Digital climate information and advisory services for de-risking aquatic food systems

Peerzadi Rumana Hossain, Raju Ahmed and Benoy Kumar Barman

December 2023

CGIAR

INITIATIVE ON

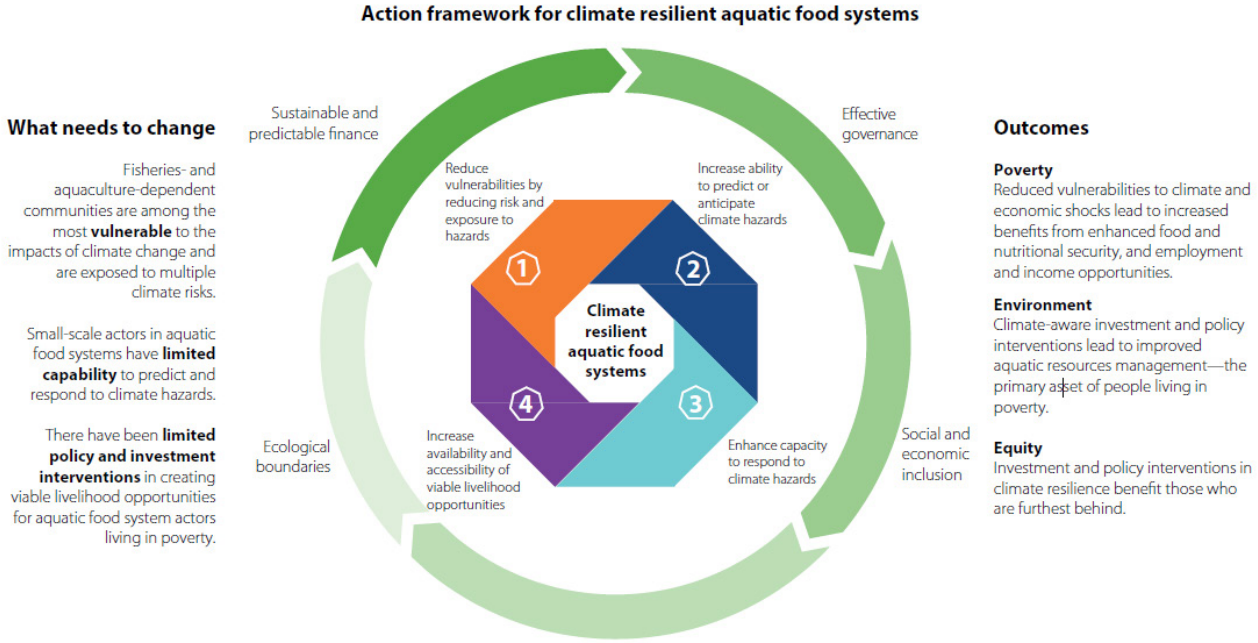
Asian Mega-Deltas

Contents

Highlights

- In Bangladesh's fisheries and aquaculture sector, the climate-exposed food system is experiencing economic loss and damage from the variabilities and extremes of climate change, resulting in food, nutrition and livelihood insecurity, social disparity and gender inequity in vulnerable communities.
- Digital climate information and advisory services (DCIAS) are instrumental to anticipate, prevent, respond to and recover from climate risks and to mitigate their footprint for a range of interconnected systems, such as food, nutrition, livelihoods, society and economy.
- Tailoring and enhancing quality, context-specific and accessible DCIAS for fish-farmers and fishers at scale is urgent to tackle the compound and cascading climate risks.
- Capacity building, at both the individual and institutional level, and climate literacy programs for vulnerable communities can substantially facilitate the adoption of DCIAS and accelerate climate informed decision-making.
- To ensure sustainability of digital platforms and to generate viable information and services, it is critical to integrate food systems with the internet of things and artificial intelligence for automated data input systems.
- National policies, plans and programs must integrate DCIAS to de-risk value chains under a range of climate risk scenarios.
- Investment mechanisms from the public and private sectors alongside donors should be prioritized and operated to account for climate risk management.

Figure 1. Action framework for climate-resilient aquatic food systems.

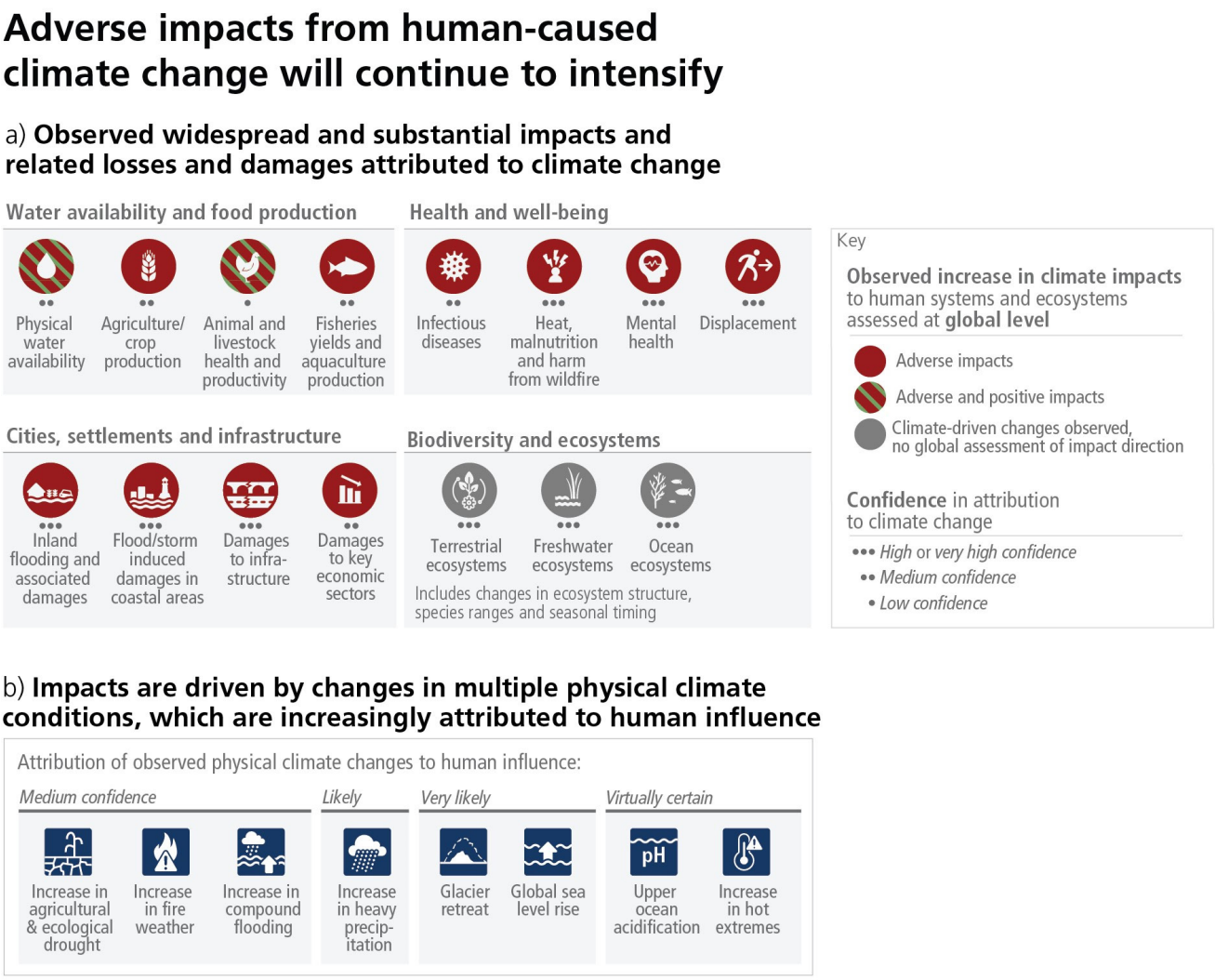


Source: *Mohammed et al. 2021.*

Why digital climate information and advisory services?

Climate change is modifying the frequency, intensity and duration of natural hazards with significant impacts on aquatic food systems in Asian Mega-Deltas (Barange et al. 2018). Small-scale fisheries and aquaculture in the Bengal Delta have become extremely vulnerable to these climate variabilities and extreme events like temperature and rainfall variations, floods, cyclones, salinization, tidal surges etc. (Das et al. 2021). As the second-most vulnerable country to the variabilities and extremes of climate change in this region, Bangladesh's aquaculture sector needs to adapt these changing climatic conditions. Most fishers, fish farmers, fish workers and their support agents live and operate in coastal regions and typically depend on climate-sensitive resources because of their low adaptive capacity (Cinner et al. 2018). As such, they have been facing several impacts of climate change, including the growing threats of extreme heat, water temperature rise, intense and erratic rain, frequent floods, cyclones and tidal surges (IPCC 2023). Consequently, they are highly exposed to climate impacts (Tigchelaar et al. 2021) and climate-induced loss and damage. For instance, a single flood in 2020 caused USD 5 million worth of loss to fish farms in the form of infrastructural damage and washed away fish and fingerlings (Saha 2020). In addition, there were significant harvest losses because of (i) high temperatures that exceeded the physiological tolerance of aquatic plants, animals and microorganisms, (ii) sudden temperature fluctuations that led to mortalities and (iii) dry and cold spells that triggered disease outbreaks and erratic or intense rainfalls (Hossain et al. 2021). These are just a few of the challenges that risk the lives and livelihoods of aquatic food producers in Bangladesh and, thus, their food and nutrition security.

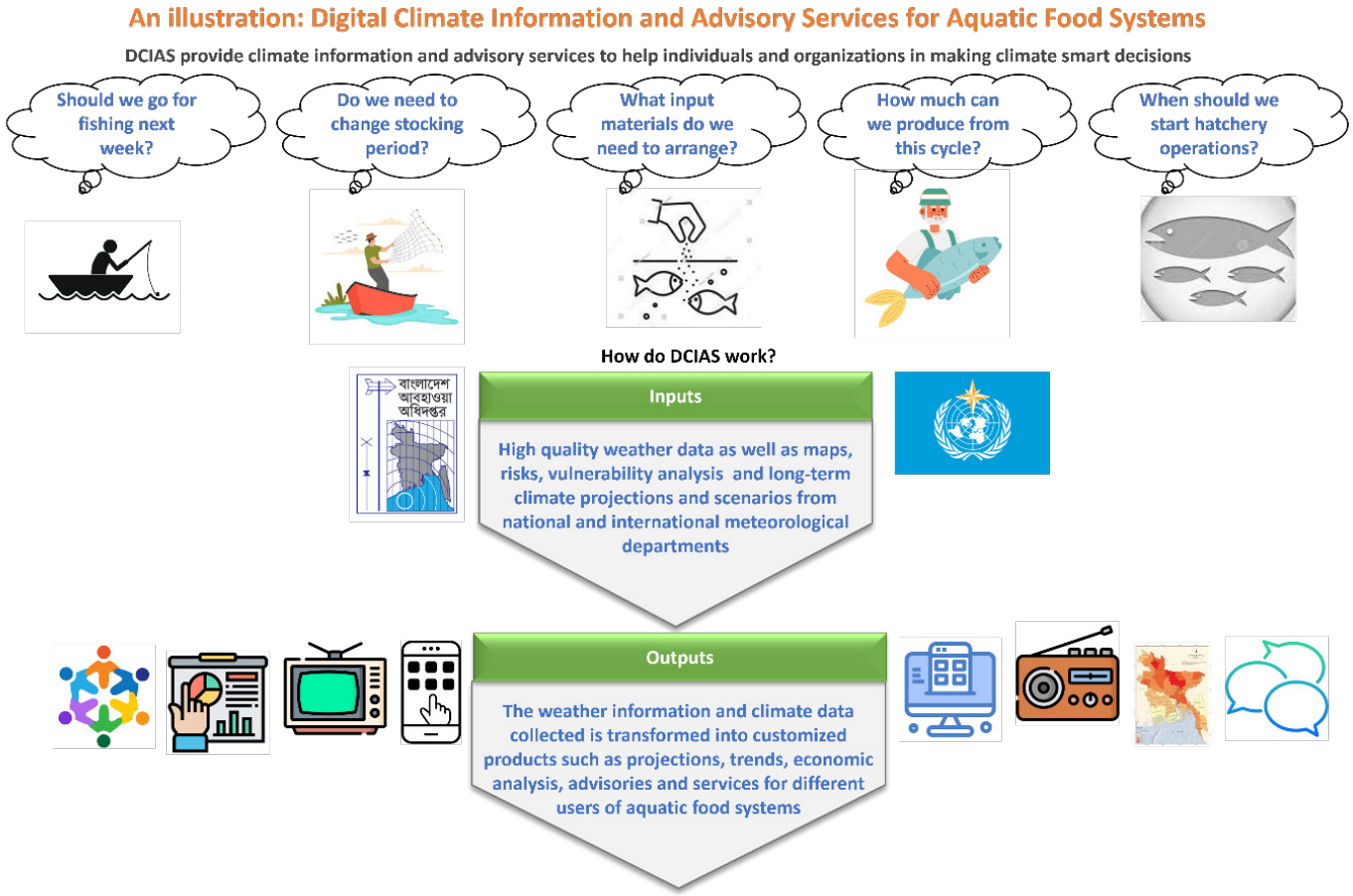
Figure 2. Adverse impacts from human-caused climate change.



Source: *IPCC 2023.*

DCIAS have already proven to be an important approach for climate-informed decision-making by managing the climate risks in different food systems sectors (Larosa and Mysiak 2020). However, the availability of context-specific and actionable DCIAS is still in its infancy for aquatic food systems, and no major efforts have been reported so far to tailor DCIAS for aquaculture to offset climate impacts in the Bengal Delta (WorldFish 2020). Therefore, in order to ensure sustainable aquatic food production, it is imperative to identify climate risks, climate-sensitive operations and management decisions for each value chain and, accordingly, to develop contextualized advisory services using timely and reliable climate information. Furthermore, the government's Digital Bangladesh 2021 portfolio has laid the foundation for digital services, which further directs the country's vision 2041 to consider the whole of society approach in digital form. Bangladesh's aquaculture and fisheries sector is highly vulnerable to the variabilities and extremes of climate change as well as climate information and services as a potential measure for managing climate risks. Taking into consideration these two factors and the government's long-term vision for digital transformation, the main objective of this policy brief is to flag recent research and interventions into DCIAS for aquatic food systems in order to make climate-informed decisions and to mainstream them in the upcoming revision process for the country's 1998 national fisheries policy . These research results can help create a timely policy instrument to de-risk aquaculture value chains, improve adaptation to climatic stressors and, thus, build climate resilience.

Figure 3. DCIAS for aquatic food systems.

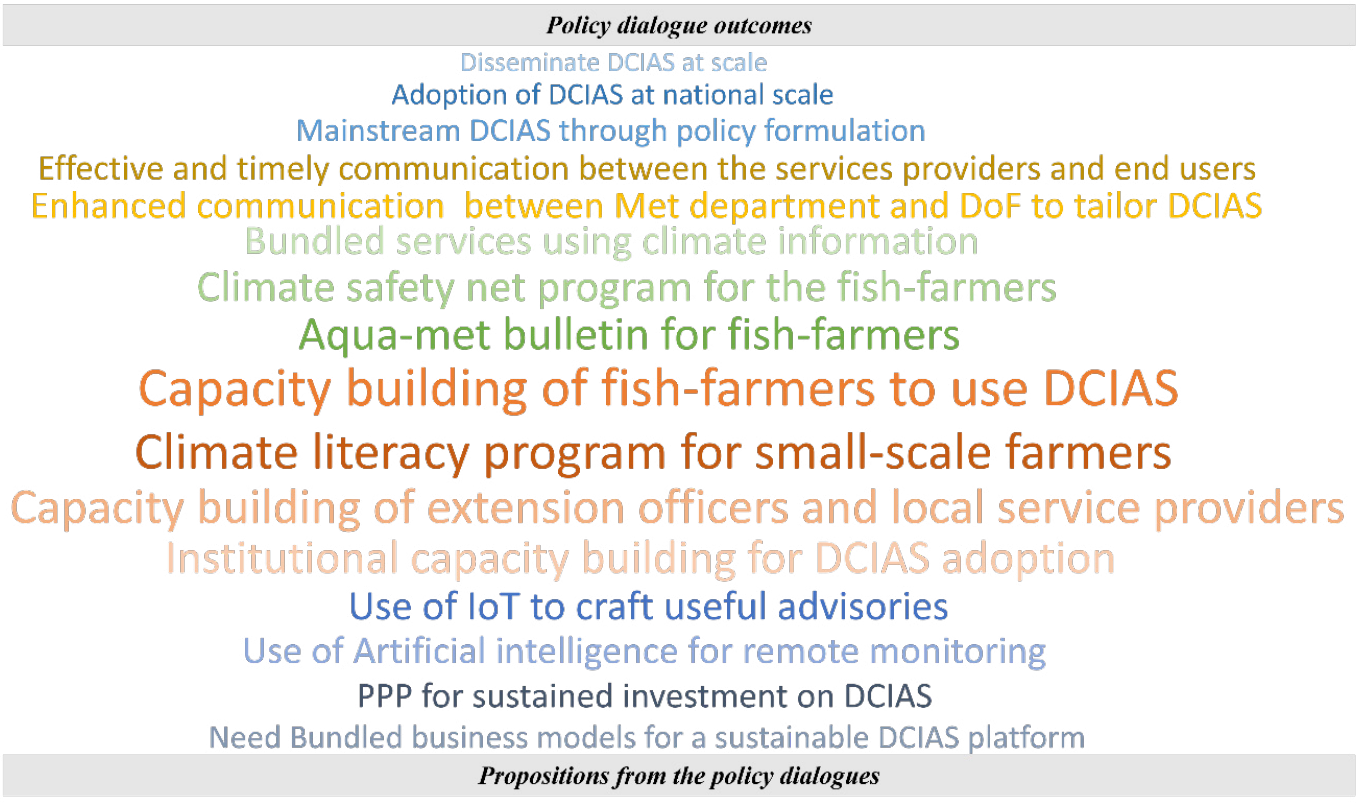


Source: *Adopted from the Global Framework for Climate Services.*

Research approach

Considering the lack of national and global research and development on DCIAS for aquatic food systems, WorldFish and its partners opened a dialogue in 2019 with value chain actors and relevant stakeholders in Bangladesh's aquaculture sector to develop a DCIAS platform in the country (WorldFish 2020). This resulted in (1) an aquaculture module to deploy in the field to collect real-time information from fish farmers, (2) a consultation meeting with key experts and (3) a systematic literature review. Through this three-step investigative approach, the research team developed a decision framework based on the temperature and rainfall thresholds for the grow-out phase of four widely cultivated and economically important fish species in Bangladesh, with a 5-day lead time for day-to-day operational management (Hossain et al. 2021). In addition, a seasonal approach to climate risk management for aquaculture was also explored with a 1-month lead time, as forecasted information before the season, particularly the number of expected days of warm and heavy rain, are critical for strategic decision-making (Montes et al. 2022). These developments raised a question on the potential economic value of DCIAS for further investment and scaling in aquaculture. Therefore, we performed an ex-ante economic valuation of climate-induced losses in aquaculture to evaluate DCIAS in Bangladesh (Islam et al. in review). These collective research results steered the research team toward policy dialogues. These dialogues were then evaluated as a potential long-term national (the 2041 vision for Bangladesh) and global (the 2030 agenda of the UN Sustainable Development Goals) impact pathway. This was followed by a multicriteria evaluation exercise to propose the specific inclusion of DCIAS during revision of the country's 1998 national fisheries policy (ICSF 2022).

Figure 4. Policy dialogue outcomes.

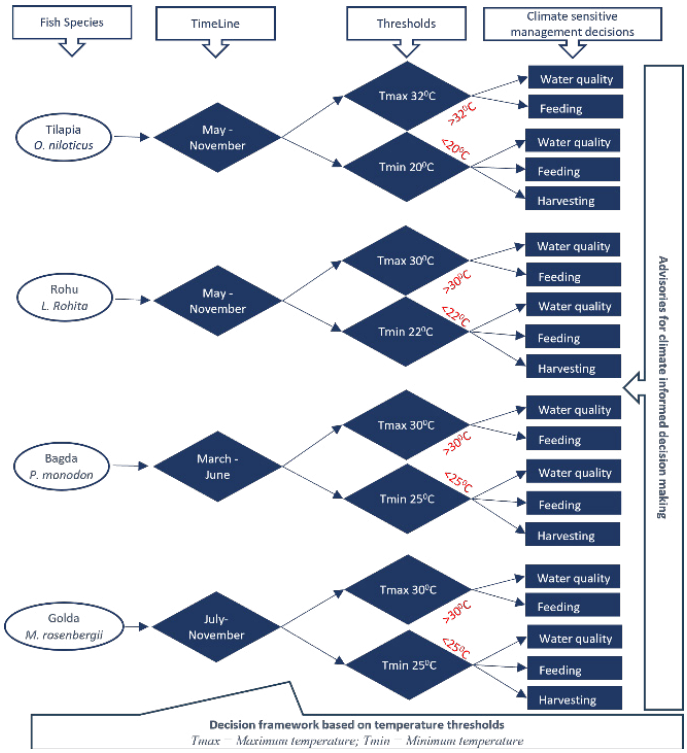


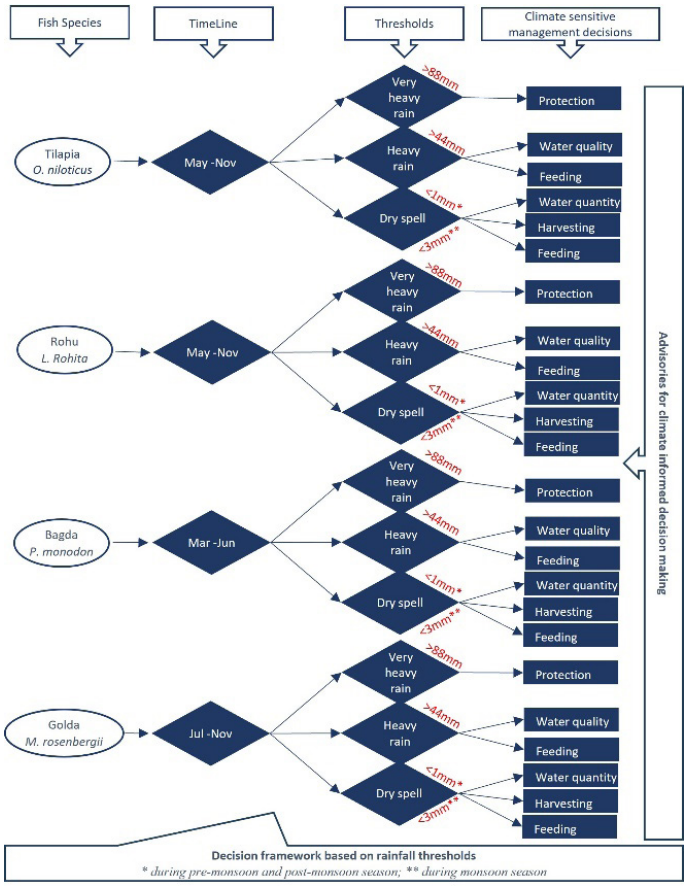
Key research findings

DCIAS can help fish farmers manage the day-to-day risks of climate-sensitive farming operations through climate-informed decision-making.

- Seasonal DCIAS can help fish farmers make strategic decisions in operational planning to reduce climate-induced loss and damage.
- DCIAS increase aquaculture production 1 percent by managing climate risks. This would provide 1 million people in Bangladesh with 24,000 t of fish as a protein source at the recommended allowance of 60 g/day.
- The potential economic value of aquaculture using DCIAS could reach as high as USD 14 million a year, if 10 percent of the damage from climate change is offset by appropriate climate services through a range of multisector efforts to establish and extend these services to end-users at scale.
- Enhancing the ability of aquatic food producers is needed to respond to climate risks using DCIAS.
- More research needs to focus on translating weather data into water temperature forecasts using modeling techniques and automated data input systems to provide farmers with precise information and context-specific services.

Source: *Hossain et al. 2021*





Research for impact: Concrete realities

Short-term forecasts on temperature and rainfall variabilities can be used in day-to-day aquaculture management decisions to reduce associated climate risks (Hossain et al. 2021). For instance, if heavy rain is forecasted 1 week in advance, fish farmers can be given actionable advisory services, like protecting their ponds with nets, heightening their pond dikes or harvesting their fish early. In this way, farmers would be able to manage the risks of fish loss and/or pond damage well in advance, as well as make decisions on feed conversion ratios, lime application and aerator use. They can also add water to balance dissolved oxygen, pH and water temperature in their ponds, and reduce the likelihood of a disease outbreak and mortalities to ensure optimal growth of their fishstock.

Seasonal forecasts can provide information on upcoming climatic conditions to aquatic food producers, allowing them to adjust their seasonal operations to manage climate risks (Montes et al. 2022). For instance, fish farmers can decide when to start preparing their ponds, stock fingerlings, increase or decrease production volume, adjust their maintenance and harvest schedule, etc. For example, in 20XX, prawn farmers in Queensland changed their stocking times based on seasonal rainfall forecasts (Spillman et al. 2015).

These climate-sensitive management decisions are crucial for managing associated costs and ensuring profit. As such, it is undeniable that short-term and/or seasonal DCIAS can play a substantial role in making climate-informed operational and/or strategic decisions to manage the associated risks (Hobday et al. 2018), reduce any correlated losses and ensure profit. However, developing short-term and/or seasonal DCIAS for aquaculture based on climatic thresholds designed using decision frameworks is still at the initial stage. Still, the scope is there to further improve advisory services, include more species and improve decision-support systems in line with the needs of end-users. This is the dynamic process of a living decision-support system.

Another aspect of DCIAS for aquatic food systems is the absence of formal training for aquatic food producers and their lack of knowledge regarding climate impacts on aquatic food systems and their associated risks (WorldFish 2020). This indicates the need for large-scale capacity development (Kumar et al. 2020) of all value chain actors and relevant institutions alongside a climate literacy program for vulnerable fishers and fish farming communities (Mohammed et al. 2021).

DCIAS can be a gender friendly approach in light of climate risks to manage (Gumicio et al. 2022). This is because engaging women in aquatic food systems, particularly in secondary activities—such as preparing feed, maintaining fishing nets, repairing equipment, sorting fingerlings and post-harvest processing—results not only in restricted involvement in regular operations but also restricted decision-making roles (Hossain et al. 2021). However, this can only happen if women actors are given (i) risk reduction information and services using such an innovative digital approach alongside (ii) access to such decision-support systems. If so, DCIAS will substantially promote their involvement in regular management decisions, strengthen their voice in decision-making and enhance their climate resilience capacity (Hossain 2022).

An ex-ante economic evaluation study shows the potential of DCIAS for aquatic food systems. It also points to the fact that investing in CIS and enabling offsetting actions by different supply chain actors, like fish farmers and hatchery owners, can create substantial benefits for Bangladesh by catalyzing aquaculture growth, enhancing nutritional security and contributing to poverty alleviation. This indicates the potential value creation and wide range of impacts of DCIAS

Box 1. Practical implications.

As explained by Carlo et al. (2022) and Hossain et al. (2021),

mache bhate bangali is an age-old saying that translates as "fish and rice are what makes a Bengali." This reveals the major economic activities in Bangladesh (i.e. fishing, aquaculture, and rice-fish farming) that sustain livelihoods and contribute to household nutrition. This densely populated and low-lying deltaic country in the humid subtropics has landscape conditions that permit the production of a diversity of aquacultural products, many of which are grown by small-scale and resource-poor farmers. However, aquaculture production in Bangladesh is subject to the challenge of coping with adverse climatic events associated with rainfall and temperature variabilities. Therefore, the availability of actionable climatic information generated and provided on an adequate time scale to allow farmers to make effective decisions could help mitigate the effects of adverse meteorological conditions through modifications aimed at more appropriate farm management. However, there is a gap in the availability and accessibility of tailored climate information for decision-making in the aquaculture sector. Local farmers and experts pointed to events of extreme heat and cold spells, erratic and intense rains as a priority when requesting climate information services. The main practical implications of the results stemming from research are related to both operational and strategic climate-informed planning and decision-making with the possibility of developing a short-term and seasonal decision-support systems for adverse climate impacts.

(Islam et al. in review). However, there is still a need for public and private sector attention to make use of this opportunity, as financial exclusion of aquatic food producers inhibits their ability to pay for goods and services to manage climate risks. Therefore, facilitating institutional arrangements to ensure aquatic food producers have equitable access to financial services and products is of paramount importance to make climate-informed decisions and offset climate risks.

Figure 5. Future projections of temperature and rainfall for Bangladesh.

Future Projected Annual Average Temperature (°C)

Climate Stress Area	Base (1981-2010)	SSP1-2.6		SSP5-8.5	
		2030s (2016-2045)	2050s (2036-2065)	2030s (2016-2045)	2050s (2036-2065)
SWM	25.8	26.5	27.1	26.2	27.7
SEE	25.6	26.2	26.8	26.1	27.5
CHT	25.3	26.1	26.7	25.9	27.4
FPE	24.9	25.7	26.4	25.4	27.0
HFF	24.5	25.3	26.0	25.1	26.8
DBA	25.5	26.2	26.9	25.8	27.5
NNW	24.9	25.6	26.3	25.2	26.9
CBL	25.3	26.0	26.8	25.7	27.4
CHI	25.2	25.9	26.6	25.7	27.3
URB	25.3	26.0	26.7	25.8	27.3
BD	25.5	26.1	26.8	25.9	27.4
BoB *	28.1	28.7	29.0	28.7	29.4

°C

24.5 25.5 26.5 27.5 28.5 29.5

Future Projected Annual Average Rainfall (mm)

Climate Stress Area	Base (1981-2010)	SSP1-2.6		SSP5-8.5	
		2030s (2016-2045)	2050s (2036-2065)	2030s (2016-2045)	2050s (2036-2065)
SWM	2129	2138	2210	2185	2215
SEE	3266	3300	3411	3374	3431
CHT	2912	2943	3040	3010	3069
FPE	2558	2579	2598	2647	2667
HFF	3653	3652	3683	3712	3783
DBA	1560	1588	1631	1638	1643
NNW	2157	2193	2191	2281	2255
CBL	1663	1692	1724	1745	1741
CHI	2686	2699	2750	2769	2800
URB	2759	2785	2840	2839	2882
BD	2579	2582	2640	2615	2669
BoB	1560	1353	1393	1628	1707

mm

1300 1800 2300 2800 3300 3800

Source: *MOEFCC 2022.*

Policy insights

DCIAS can play a substantial role in making climate-informed operational and/or strategic decisions to manage associated risks of climate change and, consequently, reduce any correlated losses.

It is important to recognize the critical role of DCIAS in climate-risk management to ensure sustainable aquatic food production in the future. In addition, sensible fisheries policy must be designed to prevent and reduce climate risks and create an enabling environment for uptake.

Providing timely, quality-assured and context-specific DCIAS is necessary to make science-based decisions and develop climate-informed policy in order to build climate resilience. This, in turn, can profoundly change the climate risk equation in the aquatic food system that underpins the food security of millions in Bangladesh.

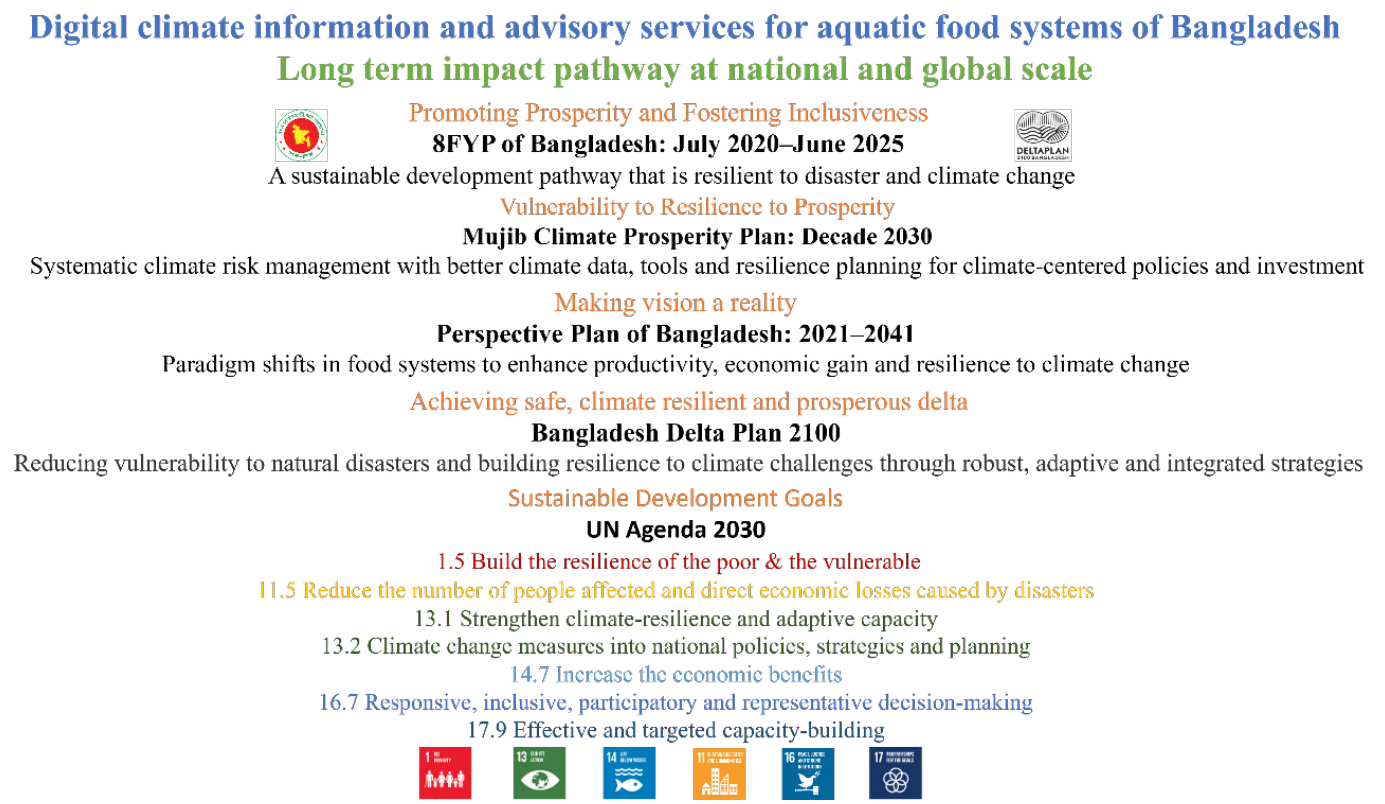
Key priorities for the future of sustainable aquatic food systems must include strengthening local adaptive capacity by providing useful DCIAS complemented with enhanced capacity to respond to and/or manage climate risks.

Recent research and development initiatives on DCIAS predominantly focus on the generation stage, which needs to be tailored and communicated to ensure last-mile use. This requires a considerable infusion of knowledge, innovation and continued investment to have impact on the ground.

It is necessary to prioritize enhanced access to DCIAS at scale, including for women and youths, in order to develop comprehensive climate risk management of the aquatic food system sector. In doing so, this will secure the broader goals of food, nutrition and livelihood security, as well as the sustainability targets of climate action goals.

To do so, the science-policy-practice interface needs to mainstream its system approach at the nexus of climate, aquatic food systems, vulnerable communities, policy and investments in order for climate safety net programs like DCIAS to co-create an evidence-based national fisheries policy. This system and/or nexus approach can aid the transition process for a country like Bangladesh, which is highly exposed to the impacts of the variability and extremes of climate change.

Figure 6. DCIAS for aquatic food systems in Bangladesh.



References

Barange M, Bahri T, Beveridge MCM, Cochrane KL, Funge-Smith S and Poulain F, eds. 2018. Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options. FAO Fisheries and Aquaculture Technical Paper No. 627. Rome: FAO. www.fao.org/3/i9705en/i9705en.pdf

Cinner J, Adger W, Allison E, Barnes M, Brown K, Cohen P, Gelcich S, Hicks C, Hughes T and Lau JAMN. 2018. Building adaptive capacity to climate change in tropical coastal communities. *Nature Climate Change* 8(2):117–23. https://www.nature.com/articles/s41558-017-0065-xv

Das S, Hazra S, Haque A, Rahman M, Nicholls RJ, Ghosh A, ... and De Campos RS. 2021. Social vulnerability to environmental hazards in the Ganges-Brahmaputra-Meghna delta, India and Bangladesh. *International Journal of Disaster Risk Reduction* 53:101983. doi: 10.1016/j.ijdrr.2020.101983

Gumucio T, Hansen J, Carr ER, Huyer S, Chiputwa B, Simelton E, ... and Schwager S. 2022. Enhancing climate services design and implementation through gender-responsive evaluation. *Frontiers in Climate* 4:908602. doi: 10.3389/fclim.2022.908602

Hobday AJ, Spillman CM, Eveson JP, Hartog JR, Zhang X and Brodie S. 2018. A framework for combining seasonal forecasts and climate projections to aid risk management for fisheries and aquaculture. *Front. Mar. Sci.* 5:137. doi: 10.3389/fmars.2018.00137

Hossain PR, Amjath-Babu TS, Krupnik TJ, Braun M, Mohammed EY and Phillips M. 2021. Developing climate information services for aquaculture in Bangladesh: A decision framework for managing temperature and rainfall variability-induced risks. *Front. Sustain. Food Syst.* 5:677069. doi: 10.3389/fsufs.2021.677069

Hossain PR. 2022. Gender-inclusive innovations for aquatic food systems transformation. City, Country: Publisher. https://digitalarchive.worldfishcenter.org/handle/20.500.12348/5118

[ICSF] International Conference on Sustainable Fisheries. 2022. Book of abstracts. Sylhet, Bangladesh: ICSF. https://digitalarchive.worldfishcenter.org/bitstream/handle/20.500.12348/5407/33de3b306cfee69bacbd09836ea93b0a.pdf?sequence=2&isAllowed=y

[IPCC] Intergovernmental Panel on Climate Change. 2023. AR6 synthesis report. City, Country: IPCC. https://www.ipcc.ch/report/ar6/syr/

Islam S, Hossain PR, Braun M, Amjath-Babu TS, Mohammed EY, Krupnik TJ et al. In review. Economic valuation of climate induced losses to aquaculture for evaluating climate information services in Bangladesh. City, Country: Publisher. Kumar U, Werners S, Roy S, Ashraf S, Hoang LP, Kumar Datta D et al. 2020. Role of information in farmers' response to weather and water related stresses in the Lower Bengal Delta, Bangladesh. *Sustainability* 12:6598. doi: 10.3390/su12166598

Larosa F and Mysiak J. 2020. Business models for climate services: An analysis. *Climate Services* 17:100111. doi: 10.1016/j.cliser.2019.100111

[MOEFCC] Ministry of Environment, Forest, and Climate Change. 2022. National Adaptation Plan of Bangladesh (2023–2050). City, Bangladesh: MOEFCC.Mohammed EY, Hossain PR, Lau J, Wahab MA, Beveridge MCM and Marwaha N. 2021. Accelerating climate resilience of aquatic food systems. Penang, Malaysia: CGIAR Research Program on Fish Agri-Food Systems. Program Brief: FISH-2021-16. https://hdl.handle.net/20.500.12348/4921

Montes C, Acharya N, Hossain PR, Babu TA, Krupnik TJ and Hassan SQ. 2022. Developing a framework for an early warning system of seasonal temperature and rainfall tailored to aquaculture in Bangladesh. *Climate Services* 26:100292 doi: 10.1016/j.cliser.2022.100292

Saha M. February 7, 2020. Floods in Gopalganj: 5,500 fish-farmers suffer 50C loss: *Dhaka Tribune*. Digital. https://archive.dhakatribune.com/bangladesh/nation/2020/08/18/floods-in-gopalganj-5-500-fish-farmers-incur-about-tk50cr-loss.

Spillman CM, Hartog JR, Hobday AJ and Hudson D. 2015. Predicting environmental drivers for prawn aquaculture production to aid improved farm management. *Aquaculture* 447:56–65. doi: 10.1016/j.aquaculture.2015.02.008

Tigchelaar M, Cheung WW, Mohammed EY, Phillips MJ, Payne HJ, Selig ER, ... & Troell M. 2021. Compound climate risks threaten aquatic food system benefits. *Nature Food* 2(9):673–82. doi: 10.1038/s43016-021-00368-9

WorldFish. 2020. A training dialogue report: Introduction to climate services for aquaculture. CGIAR Research Program on Climate Change, Agriculture and Food Security. Capacitating Farmers and Fishers to Manage Climate Risks in South Asia. Penang, Malaysia: WorldFish. Program Report: 2020-04. https://hdl.handle.net/20.500.12348/4062

Peerzadi Rumana Hossain, Scientist, WorldFish, *P.Hossain@cgiar.org*

Raju Ahmed, Assistant Director, Department of Fisheries, Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh, *rajuahmeddof@gmail.com*

Benoy Kumar Barman, Senior Scientist, WorldFish, *B.Barman@cgiar.org*

Citation

This publication should be cited as: Hossain, PR. Ahmed, R. and Barman, BK. 2023. Digital climate information and advisory services for de-risking aquatic food systems. Penang, Malaysia: WorldFish. Policy brief.

Acknowledgments

This policy brief was produced under the CGIAR Research Initiative on Asian Mega-Deltas with support from the Department of Fisheries (DOF) of the Government of the People's Republic of Bangladesh. The brief presents findings and policy lessons identified from research papers, dialogues, reports and op-eds prepared and conducted by researchers from CGIAR centers under the scope of the Initiative Opinions stated in this brief. The research articles it draws from are those of authors and do not necessarily reflect the views of the CGIAR Initiative, the DOF and/or partners. We would like to thank all funders who supported this research through their contribution to the CGIAR Trust Fund. The authors gratefully acknowledge the stakeholders in Bangladesh who joined the dialogues and shared their valuable inputs for this brief.

CGIAR Initiative on Asian Mega-Deltas

The CGIAR Initiative on Asian Mega-Deltas aims to create resilient, inclusive and productive deltas that maintain socioecological integrity, adapt to climatic and other stressors, and support human prosperity and well-being by removing systemic barriers to the scaling of transformative technologies and practices at the community, national and regional levels. To learn more about this Initiative please visit https://www.cgiar.org/initiative/asian-mega-deltas/

About WorldFish

WorldFish is a leading international research organization and a member of CGIAR, working to reduce hunger, malnutrition, and poverty by sustainably improving aquatic food systems. It collaborates with international, regional, and national partners to co-develop and deliver scientific innovations, evidence for policy, and knowledge to enable equitable, inclusive impact for millions who depend on fish for their livelihoods. www.worldfishcenter.org

Disclaimer

This publication has been prepared as an output of the CGIAR Initiative on Asian Mega-Deltas and has been internally peer-reviewed. Responsibility for the opinions expressed and any possible errors lie with the authors and not the institutions involved.

Design and production

Chua Seong Lee, Thavamaler Ramanathan and Sabrina Chong, WorldFish.

Photo credits

Front cover, Jacquelyn Turner/International Research Institute for Climate and Society.

CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to transforming food, land, and water systems in a climate crisis. Its research is carried out by 13 CGIAR Centers/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector. *www.cgiar.org*

We would like to thank all funders who support this research through their contributions to the CGIAR Trust Fund: *www.cgiar.org/funders*.

To learn more about this Initiative, please visit *www.cgiar.org/initiative/asian-mega-deltas*.

To learn more about this and other Initiatives in the CGIAR Research Portfolio, please visit *www.cgiar.org/cgiar-portfolio*

WorldFish

CGIAR INITIATIVE ON Asian Mega-Deltas