Official Journal of the World Water Council
Water Policy

Water Policy Vol 24 No 5, 797 doi: 10.2166/wp.2022.229

Capacity development for the Bangladesh Delta Plan from the perspective of delta professionals: A qualitative study

Ashraful Kabir[a,b], Abu Syed[a], Chris Zevenbergen[c], Jannatul Ferdous[a] and Assela Pathirana[c,*]

[a] Bangladesh Centre for Advanced Studies, Dhaka, Bangladesh
[b] School of Public Health and Preventive Medicine, Monash University, Melbourne, Australia
[c] IHE Delft Institute for Water Education, Delft, The Netherlands
*Corresponding author. E-mail: a.pathirana@un-ihe.org

AS, 0000-0003-4256-6793; AP, 0000-0003-0907-1764

ABSTRACT

Many deltaic regions around the world are exploring or adopting planning initiatives to address the complex challenges associated with future economic development and climate change. A key feature is their adaptive nature, also coined as adaptive delta management (ADM). ADM refers to the development of strategies and measures that allow us to adapt to change over a long time. The Government of Bangladesh has recently approved the Bangladesh Delta Plan 2100 (BDP2100) – a long-term adaptive strategy for sustainable water resources management. This study aims to explore the future capacity requirements from the perspective of water/delta professionals for implementing BDP2100. This calls for structural and institutional changes, and new skills and competencies to address the specific organisational and individual needs for effective delivery. A capacity development programme as an integral part of BDP2100 is currently under development. Adopting a qualitative approach, 16 key informant interviews were conducted with experts and professionals from the water and water-related sectors in Bangladesh. A thematic analysis approach was used to analyse the data. The participants reflected that an integrated and adaptive system is critical for sustainable delta management; collaboration and coordination between water/delta professionals (e.g., policy planners, consultants, and academics) and delta expert stakeholders with deep local familiarity (e.g., communities, activists, and civil society members) were deemed essential. In addition, a powerful independent institutional body is recommended to provide stewardship and leadership in the implementation process.

Key words: Adaptive delta management, Bangladesh Delta Plan 2100, Capacity development, Climate change, Water resources management

HIGHLIGHTS

- Deltas have embraced adaptive delta management (ADM).
- BDP2100 – ADM blueprint for Bangladesh.
- Needs quantitative and qualitative changes in water sector capacity.
- Investigated capacity needs for the success of BDP2100 as perceived by sector experts.
- Integrated, adaptive approach, and interdisciplinary collaboration should be central in capacity building (CB).
- Independent institutional body should coordinate the sector CB needs.

INTRODUCTION

Adaptation has been recognised as key to address uncertainties associated with climate change (Henstra, 2016; Zandvoort *et al.*, 2017). In the past years, many deltaic regions worldwide adopted adaptation mechanisms for addressing long-term climate-induced vulnerabilities and uncertainties (Swanson & Bhadwal, 2009; Jeuken *et al.*, 2014; Nicholls *et al.*, 2018; Zegwaard *et al.*, 2019). Literature presents several adaptive approaches to support long-term planning and flexibility, acknowledging uncertainties in key drivers of change (Walker *et al.*, 2001; Lempert *et al.*, 2003; Pahl-Wostl, 2007; Haasnoot *et al.*, 2013). Particularly, adaptive delta management (ADM) is increasingly applied to deal with uncertainties in climate change and socio-economic projection scenarios in the design and planning phases of flood risk management strategies (Zevenbergen *et al.*, 2018). ADM refers to the development of strategies and measures which are able to adapt to changes occurring over a long period (Marchand & Ludwig, 2014; Dewulf & Termeer, 2015; Zevenbergen *et al.*, 2018; Kulsum *et al.*, 2021). The ADM approach became a priority for the deltas transforming rapidly due to sea-level rise and other consequences of climate change, and to the direct impact of the climate change drivers: rapid population increase, urbanisation, deforestation, etc. (Huq & Ayer, 2008). Humans have transformed many deltas in the world to a so-called Anthropocene state (Renaud *et al.*, 2013) which are pushing them towards new tipping points that may threaten the livelihood of the communities living in the deltas as well as the sustainability and resilience of their environment (Mintzer, 1988; Giosan *et al.*, 2014).

Bangladesh is covered mainly by the Bengal delta, the largest delta on earth. Global climate change and regional (Ganges-Brahmaputra basin) and local changes continue to affect the ecosystems and livelihoods of the communities of the country (Ali, 1999; Karim & Mimura, 2008; Shahid, 2011; Nicholls *et al.*, 2016). Bangladesh ranks as the seventh most affected country by climate-related impacts and associated vulnerabilities (Eckstein *et al.*, 2021). These vulnerabilities can be exacerbated by many factors such as disadvantageous geographic location, topography, rapidly expanding urban sprawl, high poverty levels, population density, and poor institutional capacity (Goosen *et al.*, 2018; Khan *et al.*, 2021).

In response to the climate-related impacts and associated vulnerabilities, the Bangladesh Delta Plan 2100 (BDP2100) was formulated as a long-term comprehensive strategic and planning initiative to secure sustainable economic growth, enhance environmental conservation, strengthen resilience to natural disasters, and promote effective water governance (Bangladesh Planning Commission, 2018). In September 2018, the Government of Bangladesh (GoB) endorsed BDP2100. ADM is at the heart of BDP2100 taking into account multiple socio-economic and climate change scenarios allowing to change course when the future unfolds differently than anticipated (Timmermans *et al.*, 2015). Hence, it focuses neither on the business-as-usual nor the worst-case scenario but on multiple adaptation pathways that embrace the reality of uncertainty, and sometimes unpredictability, of future states (Zevenbergen *et al.*, 2018). Implementing ADM requires a continuous intensive interaction between different levels of government and a governance system relying on monitoring and evaluation. When new information becomes available – in the planning and programming and in the implementation phases – the decision to change course needs to be based on an institutionally embedded rationale, and coordinated. Often, the central government coordinates the development of the strategy. The coordination of the programming and the execution of measures are typically carried out by regional and local authorities. Especially in situations where large, expensive interventions are required for improving the functioning of the system as a whole, and the cost in terms of negative consequences to local and regional interests is high, it is important that all government levels are committed to the same outcome. ADM has been first applied in the programming of the Dutch Delta Plan and soon after in a few other deltas (Wiens *et al.*, 2017; Radhakrishnan *et al.*, 2018). ADM cannot be transposed easily from one country to another at the policy formulation level as it demands a fundamental

change in institutional capacity at multiple levels, including new knowledge and skills, hierarchical and operational relationships, and policy frameworks, and, hence, it depends on local socio-economic characteristics, culture, and governance (Zevenbergen *et al.*, 2013; Hasan *et al.*, 2020).

Evidently, effective implementation of BDP2100 requires significant capacity development at different levels. The implementation of a large programme like BDP2100 generates different dynamics than its formulation. From a top-down perspective, needs have been identified as key to the implementation: for integrating and mainstreaming the BDP2100 programme, for coordinating and collaborating among the agencies and stakeholders, for translating the Plan into sectoral short-term plans, for building the institutional framework, for mobilising resources and prioritising programme interventions, for conducting result-based monitoring and evaluation, and for creating and translating evidence-based knowledge into practices (de Heer, 2020). As such, the capacity for improved water development is viewed as a holistic and complex mechanism that functions at individual, institutional/organisational, and contextual levels. These levels are inter-related and influence each other. At the individual level, skills and competencies are to be developed; then, these are exchanged and shared among peers and groups to adjust them and confirm their suitability at the organisational level, and eventually are applied in an enabling environment (Blokland *et al.*, 2009). The Dutch Delta Approach has been referred to as a successful guidance frame for the Bangladesh BDP2100 (Hasan *et al.*, 2020). The premise of the study presented in this paper is that improved capacities at different government levels are therefore essential for further successful replication and adjustment during implementation. The study is based on interviews with experienced water professionals currently working 'on the ground' in Bangladesh in the water domain; it explores capacity requirements in water management skills and institutions to render the implementation of the BDP2100 possible.

METHODS AND STUDY DESIGN

An exploratory qualitative study was applied. We conducted 16 Key Informant Interviews (KIIs) with respondents holding complementary knowledge regarding water resource management. We selected participants based on their engagement in the implementation process of BDP2100 and their representativity for the Bangladesh water sector. Considering the constraints in resources, time, logistics (e.g., partly due to lockdowns it was difficult to identify and approach participants located outside Dhaka), and the availability of participants, this study stage focuses on participants from inside the domain of water and water-related activities. Interviews from a wider group of delta professionals (such as policy planners and analysts, consultants, academics, water resources economists, lawyers, and environmentalists) and delta stakeholders with deep familiarity with living in, and managing deltas (such as community representatives, environmental activists, and civil society members) are likely to add further insights at a later stage.

Thus, we first identified potential participants and sought their support, clarifying the study's aims, objectives, and expectations. They were selected based on: (i) at least 15 years of professional experience in relevant water and water-related sectors, (ii) their availability, and (iii) achieving an overall broad representation of the sector (government agencies, independent and non-governmental research and policy bodies, and universities, that are engaged in project design and implementation, policy formulation and planning, communication and advocacy, teaching, and consultancy) (Table 1). The number of interviews was based on the principle of data saturation, i.e., ending the interviews when no new information, dimension or concept emerged, as proposed by Guest *et al.* (2006). A stepwise procedure was followed to determine data saturation. Multiple independent interviewers conducted interviews concurrently and finalised the initial/axial codes of the harvested information after completing the first pilot interviews. After having conducted two-thirds of the interview, the research team independently developed the codes and checked whether no new information or themes emerged. If the team

Table 1 | Profile of the participants included in the key informant interviews (n=16).

Interview/ Participant No	Organisation/Institution	Areas of expertise	Gender
P1	Institute of Water Modeling Bangladesh (IWMDB)	30 years of experience in mathematical hydraulic modelling, planning of water and water-related studies	M
P2	Bangladesh Water Development Board (BWDB)	20 years of experience in surface water and groundwater management	M
P3	Bangladesh Centre for Advanced Studies (BCAS)	35 years of experience in teaching and research in water resources, management, and capacity development	M
P4	Bangladesh Water Development Board (BWDB)	25 years of experience in designing and executing surface water and groundwater management programmes	M
P5	Bangladesh University of Engineering and Technology (BUET)	20 years of experience in teaching and research in water resource engineering, management, and policy planning	F
P6	Centre for Environmental and Geographic Information Services (CEGIS)	23 years of experience in project design and implementation in system development and water capacity development	M
P7	Department of Agriculture Extension (DoAE)	34 years of experience in project design and implementation of sustainable agriculture capacity development	M
P8	Bangladesh Centre for Advanced Studies (BCAS)	19 years of project design and research experience in natural resource management, sustainable agriculture, and urban planning	M
P9	Bangladesh Centre for Advanced Studies (BCAS)	22 years of project teaching and research experience in water resources, environmental sustainability, and capacity development	M
P10	Water Resources Planning Organization (WARPO)	18 years of project management experience in the area of water resource, management, and adaptation	M
P11	Local Government Engineering Department (LGED)	23 years of project management experience in the area of sustainable water resource management	M
P12	Local Government Engineering Department (LGED)	16 years of project management experience in sustainable surface water resource management	M
P13	Local Government Engineering Department (LGED)	17 years of experience in policy planning and implementation in sustainable water resource management	M
P14	Water Resources Planning Organization (WARPO)	24 years of experience in project management and implementation in water resource management	M
P15	Institute of Water Modeling Bangladesh (IWMDB)	17 years of experience in hydraulic modelling	M
P16	Institute of Water Modeling Bangladesh (IWMDB)	26 years of experience in hydraulic modelling and water-related policy planning	M

reached agreement that this was the case, data saturation was considered achieved. Importantly, this was an iterative process shuttling back and forth between data collection, interpretation, and coding, during which the team members also reflected on their own roles as interviewers to minimise bias. The discussions followed a semi-structured question guideline that explored the changes perceived necessary at the individual level in the water

professional, in educational institutions, and in service delivery and regulatory agencies. The question guide itself was piloted and enhanced beforehand.

The medium of conversation was Bangla – the native language of both interviewers and interviewees. The interviews were audio-recorded with permission of the interviewees. A team of two interviewers (social-science graduates) conducted the interviews, while a research assistant (engineering graduate) took field notes. The interviewers were trained and experienced in the qualitative approach and data collection techniques. Before starting the interview, the research team built a good rapport with the interviewees and discussed the purpose of the study. Each interview took on average 30–45 min.

Data were analysed using thematic analysis (Braun & Clarke, 2006) to separate out distinct concepts and statements and recognise recurrence in a rigorous process. First, we transcribed all interviews verbatim from the audio records and translated the transcripts into English. Then, we developed several codes – meaningful information, ideas, or dimensions – able to capture key considerations relevant to the study objectives. A hybrid approach combining deductive and inductive coding was applied to identify the themes related to the implementation of BDP2100. Initially, a list of codes was developed to align with information available in the literature and the understanding and experiences gathered during the interviewees' engagement in their respective work domains. Three researchers repeatedly went through the transcription line-by-line and coded in line with the predefined set of codes (Fereday & Muir-Cochrane, 2006). Concurrently, additional codes were identified to fit the relevant information or statements observed during the reading of the transcriptions. The final codebook was developed by combining these. A few clusters were analysed based on the similarities of the identified codes. In the final stage, several themes were merged to report the findings. The independent coders maintained formal reviews to resolve any disagreement.

RESULTS

Five themes emerged: (1) Perceptions on potential delta professionals and stakeholders, (2) Required knowledge, skills, and attitudes, (3) Experienced vs. young delta professionals, (4) Organisational culture and capacity, and (5) Educational capacity. Within these themes, 13 sub-themes emerged (Table 2).

(1) *Potential delta professionals and stakeholders, as perceived by the interviewees*

The perceived delta professionals and 'expert stakeholders' are defined as those who are likely to have the potential to effectively contribute to the implementation of the BDP2100 through their specific skills and knowledge, and day-to-day local life experience. Over three-quarters (13 out of 16) of the participants perceived that the potential delta professionals and stakeholders would likely contribute to design and/or implementation of projects/interventions to develop infrastructure facilities, build organisational capacities, facilitate research initiatives, and enhance capacity relevant to BDP2100. The participants stated that BDP2100 should be considered an integrated, holistic effort. Therefore, professionals with various disciplines and perspectives such as engineering, social sciences, fisheries, environmental sciences, forestry, economics, livestock husbandry, and agriculture need to be included in the implementation process. Engaging professionals from diverse disciplines and backgrounds will create a more comprehensive understanding of the delta dynamic, enabling them to design and execute effective interventions in the delta. One participant stated '[The] Delta Plan is a holistic approach. It should engage experts and professionals from an interdisciplinary perspective to gain a deeper understanding of the environment and ecosystem. The engineers alone may not [be able to] understand and address different problems and dimensions related to the delta. Delta management is not about dealing with large infrastructure but is also essential to deal with the ecosystems and related services. Hence, professionals from various

Table 2 | Themes and sub-themes emerging in interviews.

	Major themes				
	Theme 1 Potential delta professionals and stakeholders, as perceived	**Theme 2 Required knowledge, skills, and attitudes**	**Theme 3 Senior and junior delta professionals**	**Theme 4 Organisational culture and capacity**	**Theme 5 Educational capacity**
Sub-themes	Involved in project formulation and implementation related to water resource management (e.g., infrastructure, organisational capacity, research, and training)	Expertise in a broad range of disciplines (e.g., social sciences, human behaviour, natural science, and technology)	Blending experiences of young and professionals	Need to foster quick and efficient coordination among organisations (government, NGOs, private sector)	Still predominantly theory-based water education (lack of practical orientations and creativity development)
	Multidimensional perspective (e.g., agriculture, environment, economics, sociology, gender, ecosystem, biodiversity, etc.)	Adaptation capacity of knowledge and information from the global perspective	Different types of responsibilities/ contributions	Autonomy and institutional capacities	Introduce demand-driven disciplines and courses in educational institutions
	People from different professions and backgrounds (e.g., policy planners, programmers, researchers, civil society, communities)	Reshape global information in line with the local needs and context		Formation of a powerful coordinating body	Learner/student-oriented teaching
				High-level autonomy and empowerment of such coordinating body	

disciplines and backgrounds are the key requirement' (P1). Similarly, another participant reflected '[The] Delta plan is a multidimensional approach. Although it focuses on the water sector, it touches upon social, environmental, gender, ecosystem, and biodiversity aspects. […] individuals and/or groups having expertise in these sectors can be the potential delta professionals' (P12). Another participant added 'If you focus on the engineers only, it will be a big mistake. You will have to involve experts and people from other disciplines such as agriculture, environment, economics, sociology, and so on because water is a cross-cutting issue. It touches everything' (P2).

Another participant explained how a team comprising people from different disciplines and backgrounds would likely be able to contribute to the design and implementation of projects: 'Engineers are designing many constructions in the haor[1] region for better water management and protect rice from flash flood. But the engineers have little or no collaboration and communication with the agronomist. Recently, locals with expertise felt that there is a potential to develop a new variety of rice that can be harvested two weeks earlier than the ones

[1] A *haor* is a wetland ecosystem in the north eastern part of Bangladesh which physically is a bowl-shaped shallow depression, also known as a back-swamp.

they are cultivating now…thus, the agronomists can contribute. But, we did not think like this two decades ago' (P1). Another participant believed that delta water management is the central focus of the BDP2100. Water is the critical element for delta agriculture, environment, fisheries, forestry, and much more that is essential for the delta's livelihoods. Therefore, the local stakeholders with deep local familiarity with these sectors are potential 'delta experts'. However, the interviewees specifically identified four groups of people as the probable delta professionals or experts. The first group comprises professionals who understand water science, notably biology, chemistry, physics, applied sciences, and water engineering. The second group consists of those who are involved in water-related policy formulation. The third group will likely implement the delta plan at the field and community levels. And the fourth group consists of the communities themselves, who are perceived to have gained extensive knowledge and experience in dealing with water-related issues throughout their lives. A participant stated 'For example, I am a water engineering expert. It does not necessarily mean that I have a better understanding about water issues than a farmer because he as farmer has a life-long experience on this issue' (P5). The importance of involving the community was reflected by other participants: 'Ultimately, the Delta Plan will be implemented at the community level. Therefore, communities need to be involved in this process. If the community does not understand what is being implemented, they will probably not respond better and more effectively. […] Why are such interventions there? Why not other areas? These questions need to be understood by the communities. […] they should be involved in the planning process' (P8). This view was reiterated by another participant who suggested two groups of potential delta professionals/experts exist: a first group are the citizens (communities) living in this delta, who may have no or little formal education, even may be illiterate; the second group consists of professionals with diverse educational backgrounds and disciplines. The participant stated 'They (community members) do not read Bangla, but they live in this delta. Nobody else lives in this delta – no engineers, no […] professors, no delta planners. […] the communities that do live in this delta are the "delta professionals". They have a different kind of knowledge – unwritten, not structured. But they are the majority and the important professionals of this delta if you want to understand the delta' (P3). Furthermore, a participant clarified how and whether community members can contribute to delta management initiatives: 'The Water Board has installed about 2,700 sluice gates across the country. Of them, nearly 2,300 do not work. Why did this happen? […] because they [the Water Board] did not understand what people wanted. What are the people's needs? What do people think? How to include them? This is a great failure. […] If you do it without going to local communities and understanding their expertise, it will create trouble for the future' (P3). The participant further noted that delta plans in other countries have included the communities, which contributed much to that process: 'When the original delta experience was developed in the Netherlands 200/300 hundred years ago, these types of people [community members] have played roles because the level of professionals from the universities with experimental scientific knowledge was not yet available. […] That may be one of the reasons why they have succeeded' (P3). Another participant shared this: 'It has now been established that an individual with the life experience is the best expert. Regarding the delta-related issues, we need to consider the community as they are experiencing so many things throughout their lives. […] communities can be a potential "delta professional"' (P4). However, one participant suggested that the 'potential delta professional' should be considered from a broader perspective: media personalities, local-level politicians (e.g., members of local government) and human rights activists may be considered delta professionals. They may contribute to policy formulation and advocacy and help reflect the community's voice in many instances: 'A wide category of people such as researchers, individual water resource specialists, government administrators, policy planners, gender specialists, human rights activists, and media personalities, might all well be considered as "delta professionals"' (P9).

On the other hand, seven out of 16 participants reflected that the Delta Plan is water-centered, and that, therefore, the primary focus should be on those who do possess experience and knowledge of the water sector proper. The 'potential delta professionals' are those who are involved in the water-related sectors: '[…] The Delta plan is considered a water-centered plan; therefore, people involved in water resource management organisations such as the Bangladesh Water Development Board and the Water Resources Planning Organisation of Bangladesh should be in the forefront as delta experts' (P16).

(2) *Required knowledge, skills, and attitudes*

More than two-thirds of the participants stated that the delta professionals' knowledge, skills, and attitudes are crucial for developing, implementing, and monitoring the Delta Plan. Professionals currently involved in this process lack this knowledge and these skills because this approach is new to Bangladesh. Many aspects of delta management (e.g., sedimentology, environmental issues, river morphology, and surface and groundwater modelling) remain underexplored. Furthermore, the interviewee thought that the professionals would likely be exposed to many new challenges during the implementation in the coming years. One participant stated 'The Delta Plan has a 100-year time horizon. Many issues relating to this plan remain unexplored or underexplored. But, we will likely be exposed to many new issues over time. Exposure to new issues will develop new knowledge. For example, we built many polders in the southern part of Bangladesh. At that time, we did not have adequate knowledge about environmental issues. Now, we are experiencing continuous water logging in that region. Thus, exposure to new issues/aspects ultimately helps spur better understanding' (P1).

Most interviewees believed that delta professionals need to explore global experiences and expertise, and customise them in accordance with the local context. They further stated that collaboration and learning opportunities between the different disciplines, institutions, and groups would dramatically improve the level of performance, enhance the overall BDP2100 experience, and gain the ability to adapt worthwhile global knowledge to the Bangladeshi context. Another participant stated 'Adapting knowledge from global experience is important. There are so many deltas plans globally. But we need to know how to adapt this knowledge and reshape it per our context. […] simultaneously, the collaboration between various disciplines and institutions should be emphasised in this process' (P6). Furthermore, the participant revealed that understanding and knowledge about the local context (e.g., on the rivers) is essential in delta management. Or, 'The nature (physical world) of rivers in Europe and Bangladesh is different. Rivers in Europe are controlled, but in Bangladesh they remain uncontrolled. Therefore, we need a delta professional who has such contextual knowledge' (P6).

The participants opined that project planning is an essential challenge at all levels. Project planning involves professionals from various disciplines such as agriculture, environmental science, and economics. Therefore, these professionals should have adequate training and orientation about project-related problems in different planning and implementation stages. They further mentioned that every step (i.e., designing, reviewing/approving, implementing, and monitoring) is equally essential. Therefore, delta professionals should gain knowledge relating to each aspect. They also emphasised that knowledge on more effective planning is the first priority. The delta professionals should understand possible future scenarios in delta-related issues. One participant echoed 'We [should] have a mature group of people able to devise a constructive strategy for Bangladesh to face the future' (P1).

However, some interviewees thought that as activities in a delta plan involve multiple issues and dimensions, delta professionals should have a more holistic knowledge about the delta and the people living in it. Delta professionals need to gain an understanding of some core issues that impact the livelihood of the delta's inhabitants, such as agriculture, environment, and disaster management. Still, one participant reflected that knowledge on optimum use of surface water, renewable energy, and silt management, are the critical aspects; thus, the

development of evidence-based knowledge needs to focus on these aspects: 'Knowledge of the optimum use of renewable energy (solar energy/wind energy) and surface water is important because we are not likely to extract groundwater using fossil fuel energy for much longer. So, we need to develop knowledge about renewable energy. […] knowledge about silt management should also be focused on in the Delta Plan' (P12). Two participants found that knowledge on sedimentology is vital in this process since it has a greater impact on *char* (island) formation: 'We need to understand sedimentology, its process, and implications. I feel there is still a deficiency in this issue' (P8).

Five out of 16 participants revealed that the communities in this delta are seriously affected by the hydrometeorological and geological factors that create vulnerabilities to natural disasters. Considering this perspective, the delta professional should have solid knowledge on whether and how natural disasters affect the livelihood of the delta communities. Furthermore, the participant clarified that as the Delta Plan covers various aspects of delta formation, we need to understand this process. Nearly one-third of participants stated that delta professionals need to know the environmental, economic, and societal dimensions, including impacts on and interactions with local livelihoods. One participant stated 'There will be some [negative] impacts if we implement any projects (such as the Delta Plan). So, we need to know how to minimise the negative impacts on the environment which an environmentalist can assess. […] We need to know the cost-benefit analysis that an economist can calculate. […] We need to know the social cost of this project that social scientists can describe. Thus, we need to draw upon multiple disciplines' (P9).

Regarding the attitude of delta professionals, more than one-third of the participants reflected that some staff working with government agencies appear reluctant to consider opinions and views from other professionals: '[…] you will see that the entire plans are done by the engineers of the Water Development Board alone. In consequence, it causes many problems. […] The problem is that our attitudes probably do not allow us to appreciate opinions from other organisations and disciplines' (P1). The participants mentioned that plans should be developed based on scientific research and a proper stakeholder consultation process. However, the participants believed that there is a scope for reviewing and updating the Delta Plan through stakeholder participation at different junctures. Such modification will likely develop relevant new understanding, knowledge, and skills.

(3) *Senior and junior delta professionals*

More than two-thirds of the interviewees thought that the teams implementing the Delta Plan should aim to make experienced (senior) and less-experienced (junior) professionals work together. The following quotes reflected this: 'There are many layers in an organisation. They are equally important. […] I think more importantly all of these need to understand the issues they are working for' (P6). And 'Combined teams will be needed. They can be a mixture of cadres – people who have experience in policy formulation, project design (senior/experienced), and knowledge of new technology (young professionals)' (P10).

Some participants opined that every organisation should adopt the policy to continually recruit and train new employees at the professional levels so they can take the lead in the future. Continuous replenishment of the workforce is vital so that no vacuum in expertise and leadership occurs in the future. A participant stated 'I can tell you about a crisis […]. The Department of Forestry has not included or recruited any young professionals in the last 17 years. The Department has come to an absolute crunch for lack of young professionals able to take over in five years. […] And by that time, the world has changed. [The older generation of] Forestry staff probably knew [paper] maps but not GIS. But everything is now based on GIS-based analysis. […] New knowledge has to be accommodated' (P3).

On the other hand, some participants opined that the older (experienced) staff should effectively formulate projects and the younger staff should contribute to the implementation process. One participant reflected 'Senior

people should be engaged in planning, while young professionals can participate in implementing interventions/projects' (P14). One participant viewed that young professionals need to be given more importance because they will serve longer: 'The experienced professionals will likely retire much sooner than a younger one. The younger will have to take the lead' (P1). However, the participant cautioned that the most critical aspect is the involvement of younger staff in the project development. Under the existing organisational culture, the senior professionals tend to be reluctant to provide adequate space for new staff to participate in project development and learn from it. Too often, young staff remain outside project formulation and implementation since the seniors are not inclined to include them. Thus, the participants emphasised that young professionals should be part of a learning process. One participant focused on the mid-level professional, stating 'The Delta Plan is a long-term plan. A person who, for example, has only five years' service left will retire soon. Then, who will take over? Often, we need to hire the same, retired person but now as a consultant. This cannot be effective. […] We need to focus on the capacity of mid-level employees because they will provide services for a long time' (P5).

(4) *Organisational culture and capacity*

The participants felt that the organisations involved in the Delta Plan need to strengthen their capacity for implementation. The majority of the participants stated that many unexpected project-related challenges are due to emerge during the execution of the Plan. The respective organisations will have to respond to these, and thus these organisations need to strengthen their ability to absorb new information and adjust swiftly and effectively. One participant explained that 'For example, there is no climate change cell [section/division] in our organisation. But it can be very relevant in the coming years in the course of changing climatic context' (P1).

The majority of interviewees expressed concern about the organisational culture since many organisations (predominantly, government agencies) operate as complex bureaucracies. Organisations need to adopt a culture able to support faster decision-making. Communication and coordination between the different government portfolios and departments is presently considered lacking. Furthermore, organisations that have the mandate for policy formulation often lack adequate autonomy; they remain highly dependent on the ministries. As a result, staff working with these organisations may lose motivation and enthusiasm: 'If you look at the Water Resources Planning Organisation, you will probably understand the situation: it is expected to function independently and play a dynamic role in the water-related policy domain. […] But there is a weakness in this regard' (P2).

One participant reported that the government institutions lack adequate capacity because many positions with decision-making authority under several ministries remain vacant, and the existing workforce cannot develop its skills. The participant concluded that the government organisations need to be strengthened to allow proper implementation of the Delta Plan. Three participants (out of 16), however, thought that key organisations already possess significant ability to implement the Delta Plan, and point at the BWDB which has extensive experience in water resource management. They also reported that some employees of these organisations may lack formal academic qualifications but are nonetheless technically sound thanks to long years of learning experience on the job. They also pointed out that, on the other hand, many staff have academic degrees but lack practical exposure and understanding of real-world issues.

Concerning the implementation of the Delta Plan, the participants reported a lack of effective communication among institutions and stakeholders, especially among the governmental institutions. Consequently, some issues fail to gain attention, and costs rise. One participant stated 'I notice, even in my organisation, that one division is reluctant to communicate [with] another one regarding issues in which they both have stakes. It happens because of the organisation's culture. I think intra-organisation communication needs to be enhanced for better performance and cost-effectiveness' (P1). The participant reflected that a Delta 'cell', 'commission', or 'centre' could facilitate more effective communication and coordination between the multitude of stakeholders, agencies,

and organisations to take better, cost-effective initiatives. However, the participants are concerned about the positioning and the stewardship of such a new body. Some expressed concern that the most potent stakeholders and partners (predominantly, the government agencies) may be interested in leading such an entity on their own, still ignoring the views of smaller players. One participant mentioned 'We have been trying to formulate a flood inundation project in the coastal region to help forecast the potentially flooded area caused by cyclones. […] The BWDB claimed the sole authority since they are mandated to deal with flood forecasts. [On the] other hand, the Bangladesh Meteorological Department also claimed this authority as they are mandated for cyclone forecasting. […] Ultimately, we failed to create that project' (P1). Five (out of 16) participants claimed that if the Delta authority remains under the Prime Minister's Office (PMO), every department and agency will participate actively, and the above problems could be averted: 'I believe every department and agency will collaborate if the PMO coordinates the process' (P1). Another participant said 'It should be headed by a minister or state minister under the PMO whose key responsibility is [to] make this document live in [its] true sense. The commission should receive the adequate budget for its operation and report to the PMO' (P2).

The key focus for such a coordinating body should be its level of autonomy and empowerment: 'A potent authority will be needed to deal with all activities related to the Delta Plan because it has to collaborate with all these ministries and departments to make it more functional' (P15). One participant suggested that such bodies need to be independent from the bureaucracy: 'No bureaucratic institution will work. […] The proposed centre or commission should truly be independent' (P7).

(5) *Educational capacity*

The participants expressed concern about the current weak institutional capacity for creating a skilled and qualified workforce to implement a Delta Plan which would likely necessitate a dedicated contingent of experienced and knowledgeable staff; conventional training of existing staff would be insufficient. Given the longer-term horizon of a Delta Plan, this needs to be addressed foremost by the higher education system. Universities and higher educational institutes should be encouraged to introduce new relevant subjects and courses aiming to create a cadre of influential 'delta professionals' with the right blend of knowledge, skills, and attitudes. One participant clarified that 'Certain aspects related to the Delta Plan should be included in the [curricula of the] universities to help develop a new generation of staff with the appropriate knowledge. Graduates of such programmes should understand and have good exposure to adaptive delta management' (P1).

Some participants were of the opinion that the education system in Bangladesh will struggle to educate 'delta professionals' since the education system has not kept pace with current developments in the field. Furthermore, the system does not sufficiently motivate students to be engaged, such as taking part in discussion during the learning process. Such lack of critical disposition hampers acquisition of new knowledge and the development of the right attitudes. A participant reflected that 'We are not updating our education system to the requirements of the individuals, the society, or the country. We are teaching using 30 years old syllabi and still think that we can produce modern, inquisitive graduates! Knowledge has moved on. […] but we are still frozen in an older world' (P2).

Students are perceived as having settled in this lack of motivation for questioning, and they tend to not consult the original textbooks but are satisfied with the notes provided by the lecturers. Some interviewees would advise universities that they need to develop foresight on the disciplines and courses of relevance for future delta management. The universities and other education institutes should focus on the market demand and anticipate the changes. Participants also offered advice on how universities and educational institutions can improve curricula. They should seek to incorporate new topics that are emerging in the context of changing situations in society. The universities should have standard policy to continually examine what type of human resources are needed by the country in evolving contexts and how they can help develop these resources. One participant pointed out

the weak capacity in educational institutions such as universities, colleges, and research organisations, to initiate programmes that are essential for implementing a Delta Plan. For example 'There are many universities in Bangladesh, but none of them offers an undergraduate programme in hydrology. Rather, they offer some fundamental courses in hydrology under civil engineering or hydraulic engineering. However, globally many universities offer such an undergraduate programme which is very important for better water resource management. Many students go to India or The Netherlands to pursue Master's degrees in hydrology. But I believe there is no more suitable country than Bangladesh for studying hydrology. It is our failure' (P2). Another participant reflected that 'Our knowledge has to be appropriate. I don't know which discipline would be best for this huge complex idea of delta plans over a long period. But geology, engineering, water resources, soil chemistry and sedimentology, all matter' (P3).

A few participants added that in Bangladesh a severe shortage exists of trained professionals in water resource management. The country, thus, has come to depend heavily on international and national consultants. The people working in this sector are too exclusively focused on the theoretical aspects instead of on the practical applications of those theories; therefore, they miss an adequate practical, real-world orientation: 'I would say that there is a huge knowledge gap among us. However, some experts do consultancy in this sector who possess a good level of expertise. [However] Truly speaking, they may lack [continued] commitment as they are not permanently holding any positions in the organisations they work for' (P2). Some participants advocated to make education more problem-oriented and geared to real-life situations: 'Our education is not practice oriented; it rather focuses on theoretical aspects. We should be focused on practice-oriented and problem-solving education. […] We should think about the future need and act accordingly' (P7). 'Young professionals need to be engaged in a real-world situation, toward problem-oriented approaches. There should be more internship opportunities during the educational programs [so that they can experience real-world situations]' (P8). 'We lack problem-oriented education. Our education system is heavily biased towards theory exams. […] Our education seems not application-oriented' (P5).

Nonetheless, one participant reported that the educational institutes' capacity for addressing new thematic issues related to water resource management has recently increased as many new education programmes in this area have been started: 'Some universities in Bangladesh are offering new programmes and courses such as meteorology and oceanography' (P2). However, he opined that offering new courses and programmes may not suffice. Instead, the overall quality of education has to be improved, and significant investment is needed in equipment and laboratory facilities: 'We have a sufficient number of educational departments, but the concern is whether they are producing a qualified workforce. We need to focus on that question' (P14).

DISCUSSION

This study explores the future capacity requirements for implementing BDP2100 by analysing structured interviews with selected key water professionals. The formulation of and debate on BDP2100 are relatively new endeavours for GoB as it approved the Plan in 2018 as a water management strategy for the next decades (Bangladesh Planning Commission, 2018). Thus, many implementation aspects of BDP2100 have yet to be further examined or operationalised to suit the Bangladeshi context (Hasan *et al.*, 2020). A critical data gap exists in the literature that limits comparison and transposition modality between different country contexts. We found that capacity development is not yet integrated into BDP2100 although an array of factors related to capacity deficits will significantly affect the implementation of BDP2100.

The outcomes of this study suggest that BDP2100 implementation will likely create the demand for professionals from a diversity of disciplines, notably hydrology, civil and hydraulic engineering, social sciences, economics, shipping, fisheries, environmental science, forestry, livestock husbandry, agronomy, etc. They also confirm the value of structural involvement of 'expert stakeholders' with deep familiarity with local land and

water features, habits and potential coping strategies. Earlier studies also concluded that structural interaction and collaboration between actors and parties from diverse backgrounds and roles can increase the understanding in the social, ecological, and economic aspects of deltas (Pekkarinen & Harmaakorpi, 2006; Sol & Wals, 2015). Many studies reflecting different settings demonstrated that participatory multi-stakeholder approaches facilitate innovation and improve community capacity for sustainable delta management (Blokland *et al.*, 2009; Cundill, 2010; Warner, 2010; Brouwer *et al.*, 2016). Jønch-Clausen & Fugl (2001) argued that working with a broad range of stakeholders and parties, and of management levels, correlated with better water resource management. Their study highlighted the value of the integration between and across different elements of the social and natural systems. Such integration enables stakeholders and institutions to be involved in decision making in the planning and design processes. Mcdonnell (2008) observed that the inter-connectedness of professionals from different domains helps increase the deeper understanding of the social, political, and cultural dimensions of water, eventually enhancing water resource management. Our data also suggest that interviewees concur on the importance of community involvement. Historically, community involvement has not been a high priority in policy planning and implementation in Bangladeshi delta management initiatives (Kulsum *et al.*, 2020, 2021).

A relatively small proportion of study participants thought that collaborative work (and learning opportunity) between individuals, professional groups, and institutions would effectively contribute to successful implementation of the Delta Plan. Studies in other contexts noted that collaboration among different disciplines and institutions does advance new knowledge in water and environment domains which, in turn, helps implementation effectiveness (Pohl, 2005; Harris & Lyon, 2013; Holm *et al.*, 2013; Rice, 2013). Collaboration between natural, social, and technical scientists was perceived as beneficial for better water resource management, in line with other studies (Holm *et al.*, 2013). Studies conducted in different contexts also noted that interdisciplinary and interprofessional collaborative work and learning raise the potential to enhance the effectiveness in implementing complex programmes that encompass, e.g., natural resource management, land use planning, drainage management, surface and groundwater management, livelihood development, agriculture and environmental management, and disaster management (Abdeldayem *et al.*, 2005; Mollinga, 2009). Building on this experience and taking account of the outcomes of our study, it is suggested to develop an operational framework in which a broader spectrum of knowledge, skills and attitudes on water management can be mobilised and reflection and interaction on different insights and opinions can be structured and formalised.

The participants in the study concur on the necessity to compose teams that are also heterogeneous in seniority. A combination of senior (experienced) and junior (young professionals) team members is assumed to strengthen the sustainability of projects and ensure the continuity of institutional knowledge. However, literature on this is limited. From Bangladesh's perspective, such a mix of the workforce in teams is a considerable challenge as young professionals are still rarely actively involved in project formulation and execution, which also acts as a barrier to their professional development.

The study's outcomes highlight the need for a positive organisational culture that facilitates cooperation in and across the organisations, departments and stakeholder groups, and enables adaptive planning. Grigg (2008) found that institutional barriers often are a cause of poor project outcomes. This likely applies to Bangladesh where government agencies and authorities function in a complex bureaucracy, and more conducive intra- and inter-organisational cultures may be a condition for better water management and governance (Alam & Quevauviller, 2014; Alam *et al.*, 2018). Effective communication and coordination among stakeholders (notably government agencies, NGOs, and private organisations) will likely help improve overall organisational capacity, a prerequisite for the implementation of the Bangladesh Delta Plan (Kulsum *et al.*, 2020; Mutahara *et al.*, 2020). Akpabio *et al.* (2007) and Akpabio (2008) arrived at similar conclusions for the Cross Basin River, Nigeria, where insufficient staff capacity, inadequate management systems, and closed-door politics were factors negatively affecting the integrated water resource management projects.

Pathirana *et al.* (2012) showed that often water professionals lack a practical problem-orientation because the traditional pedagogical approaches in water education are teacher – rather than pupil-centered. Also, the outcomes of the current study reveal that water education in Bangladesh tends to substantially limit learners' orientation to practical situations and problems limiting their opportunities to enhance their understanding of, and capacity for, problem solving. Instead, the prevailing teaching methodology tends to prioritise concepts and theories. As a result, the water professionals emerging from such education are inclined to focus on the theoretical perspective of that particular discipline, often limiting their capacity to comprehensively analyse the issues from a practical perspective. Thus, the pedagogic methodologies would need to be adjusted to enhance problem-oriented learning heuristics.

To help initiate, oversee and implement the meaningful involvement of the interest groups and government agencies with their diverse disciplines and backgrounds, a high-level coordinating body is recommended by a majority of respondents in this study. Other studies (Loucks, 2003; Pahl-Wostl *et al.*, 2007) proposed similar recommendations, i.e., to ensure unbiased and effective communication and collaboration between multiple, and often competing, interest groups. Our study's outcomes also suggested that such a body is able to define and demarcate specific roles and functions between the stakeholders and parties such as during design, implementation, and monitoring of outcomes.

This study has limitations. The findings of this study were based on a comparatively small sample size. We were unable to include participants from outside the domain of the water and water-related sectors in Bangladesh due to logistical reasons such as the study resources and availability of participants. Conducting interviews with a more diverse group of professionals (notably policy analysts, resource economists, and water resources lawyers and environmentalists) and 'expert stakeholders' deeply familiar with deltas (notably community representatives, environmental activists, and civil society members) would add insight and depth. At the same time, we are confident that the participant selection, the interview design and analysis, and the obtained responses are representative of the opinions and perceptions in the key professional and government circles.

CONCLUSION

The implementation of the BDP2100 requires several specific measures for capacity development in a two-pronged approach. Firstly, the capacity of individual professionals – in the sense of their knowledge, skills, and attitudes that combine into an operational capability – needs to be strengthened so that this can contribute to the development of a new community of specialised 'delta professionals'. Importantly, this operational capability should encompass skills and organisational procedures for more effective communication and collaboration between the different disciplines, as well as with the other 'expert stakeholders' at local and national levels. Secondly, a change at the organisational scale is necessary driving structural inter- and intra-agency collaboration to secure collaboration in a long-term, adaptive implementation framework, and generating a greater degree of dynamism. These two prongs are correlated and will reinforce each other.

Professionals are broadly called to develop a continuous, structural learning culture that is embedded in the team compositions and operational procedures in the delta management organisations, knowledge institutions, and institutions of higher learning.

ACKNOWLEDGEMENTS

This research was funded by Nuffic: the Dutch organisation for internationalism in education, under the project DeltaCap (project code: INNOCAP/BGD/278). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

REFERENCES

Abdeldayem, S., Hoevenaars, J., Mollinga, P. P., Scheumann, W., Slootweg, R. & Van Steenbergen, F. (2005). Agricultural drainage: towards an integrated approach. *Irrigation and Drainage Systems 19*, 71–87.

Akpabio, E. M. (2008). Integrated water resources management in the Cross river basin, Nigeria: how can we reconcile institutional boundaries and interests? *International Journal of River Basin Management 6*, 267–276.

Akpabio, E. M., Watson, N. M., Ite, U. E. & Ukpong, I. E. (2007). Integrated water resources management in the Cross River Basin, Nigeria. *Water Resources Development 23*, 691–708.

Alam, M. M. & Quevauviller, P. (2014). An evaluation of Integrated Water Resources Management (IWRM) activities in Bangladesh. *Asia Pacific Journal of Energy and Environment 1*, 22–38.

Alam, G. M., Alam, K., Mushtaq, S. & Leal Filho, W. (2018). How do climate change and associated hazards impact on the resilience of riparian rural communities in Bangladesh? Policy implications for livelihood development. *Environmental Science & Policy 84*, 7–18.

Ali, A. (1999). Climate change impacts and adaptation assessment in Bangladesh. *Climate Research 12*, 109–116.

Bangladesh Planning Commission (2018). *Bangladesh Delta Plan 2100 (Abridged Version)*. General Economics Division, Bangladesh Planning Commission, Government of the People's Republic of Bangladesh. Available at: https://oldweb.lged.gov.bd/UploadedDocument/UnitPublication/1/756/BDP%202100 %20Abridged%20Version%20English.pdf (accessed 30 May 2021).

Blokland, M., Alaerts, G., Kaspersma, J. & Hare, M. (2009). *Capacity Development for Improved Water Management*. CRC Press/Taylor & Francis, London.

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology 3*, 77–101.

Brouwer, H., Woodhill, J., Hemmati, M., Verhoosel, K. N. & Van Vugt, S. (2016). *The MSP Guide: How to Design and Facilitate Multi-Stakeholder Partnerships*. Practical Action Publishing, Rugby.

Cundill, G. (2010). Monitoring social learning processes in adaptive comanagement: three case studies from South Africa. *Ecology and Society 15*(3), 28–34.

De Heer, J. (2020). *Strategisch Management Voor Bangladesh Delta Plan 2100*. Available at: https://www.twynstragudde.nl/inzichten/strategisch-management-voor-bangladesh-delta-plan-2100 (accessed 24 January 2022).

Dewulf, A. & Termeer, C. (2015). Governing the future? The potential of adaptive delta management to contribute to governance capabilities for dealing with the wicked problem of climate change adaptation. *Journal of Water and Climate Change 6*, 759–771.

Eckstein, D., Künzel, V. & Schäfer, L. (2021). *Global Climate Risk Index 2021. Who Suffers Most from Extreme Weather Events, 2000–2019*. Germanwatch, Bonn/Berlin.

Fereday, J. & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods 5*, 80–92.

Giosan, L., Syvitski, J., Constantinescu, S. & Day, J. (2014). Climate change: protect the world's deltas. *Nature News 516*, 31.

Goosen, H., Hasan, T., Saha, S., Rezwana, N., Rahman, R., Assaduzzaman, M., Kabir, A., Dubois, G. & Van Scheltinga, C. (2018). *Nationwide Climate Vulnerability Assessment in Bangladesh. Final Draft*. Dhaka.

Grigg, N. S. (2008). Integrated water resources management: balancing views and improving practice. *Water International 33*, 279–292.

Guest, G., Bunce, A. & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods 18*, 59–82.

Haasnoot, M., Kwakkel, J. H., Walker, W. E. & Ter Maat, J. (2013). Dynamic adaptive policy pathways: a method for crafting robust decisions for a deeply uncertain world. *Global Environmental Change 23*, 485–498.

Harris, F. & Lyon, F. (2013). Transdisciplinary environmental research: building trust across professional cultures. *Environmental Science & Policy 31*, 109–119.

Hasan, S., Evers, J. & Zwarteveen, M. (2020). The transfer of Dutch delta planning expertise to Bangladesh: a process of policy translation. *Environmental Science & Policy 104*, 161–173.

Henstra, D. (2016). The tools of climate adaptation policy: analysing instruments and instrument selection. *Climate Policy 16*, 496–521.

Holm, P., Goodsite, M. E., Cloetingh, S., Agnoletti, M., Moldan, B., Lang, D. J., Leemans, R., Moeller, J. O., Buendía, M. P. & Pohl, W. (2013). Collaboration between the natural, social and human sciences in global change research. *Environmental Science & Policy 28*, 25–35.

Huq, S. & Ayer, J. (2008). *Climate Change Impacts and Responses in Bangladesh; A Report of European Parliament. IP/A/CLIM/IC/2007-106*.

Jeuken, A., Haasnoot, M., Reeder, T. & Ward, P. (2014). Lessons learnt from adaptation planning in four deltas and coastal cities. *Journal of Water and Climate Change 6*, 711–728.

Jønch-Clausen, T. & Fugl, J. (2001). Firming up the conceptual basis of integrated water resources management. *International Journal of Water Resources Development 17*, 501–510.

Karim, M. F. & Mimura, N. (2008). Impacts of climate change and sea-level rise on cyclonic storm surge floods in Bangladesh. *Global Environmental Change 18*, 490–500.

Khan, M. R., Huq, S., Risha, A. N. & Alam, S. S. (2021). High-density population and displacement in Bangladesh. *Science 372*, 1290–1293.

Kulsum, U., Timmermans, J., Khan, M. S. A. & Thissen, W. (2020). A conceptual model-based approach to explore community livelihood adaptation under uncertainty for adaptive delta management. *International Journal of Sustainable Development & World Ecology 27*, 583–595.

Kulsum, U., Timmermans, J., Haasnoot, M., Khan, M. S. A. & Thissen, W. (2021). Why uncertainty in community livelihood adaptation is important for adaptive delta management: a case study in polders of Southwest Bangladesh. *Environmental Science & Policy 119*, 54–65.

Lempert, R. J., Popper, S. W. & Bankes, S. C. (2003). *Shaping the Next One Hundred Years: New Methods for Quantitative, Long-Term Policy Analysis*. RAND Corp., Santa Monica, CA.

Loucks, D. P. (2003). Managing America's rivers: Who's doing it?. *International Journal of River Basin Management 1*, 21–31. DOI: 10.1080/15715124.2003.9635189.

Marchand, M. & Ludwig, F. (2014). *Towards a Comprehensive Framework for Adaptive Delta Management*. Delta Alliance, Delft/Wageningen, Netherlands. Available at: http://www.delta-alliance.org/gfx_content/documents/documentation/TowardsaComprehensiveFrameworkforAdaptiveDeltaManagement.pdf.

Mcdonnell, R. A. (2008). Challenges for integrated water resources management: how do we provide the knowledge to support truly integrated thinking? *International Journal of Water Resources Development 24*, 131–143.

Mintzer, I. (1988). Living in a warmer world: challenges for policy analysis and management. *Journal of Policy Analysis and Management 7*, 445–459.

Mollinga, P. P. (2009). Towards the transdisciplinary engineer: incorporating ecology, equity and democracy concerns into water professionals' attitudes, skills and knowledge. *Irrigation and Drainage 58*, S195–S204.

Mutahara, M., Warner, J. & Khan, M. (2020). Multi-stakeholder participation for sustainable delta management: a challenge of the socio-technical transformation in the management practices in Bangladesh. *International Journal of Sustainable Development & World Ecology 27*, 611–624.

Nicholls, R., Hutton, C., Lázár, A., Allan, A., Adger, W., Adams, H., Wolf, J., Rahman, M. & Salehin, M. (2016). Integrated assessment of social and environmental sustainability dynamics in the Ganges-Brahmaputra-Meghna delta, Bangladesh. *Estuarine, Coastal and Shelf Science 183*, 370–381.

Nicholls, R. J., Hutton, C. W., Adger, W. N., Hanson, S. E., Rahman, M. & Salehin, M. (2018). *Ecosystem Services for Well-Being in Deltas: Integrated Assessment for Policy Analysis*. Springer Nature, London/Berlin.

Pahl-Wostl, C. (2007). Transitions towards adaptive management of water facing climate and global change. *Water Resources Management 21*, 49–62.

Pahl-Wostl, C., Sendzimir, J., Jeffrey, P., Aerts, J., Berkamp, G. & Cross, K. (2007). Managing change toward adaptive water management through social learning. *Ecology and Society 12*(2), 30.

Pathirana, A., Koster, J., Jong, E. D. & Uhlenbrook, S. (2012). On teaching styles of water educators and the impact of didactic training. *Hydrology and Earth System Sciences 16*, 3677–3688.

Pekkarinen, S. & Harmaakorpi, V. (2006). Building regional innovation networks: the definition of an age business core process in a regional innovation system. *Regional Studies 40*, 401–413.

Pohl, C. (2005). Transdisciplinary collaboration in environmental research. *Futures 37*, 1159–1178.

Radhakrishnan, M., Pathirana, A., Ashley, R. M., Gersonius, B. & Zevenbergen, C. (2018). Flexible adaptation planning for water sensitive cities. *Cities 78*, 87–95.

Renaud, F. G., Syvitski, J. P., Sebesvari, Z., Werners, S. E., Kremer, H., Kuenzer, C., Ramesh, R., Jeuken, A. & Friedrich, J. (2013). Tipping from the Holocene to the Anthropocene: how threatened are major world deltas? *Current Opinion in Environmental Sustainability 5*, 644–654.

Rice, M. (2013). Spanning disciplinary, sectoral and international boundaries: a sea change towards transdisciplinary global environmental change research? *Current Opinion in Environmental Sustainability 5*, 409–419.

Shahid, S. (2011). Impact of climate change on irrigation water demand of dry season Boro rice in northwest Bangladesh. *Climatic Change 105*, 433–453.

Sol, J. & Wals, A. E. (2015). Strengthening ecological mindfulness through hybrid learning in vital coalitions. *Cultural Studies of Science Education 10*, 203–214.

Swanson, D. & Bhadwal, S. (2009). *Creating Adaptive Policies: A Guide for Policymaking in an Uncertain World*. IDRC, Toronto.

Timmermans, J., Haasnoot, M., Hermans, L., Kwakkel, J. H., Rutten, M. & Thissen, W. A. (2015). Adaptive delta management: roots and branches. In *E-proceedings of the 36th IAHR World Congress*, 28 June–3 July 2015, The Hague, the Netherlands.

Walker, W. E., Rahman, S. A. & Cave, J. (2001). Adaptive policies, policy analysis, and policy-making. *European Journal of Operational Research 128*, 282–289.

Warner, J. (2010). Integration through compartmentalization? Pitfalls of 'poldering' in Bangladesh. *Nature and Culture 5*, 65–83.

Wiens, J. A., Zedler, J. B., Resh, V. H., Collier, T. K., Brandt, S., Norgaard, R. B., Lund, J. R., Atwater, B., Canuel, E. & Fernando, H. J. (2017). Facilitating adaptive management in California's Sacramento–San Joaquin Delta. *San Francisco Estuary and Watershed Science 15*(2), DOI: 10.15447/sfews.2017v15iss2art3.

Zandvoort, M., Campos, I. S., Vizinho, A., Penha-Lopes, G., Lorencová, E. K., Van Der Brugge, R., Van Der Vlist, M. J., Van Den Brink, A. & Jeuken, A. B. M. (2017). Adaptation pathways in planning for uncertain climate change: applications in Portugal, the Czech Republic and the Netherlands. *Environmental Science & Policy 78*, 18–26.

Zegwaard, A., Zwarteveen, M., Van Halsema, G. & Petersen, A. (2019). Sameness and difference in delta planning. *Environmental Science & Policy 94*, 237–244.

Zevenbergen, C., Van Herk, S., Rijke, J., Kabat, P., Bloemen, P., Ashley, R., Speers, A., Gersonius, B. & Veerbeek, W. (2013). Taming global flood disasters. Lessons learned from Dutch experience. *Natural Hazards 65*, 1217–1225.

Zevenbergen, C., Khan, S. A., Van Alphen, J., Terwisscha Van Scheltinga, C. & Veerbeek, W. (2018). Adaptive delta management: a comparison between the Netherlands and Bangladesh Delta Program. *International Journal of River Basin Management 16*, 299–305.

First received 11 October 2021; accepted in revised form 19 April 2022. Available online 13 May 2022