to the business as usual pathway.

The alternative pathway can develop in several ways. Preferred options from the panel are: (i) purchasing RO-water for drinking, if

existing RO plants are maintained well or more RO plants are set up by private actors (n = 17), (ii) rainwater harvesting (n = 2), which depends on access to rainwater harvesting technologies and water testing by PHE.

Groundwater and pond water were both equally preferred (n = 9) alternate domestic water options. Use of groundwater depends on the financial resources, as groundwater pumping infrastructure is costly. Most panel members had a preference for less costly shallow hand pumps (n = 5) to access easily available groundwater. Ground water supply required creating new informal arrangements to share investment costs between households and develop groundwater regulation rules to prevent overexploitation. Groundwater regulation, in the future would continue to be the responsibility of the State water investigation department. Using water of the ubiquitous ponds (n = 9) was also a suitable alternate option. PHE were considered important for pond maintenance. Each alternative source is furthermore suited for different drivers e.g., households would prefer groundwater if the 'unplanned wetland development' or 'urban expansion' drivers occur and RO water or rainwater if the 'climate change' driver occurs.

The household water pathways were evaluated based on the following values: water quality, affordability, time for water collection, equal access and convenience. In Fig. 7, only the most commonly selected response is shown. Piped water (the preferred pathway) was scored best, together with RO water (Fig. 7). The alternative pathway for domestic water reveals that pond water is more favorable than groundwater given that it scores poorly on 'less time for water collection'.

4.3. Evaluation results from pathways building activities in peri-urban Kolkata

The application of the delphi-based pathways method was evaluated from the 4 enumerators' and 15 participants' perspective based on the framework by Midgley et al. (2013) and Thissen and Twaalfhoven (2001) (Table 2). Inputs were collected via an electronic and paper-based survey.

All 15 survey respondents (study participants) understood the purpose of the Delphi study, the goals of each Delphi round and agreed with the final pathways diagrams. The study achieved learning on 3 main categories: institutions, local problems, adaptive planning (Fig. 8). Unanimously, the participants agreed that they could apply pathways thinking to other kinds of problems – indicating a higher-order learning effect.

Panel responses further indicated that the method's strength lies in addressing real-world problems and thinking about the future, although the latter was found challenging (n = 12) (Fig. 9). A success was the different population groups entering into a dialogue. One respondent also recommended including more villages from the area in future pathways studies. However, practically conducting interviews via telephone was challenging and less stimulating. Participants unanimously indicated a preference for in-person meetings in the evaluation survey. On the other hand, the availability of physical questionnaire copies and preparatory videos was positively evaluated (Fig. 9), underlining the importance of facilitators and well-designed materials when face to face communication is not possible.

Meanwhile, all four enumerators evaluated their understanding of the pathways concepts, methods, and objectives in each Delphi round as 'difficult'. The positive scoring (very helpful, n = 5) of the training workshops and manual illustrates that enumerator trainings is an essential success factor.

An important finding was how time intensive the Delphi method was considered by enumerators. Average discussion times were 35, 36, and 58 min for rounds 1, 2, and 3 respectively. Additional time was also spent preparing for interviews (including trainings), data entry, and follow up work. Although enumerators were compensated, one dropped out of the study after rounds 1 and 2 respectively and had to be replaced, adding to the training time.

Challenges mentioned by the enumerators were the bringing together of panel members of different sociodemographic backgrounds and the translation of materials to Bengali, sharing material via (smart) phone, management of appointments and keeping up

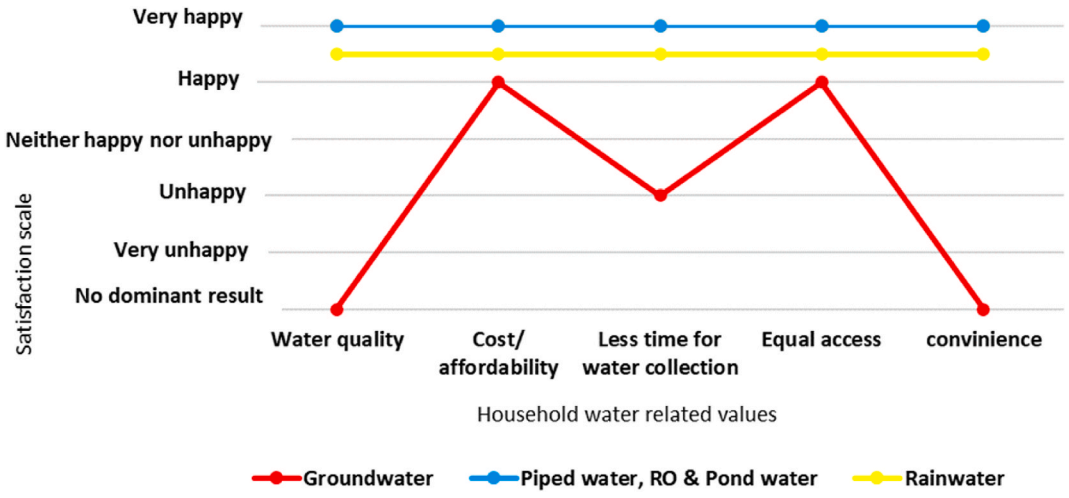

Fig. 7. Scoring of household water pathways according to actors' values.

Table 2
Evaluation criteria for adaptation pathways application in peri-urban Kolkata.

	Enumerator evaluation criteria	Participant evaluation criteria
Outcomes	Insights gained from the Delphi study	Insights gained from pathways: planning, future development, flexibility, local problem understanding, problem solving, institutions
	Discussing pathways concepts with panel members from different backgrounds	Understanding pathways related questions, video materials
	Understanding the concepts, methods, and objectives of the Delphi study	Problem framing through adaptation pathways: Sharing perspectives & future oriented thinking
		Accurate reflection of the problem context in the constructed pathways
Delphi process	Data entry tasks & translation of Delphi materials	Communication methods during the Delphi rounds
	Time management: managing project workload, completing tasks in specified timeframes	Preparation time and duration of each Delphi round
	Panel communication: sharing preparatory materials, scheduling telephone meetings, conducting meetings and follow up	Study accessibility via telephone
	Communication with investigator, digital communication within research team	Support provided by the enumerators during the study
	Support, training, and feedback provided by the investigator & coordinator	

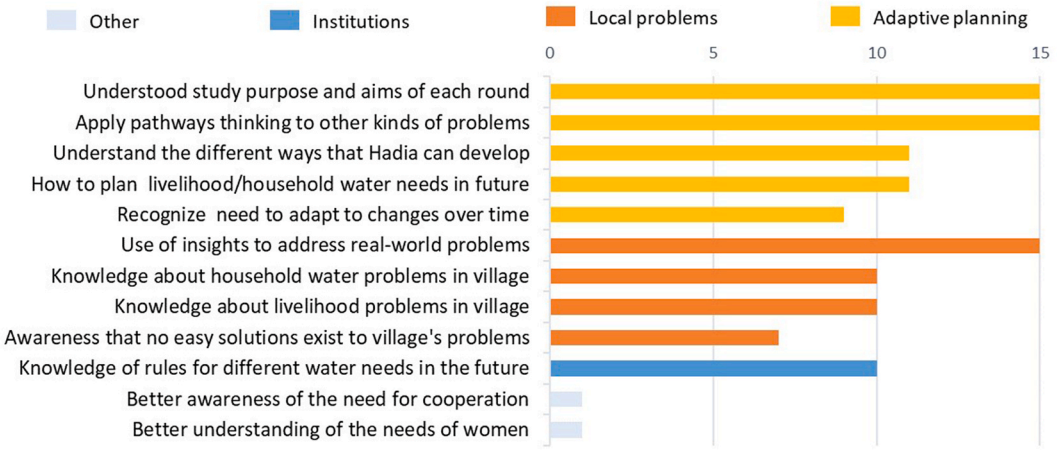

Fig. 8. Participant evaluation of the pathways building study overall.

the panelists' interest in the study over the three rounds (Fig. 10). Enumerator suggestions for future use include "simplifying questionnaire with shorter questions, easy descriptions, without repetition" and having "customized questionnaires for different types of actors".

5. Discussion

5.1. Facilitating pathways discussions using the Delphi method

In the pathways literature, few studies (see for example, Ryan et al., 2022) describe and reflect on the facilitation process of building adaptation pathways with stakeholders. This paper addresses this gap by offering a very structured process to discuss pathways elements with local stakeholders and translate these into an adaptation pathways schematic. The Delphi method does not specify the content of multi-stakeholder discussions, rather only specifies how to structure deliberative processes in an iterative way. In this sense, a Delphi is easily adaptable to pathways elements during the pathways building process. To our knowledge, a Delphi type approach for building adaptation pathways is not yet explored.

The Delphi method enhances the pathways methodology through structured, iterative discussions with local actors. It helps solicit individual opinions at each step in the pathways building process, something which is less achievable in a traditional workshop setting. The iterative format benefits participants by encouraging meaningful reflection on the relative importance of pathways inputs generated from the group as a whole. It forces participants to consider the opinions shared by others and compare it to their own perceptions and ranking. In peri-urban Kolkata, individual responses to pathways elements (e.g. actions, scenarios) over successive rounds showed that some participants' opinion changed over time after reviewing group-level results. Discussing and sharing opinions across backgrounds and gender was also positively evaluated by both enumerators and participants from this context. This is why a Delphi study is recommended as a complement to forecasting exercises (Grime and Wright, 2016). A few studies illustrate this (Bañuls

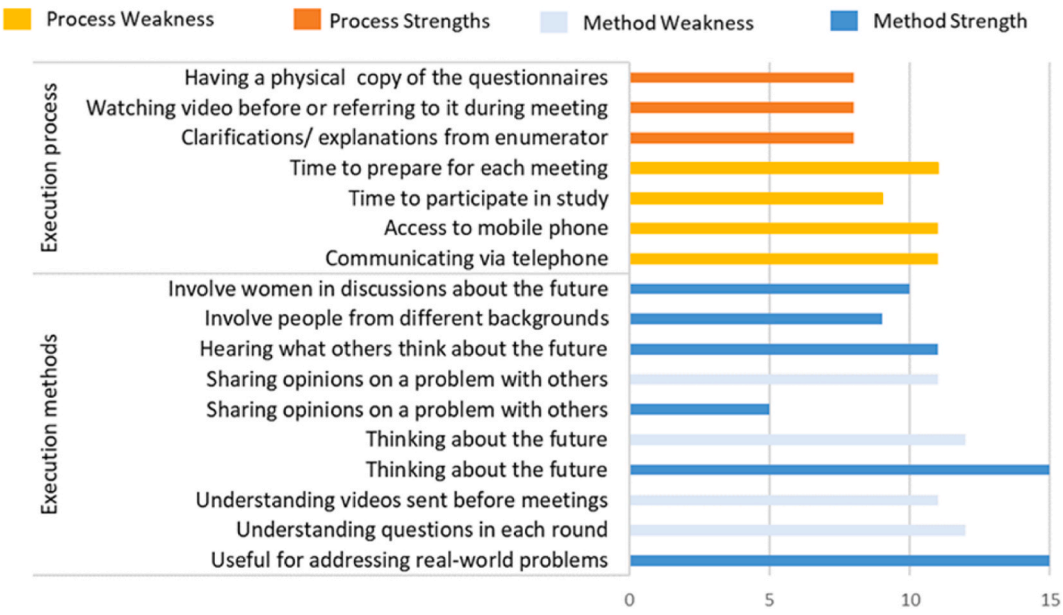

Fig. 9. Participant evaluation of execution methods and process.

and Turoff, 2011; Renzi and Freitas, 2015), though not for the purpose of building adaptation pathways or with local stakeholders specifically.

Although we lack any basis to say whether a Delphi is better than other facilitation methods, we see signals that it helps reach consensus and navigate conflict areas. This emphasis on consensus building in group communication and judgments regarding complex problems is one benefit of a Delphi (Grime and Wright, 2016). Our methodology offers a way to construct pathways by emphasizing the collective interests while also highlighting where certain groups deviate and consensus cannot be achieved. The pathways developed for Hadia village reveals fundamental differences in baseline conditions and underlying values across water-use sectors. It is reflected in the very different adaptation strategies for each sector in the future. Similarly, the pathways revealed differences in financial and socio-economic capabilities within the fishing community or household water users that shapes their long term adaptive capacity to adapt to changing conditions over time. Pandey et al. (2021) attempt something similar by designing pathways separately from different actors perspective, yet, this study does not attempt to synthesize across the different pathways. Herein our Delphi-based approach adds value.

On the other hand, a Delphi study proved to be a very intensive process. The study in peri-urban Kolkata lasted almost 11 months from participant selection until the final reflection workshop. A detailed baseline assessment makes it even longer. This was partly due to the time needed to develop the methods during the study and unforeseen delays (Covid-19, the occurrence of cyclone Amphan, local elections, public holidays, changes in the enumerator team etc.). One-on-one iterative discussions incorporates a lot more detail concerning pathways elements, however, keeping participants engaged or interested over a long study period proved challenging. At the same time, the longer duration also helps disconnects the results from topical events in the study context, which may lead to a very strong bias.

Investigators who conduct pathways exercises with local stakeholders must be aware of inevitable biases that can be introduced in a Delphi study given that it relies on human judgment. Participant bias results from imperfect panel selection affecting accountability of the perspectives reflected in how to address a problem (Davidson, 2013). In peri-urban Kolkata, the panel needed to capture the lived-in realities of managing peri-urban water needs by public authorities as well as local water users. This determined our selection criteria for the participants in the Delphi study. Investigator bias can also occur during the synthesis of responses and feedback stage (Grime and Wright, 2019). We attempted to narrow this bias in our application by reviewing response categories with other scientific and local team members or clarification with participants in subsequent rounds. Translating pathways concepts into the local language was also challenging, for which a glossary of local terms was provided and substantial time was dedicated towards enumerator training. Nevertheless, certain pathways concepts proved very challenging to discuss with the panel (e.g. signals) for which examples were provided. This too introduces external opinions into the discussions. Future work can focus on reducing investigator bias with the help of unbiased experts using standardized checklists, grading rubrics, or qualitative summation methods (Davidson, 2013; Grime and Wright, 2019).

5.2. Contributions to the adaptation pathways literature

Our methodology enhances existing pathways approaches through explicit discussions about values, institutions, and multi-actor aspects. These emphasized elements share similarities with that of the Values-Rules-Knowledge framework to consider the decision

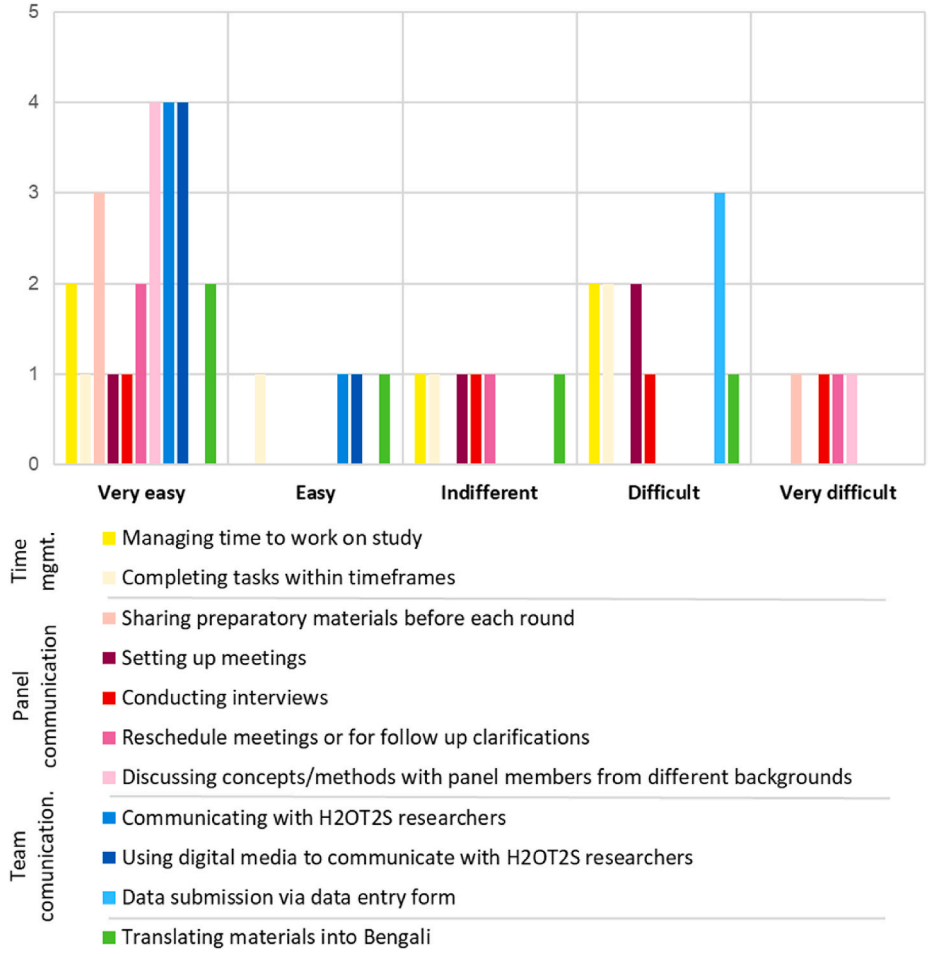

Fig. 10. Enumerator evaluation of the Delphi process.

context in adaptive planning efforts (Gorddard et al., 2016). This framework has been applied to adaptation projects in Australia (Gorddard et al., 2016; Prober et al., 2012, 2017). However, in these cases it was used for retrospective analysis or was not directly incorporated into a participatory pathways building process. In this way, we illustrate how to structure this through a Delphi study.

Delphi questionnaires are designed to not only elicit responses but also the reasoning behind this response (Grime and Wright, 2019). This reveals the underlying values of the participants which is considered useful when building adaptation pathways (Lawrence et al., 2018). For example, narrative responses about future development in round 1 revealed participants values concerning the future more generally and specific to different water use sector. Another useful methodological contribution is the value analysis method that complemented the Delphi study (see Table 1). It was used to analyze normative responses using the logic of means-end objectives networks and fundamental objectives hierarchies. This added rigor to the structuring and analysis of inputs in the initial stages of the pathways building process and in this way, makes a novel contribution to the existing toolbox of analytical methods for building adaptation pathways.[3]

Our approach shows how to incorporate institutions (both formal and informal) and multi-actor characteristics at the decision node where shift from one pathway to another occur. These societal attributes are shown to enable or limit adaptation options (Gorddard et al., 2016; Schneider et al., 2020). In peri-urban Kolkata, we were unable to obtain the desired level of detail regarding formal institutions and responsible actors to enable different future pathways. This was largely due to the knowledge limitations of the mostly community level stakeholders that were engaged in the process as a result of their isolation from policy-making arenas. These gaps may be addressed by involving suitable government stakeholders or policy experts in later rounds. Nevertheless, it brings focus to the enabling conditions to facilitate future adaptation strategies.

Certain pathways elements could be further developed in our methodological approach. We struggled with capturing the dynamic within the pathways using signposts, triggers as these were challenging concepts for the participants. Likewise, the concept of

[3] Results from the value analysis for Hadia village is available in the supplementary materials.

uncertainty was loosely addressed due to similar translation challenges, leading us to focus instead on the likelihood of drivers along a 15 year timeline. This is perhaps suited to our normative focus compared to applications which examine scenarios in terms of probability or identifying the most robust strategies during the baseline assessment or through exploratory modelling (see Haasnoot et al., 2013; Moallemi and Malekpour, 2018). Project time limitations also meant sacrificing certain analytical goals. A restricted three round Delphi, meant focusing on only the most extreme future scenarios from the 8 that were described by the panel for Hadia village and likewise, evaluating the pathways based on value satisfaction comparison to other multi-criteria decision analysis, cost-benefit, or real options analysis (de Ruig et al., 2019; Ryan et al., 2022). Extending the Delphi method with one or two additional rounds opens up the possibility to incorporate more detail to refined the pathways and the use of other analytical methods to evaluate them.

Building pathways through a Delphi type study allows stakeholders to be located virtually anywhere. We illustrate this not only in this paper but in a similar pathways building study with Indian and international experts (Luft et al., 2022). It allows meaningful engagement with remote communities or stakeholders even when physical interactions are not possible as was the case in this study due to the Covid-19 pandemic. Our evaluation results reveal the difficulty in doing pathways building over the telephone. Future work can experiment with other mediums for conducting the Delphi rounds or a combination of different types of facilitation methods.

6. Conclusions

The aim of this paper was to design, test, and evaluate a novel Delphi-based adaptation pathways methodology. It was motivated by the lacunae in the literature regarding how to structure normative pathways as a participatory research process with local stakeholders. The focus was on involving stakeholders with varying perspectives about a problem and without experience in pathways thinking.

Our presented methodology translates generic descriptions of designing pathways into a Delphi type study. Each round forces participants to critically examine their own perspective versus those of the other panelists with the effort to build consensus on future planning – as far as possible. A focus is laid on possible achievements based on shared norms while showcasing where stakeholders diverge in their strategic preferences for the future. Being consulted individually and anonymously, all members of the panel can express their views without facing barriers related to their positionality.

This method furthermore offers a more explicit consideration of institutions (*rules*), which influence stakeholders' ability and willingness to shift between different pathways. This has a potential to open up discussions about institutional change and resulting changes in strategies. Moreover, the incorporation of value analysis methods during the Delphi was extremely useful in identifying underlying values behind the actions and scenarios that were discussed.

Through our pilot application in peri-urban Kolkata, we successfully introduced pathways thinking to stakeholders with no prior experience, who are remotely situated and who have varying levels of literacy and technical knowledge. Moreover, we did this remotely due to the interaction constrains posed by the Covid-19 pandemic. This required specific design choices such as conducting the Delphi via telephone. Preparatory materials were useful for guiding discussions, sharing group results, and visually communicating the pathways concepts. While participants found it challenging to think about the future, evaluation findings demonstrate its power in exploring real-world problems in a participatory way.

It is clear that our method offers something different from the existing participatory pathways approaches and there seems to be clear advantages in this Delphi-based way of doing things as well as disadvantages (e.g. intensive process). We see opportunities to further develop this methodology with additional Delphi rounds to address aspects that are poorly captured in the existing study set up e.g., uncertainty and inclusion of a broader range of scenarios beyond the two extremes. Other forms of stakeholder engagement beyond telephone survey should also be explored.

In terms of application areas, future work should be directed towards piloting the Delphi-based adaptation pathways methodology across peri-urban contexts to develop generalizable recommendations for policymaking. We also seek to explore the potential of this method in other contexts as it allows for strengthening the agency of local stakeholders planning processes. Thus, the methodology can support planned transformations to desired futures. A future challenge lies in developing multi-level coordinated pathways including local actors and government institutions on different scales.

Author statement

S L Gomes: Conceptualization, Methodology, Writing – original & revised drafts, Investigation, Formal analysis, Visualization, Data curation **L M Hermans**: Conceptualization, Funding acquisition, Project administration, Methodology (feedback), Writing – review & editing **C Butsch**: Conceptualization, Funding acquisition, Methodology (feedback), Writing – review & editing **P S Banerjee:** Investigation, Validation, Resources, Writing – review & editing **S Luft:** Conceptualization, Methodology (study evaluation) **S Chakraborty:** Conceptualization, Funding acquisition, Project administration, Methodology (study evaluation).

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.

Data availability

Raw data can be made available following all H2O-T2S publications or data access consent from all consortium partners. Personal information will be anonymized to protect study participants.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.envdev.2023.100822.

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