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

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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.

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.

Adverse impacts from human-caused climate change will continue to intensify

a) Observed widespread and substantial impacts and related losses and damages attributed to climate change

<table>
<thead>
<tr>
<th>Water availability and food production</th>
<th>Health and well-being</th>
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<tbody>
<tr>
<td>Physical water availability</td>
<td>Infectious diseases</td>
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<tr>
<td>Agriculture crop production</td>
<td>Heat, malnutrition and harm from wildfire</td>
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<td>Animal and livestock health and productivity</td>
<td>Mental health</td>
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<td>Fisheries yields and aquaculture production</td>
<td>Displacement</td>
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Cities, settlements and infrastructure

Biodiversity and ecosystems

- Inland flooding and associated damages
- Floodstorm induced damages in coastal areas
- Damages to infrastructure
- Includes changes in ecosystem structure, species ranges and seasonal timing

b) Impacts are driven by changes in multiple physical climate conditions, which are increasingly attributed to human influence

<table>
<thead>
<tr>
<th>Attribution of observed physical climate changes to human influence:</th>
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<tbody>
<tr>
<td>Medium confidence</td>
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<tr>
<td>Increase in agricultural &amp; ecological drought</td>
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<tr>
<td>Increase in compound flooding</td>
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<tr>
<td>Increase in hot extremes</td>
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</tbody>
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Key

- Adverse impacts
- Adverse and positive impacts
- Climate-driven changes observed, no global assessment of impact direction

Confidence in attribution to climate change

- *** High or very high confidence
- ** Medium confidence
- * Low confidence

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.

An Illustration: Digital Climate Information and Advisory Services for Aquatic Food Systems

DCIAS provide climate information and advisory services to help individuals and organizations in making climate smart decisions.

- Should we go for fishing next week?
- Do we need to change stocking period?
- What input materials do we need to arrange?
- How much can we produce from this cycle?
- When should we start hatchery operations?

How do DCIAS work?

**Inputs**

High quality weather data as well as maps, risks, vulnerability analysis and long-term climate projections and scenarios from national and international meteorological departments.

**Outputs**

The weather information and climate data collected is transformed into customized products such as projections, trends, economic analysis, advisories and services for different users of aquatic food systems.

DCIAS equip the climate-sensitive sectors like aquaculture and fisheries, vulnerable communities (like fish-farmers & fishers) and policy makers with better information and services to help the society adapt to climate change, variabilities and extremes.

**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.

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<th>Policy dialogue outcomes</th>
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<tr>
<td>Disseminate DCIAS at scale</td>
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<td>Adoption of DCIAS at national scale</td>
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<td>Mainstream DCIAS through policy formulation</td>
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<td>Effective and timely communication between the services providers and end users</td>
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<td>Enhanced communication between Met department and DoF to tailor DCIAS</td>
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<td>Bundled services using climate information</td>
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<td>Climate safety net program for the fish-farmers</td>
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<td>Aqua-met bulletin for fish-farmers</td>
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<td>Capacity building of fish-farmers to use DCIAS</td>
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<td>Capacity building of extension officers and local service providers</td>
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<td>Institutional capacity building for DCIAS adoption</td>
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<td>Use of IoT to craft useful advisories</td>
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<td>Use of Artificial intelligence for remote monitoring</td>
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<td>PPP for sustained investment on DCIAS</td>
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<td>Need Bundled business models for a sustainable DCIAS platform</td>
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Propositions from the policy dialogues
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

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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.
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.**

**Digital climate information and advisory services for aquatic food systems of Bangladesh**

**Long term impact pathway at national and global scale**

**Promoting Prosperity and Fostering Inclusiveness**

8FP of Bangladesh: July 2020–June 2025

A sustainable development pathway that is resilient to disaster and climate change

**Vulnerability to Resilience to Prosperity**

Mujib Climate Prosperity Plan: Decade 2030

Systematic climate risk management with better climate data, tools and resilience planning for climate-centered policies and investment

**Making vision a reality**

Perspective Plan of Bangladesh: 2021–2041

Paradigm shifts in food systems to enhance productivity, economic gain and resilience to climate change

Achieving safe, climate resilient and prosperous delta

Bangladesh Delta Plan 2100

Reducing vulnerability to natural disasters and building resilience to climate challenges through robust, adaptive and integrated strategies

**Sustainable Development Goals**

UN Agenda 2030

1.5 Build the resilience of the poor & the vulnerable

11.5 Reduce the number of people affected and direct economic losses caused by disasters

13.1 Strengthen climate-resilience and adaptive capacity

13.2 Climate change measures into national policies, strategies and planning

14.7 Increase the economic benefits

16.7 Responsive, inclusive, participatory and representative decision-making

17.9 Effective and targeted capacity-building
References


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