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Dataset of production characteristics and performance of small-scale carp aquaculture systems in Bangladesh

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KEYWORDS

inland aquaculture, food security, livelihoods, household survey, Bangladesh, carp, poly culture

1 Introduction

Small-scale inland aquaculture has considerable potential to generate socioeconomic benefits in low- and middle-income countries. Hundreds of millions of people globally rely on inland aquaculture, contributing substantial economic and employment benefits to national and regional economies (FAO, 2022). Inland aquaculture also has substantial benefits for rural livelihoods and poverty alleviation (Béné et al., 2016), nutrition and food security (Wang et al., 2024) and gender empowerment (Dam Lam et al., 2022), among others.

Carps are the most widely produced inland aquaculture species (particularly in Asia), accounting for 53.8% of global inland aquaculture production in 2022 (FAO, 2024). Carp aquaculture (especially in Asia) has contributed substantially to global inland aquaculture expansion (Zhang et al., 2022), especially through carp polyculture systems (Naylor et al., 2021).

Small-scale aquaculture systems generally rely on relatively small farms and simple (often rudimentary) technologies, which often constrain the actual output, productivity and efficiency of the sector, and as an extension its potential to enhance food security and offer sustainable livelihoods (Wang et al., 2023). However, far from being homogenous, small-scale inland aquaculture systems (incl. carp) have radically different characteristics in low- and middle-income countries in terms of production models and commercialization practices (Short et al., 2021).

Many efforts have sought to improve the performance of small-scale inland aquaculture systems in low- and middle-income countries. Improvement efforts mainly rely on the promotion of improved production practice/technologies, dissemination of knowledge about production/processing/marketing/nutrition, promotion of improved fish feed and species, or combinations of the above Henriksson et al. (2021). However, many factors have constrained such efforts (Morgan et al., 2017), including our incomplete understanding of differentiation in the characteristics and performance of aquaculture systems (particularly small-scale systems), as well as of the differentiation in the needs, preferences and capacities of producers (Short et al., 2021). This is compounded by the general lack of comprehensive and consistent national/regional aquaculture statistics, the dynamic and fast-changing nature of the sector, and the lack of high-quality

and fine-grained datasets compared to land-based agricultural systems. Collectively such information gaps contribute to the general failure to appreciate the considerable heterogeneity in the sector (both between and within countries), and design fit-for-purpose policies and interventions to improve the performance of small-scale aquaculture systems (Short et al., 2021).

Bangladesh experiences many of these circumstances. Aquatic food contributes significantly to the growing demand for animal-based protein due to various interconnected environmental, cultural and socioeconomic reasons. Inland aquaculture caters currently for most of the national fish demand, with the country currently ranking as the 5th largest aquaculture producer globally (FAO, 2022). The aquaculture sector has expanded substantially in the past decades, with an estimated 4.3 million households (20% of the rural population) operating at least one homestead pond that is usually small in size (0.08–0.10 ha on average). Carps are, by a wide margin, the most widely produced aquaculture species in Bangladesh, accounting for 55.4% of the total aquaculture output (DoF, 2022). Carp aquaculture is practiced across the entire country, and is overwhelmingly geared toward household self-consumption and/or the national market (Henriksson et al., 2018).

However, despite this clear importance of carp aquaculture systems in Bangladesh, and the broader region, we lack consistent and comprehensive datasets about their characteristics and performance across the country (and other parts of South and Southeast Asia). Although many public and private organizations have been actively trying to improve the performance of the sector through diverse interventions, these efforts are constrained by the lack of good understanding of producer differentiation, especially among small-scale producers that are one of the most dynamic segments in the sector (Henriksson et al., 2018; Karim et al., 2016). Arguably, the good understanding of the characteristics, performance and needs of (small-scale) producers could help inform the design and targeting of aquaculture interventions in Bangladesh, and other similar contexts.

This Data Report outlines a dataset that contains the production characteristics and socioeconomic performance of small-scale carp aquaculture systems in Bangladesh (Rossignoli et al., 2023a). The dataset was collected through in-person structured surveys with 4,540 carp producers in 54 areas (upazillas)[1] spanning the entire country. In terms of production characteristics, the dataset contains variables related to farm sizes, fish species, aquaculture production technologies, feed/seed use, aquaculture knowledge, and aquaculture incomes and expenditures, among others. In terms of performance, the dataset contains variables that can generate indicators of rural livelihoods (e.g., on-farm/off-farm income), multidimensional poverty, food security and environmental performance, among others.

1 Upazilas are administrative divisions in Bangladesh. They are the third tier of administrative levels in Bangladesh, below Divisions and Districts, and above Unions/Municipalities and Villages/Wards. They could be considered as analogous to counties.

2 Methods

2.1 Dataset design and main variables

The dataset was collected through a structured household-level survey that elicited the characteristics and the socioeconomic performance of carp aquaculture systems in Bangladesh. The dataset (and the base household survey) consists 10 modules that collectively contain comprehensive information about the aquaculture production systems, demographic characteristics and socioeconomic profile of households.

Module A and B contains variables about the location and demographic characteristics of the respondent and their household (Module A), as well as about land tenure and size (Module B). Considering that the main focus of the survey is carp aquaculture system characteristics and performance, the survey respondents were the household members mainly responsible about pond operation and also had a good understanding of other livelihood activities within the household (Section 2.4). This was practically always either the household head or the spouse.

Module C contains variables about aquaculture production, commercialization and knowledge. It is by far the most extensive module of the dataset in terms of the number of questions and variables. Specifically, for each pond operated by the household, this module captures by fish species the amounts produced, sold (raw or processed), gifted and self-consumed, as well as the generated income. The module also contains variables about all the material inputs (e.g., feed, seed), production methods (including Better Management Practices; BMPs), and aquaculture labor, assets, expenditures and knowledge.

Module D contains variables about other on-farm livelihood activities related to agriculture and livestock production. Variables encompass the production, consumption and sales of all major crops/vegetables and livestock, the generated income, as well as relevant input costs (e.g., agrochemicals, labor).

Module E contains variables about the participation of households in different producers' groups. Furthermore, it includes variables about their access to credit and aquaculture/agriculture knowledge, training and extension.

Module F and G contains the base variables to construct two standardized metrics of food security and poverty respectively. Module F contains the base variables to develop the Food Consumption Score (FCS), a measure of dietary diversity (WFP, 2008). Module G contains the base variables to calculate the multi-dimensional poverty index (MPI), a composite measure of poverty (Alkire and Santos, 2014).

Module H contains variables about: (a) off-farm income, such as income streams from paid labor, side-business, or remittances, and (b) expenditure divided by main household budget items. This module does not contain variables about on-farm income and expenditure, as these are captured in Modules C-D.

Modules I and J contain variables about household vulnerability to climatic shocks and the COVID-19 pandemic. Module I contains variables about: (a) the exposure of the households to different climatic hazards (e.g., floods, droughts, storms), (b) the effect of hazards on aquaculture output, livelihoods and food security, and (c) the coping mechanisms or adaptive strategies implemented by households to mitigate the effects of such hazards. Module

J contains similar variables about the disruption of aquaculture activities during the COVID-19 pandemic. Perception variables are measured through Likert scales tailored to reflect the type of disruption and the measured outcome.

All questionnaire modules overwhelmingly contain close-ended question. Depending on the question the respondents either provided actual numerical values (numerical variables) or the enumerators had to assign pre-existing options depending on respondent answers (categorical variables). The latter included the perception-based questions where respondents rated their satisfaction with their fish production (in Module C) or vulnerability to climatic hazards and COVID-19 pandemic (in Module I-J). Variables about all productive activities (in Module C-D) and off-farm income and expenditures (in Module E) were for the previous aquaculture production season, and entailed a 12-month recollection period.

Finally, there were very few open-ended questions, which were used as an opportunity to ask respondents to justify some of their answers to previous questions if they wished so. These variables are provided as open text in the database.

2.2 Site identification and selection

The biggest challenge for collecting the dataset was the lack of high-quality, consistent, comprehensive and spatially-disaggregated datas about the prevalence and characteristics of aquaculture producers. In particular the relevant national statistics in Bangladesh tend to report very basic information about fish output, without delving deeper on production characteristics or reporting information for lower levels of administration (e.g., upazila level). Regarding the latter, the available production data are generally available for higher administration levels such as divisions ($n = 8$) or districts ($n = 64$) (DoF, 2022). This data resolution is too coarse to allow for the good understanding of the distribution and differentiation of inland aquaculture systems because any given division or district may contain several different areas where aquaculture is very intensive or not performed at all (including anything in between).

Arguably it is more appropriate to undertake aquaculture characterization studies at lower levels of administration such as at the upazila level ($n = 495$), which is roughly equivalent to the level of the county (see Footnote 1). Due to the lack of reliable carp production data (incl. carp output, and numbers of producers) at the upazila level, we followed the multi-stage approach outlined below to identify appropriate study upazilas.

First, we conducted eight expert workshops that collectively brought together 215 experts from eight regions of Bangladesh[2]. The experts were collectivelly knoweldgeable on all stages of aquaculture value chains in Bangladesh, and particularly their respective regions. They covered very diverse expertise spanning from farm/agricultural economics to fish biology, breeding, aquatic ecology, and different fields of social sciences. During these expert workshops we elicited information about which areas in each region contain substantial carp production (hotspots), and which areas have strong potential for carp aquaculture in the future even if there is no substantial carp production currently. The workshops provided a list of possible study areas at the upazila level, which were further corroborated through discussions with regional fisheries offices and triangulated with secondary data from national aquaculture and fisheries statistics (wherever available) (DoF, 2022).

Through this process we drafted a list of 54 upazilas for survey implementation, 30 of which were identified as carp aquaculture hotspots and 24 as having this potential (Figure 1a). These upazilas are spread across the entire country, with the exception of the eastern part of Chittagong Division that has low inland aquaculture output and potential in general (also corroborated from national statistics (DoF, 2022)).

For the final triangulation, we cross-checked each of the 54 upazilas with the outcomes of an aquaculture suitability assessment that identified aquaculture suitability accross the country. The suitability analysis was developed by the research team using secondary spatially-disaggregated datasets for 10 indicators of aquaculture suitability. We created in a GIS environment layers for each of these indicators for the entire country, and then combined them in a composite metric that identified areas of high, moderate and low suitability for aquaculture. The final aquaculture suitability map had a resolution of 30×30 m. We then overlayed the suitability map with the upazilas identified through the expert consultation process (Figure 1a) to ensure that the selected upazilas mainly consisted of areas characterized with good suitability for aquaculture (Figure 1b). This cross-referencing demonstrated that all of the 54 selected upazilas fell overwhelmingly in areas of high and moderate aquaculture suitability. The Supplementary material contains more information about the analytical approach and underlying datasets of the suitability analysis (see Section S1, Supplementary Table 1, and Supplementary Figure 1 in Supplementary material).

2.3 Sample identification and selection

The lack of an existing centralized, consistent and comprehensive databases of carp producers in Bangladesh (or specific regions) (see Section 2.2) complicated sample identification and collection. To overcome this, we followed a multi-stage approach both to identify respondents and randomize their selection. In summary, respondent selection relied on the development of carp producer lists in each study upazila and the randomized selection of respondents from that list.

First, we established with input from the Fisheries Offices in each selected upazila: (a) the main locations of carp production (e.g., blocks, unions), and (b) current availability of comprehensive carp producer lists. In most study upazilas such producers' lists were either non-existent or quite outdated (8–10 years old). This justified the development of new carp producers' list in each study upazila.

Second, the development of producers' lists started with the random selection of blocks and/or unions in each upazila that contained carp production, as indicated by the respective Fisheries

2 A comprehensive presentation of the design, implementation, and outcomes of the expert workshops can be found in Rossignoli et al. (2023b).

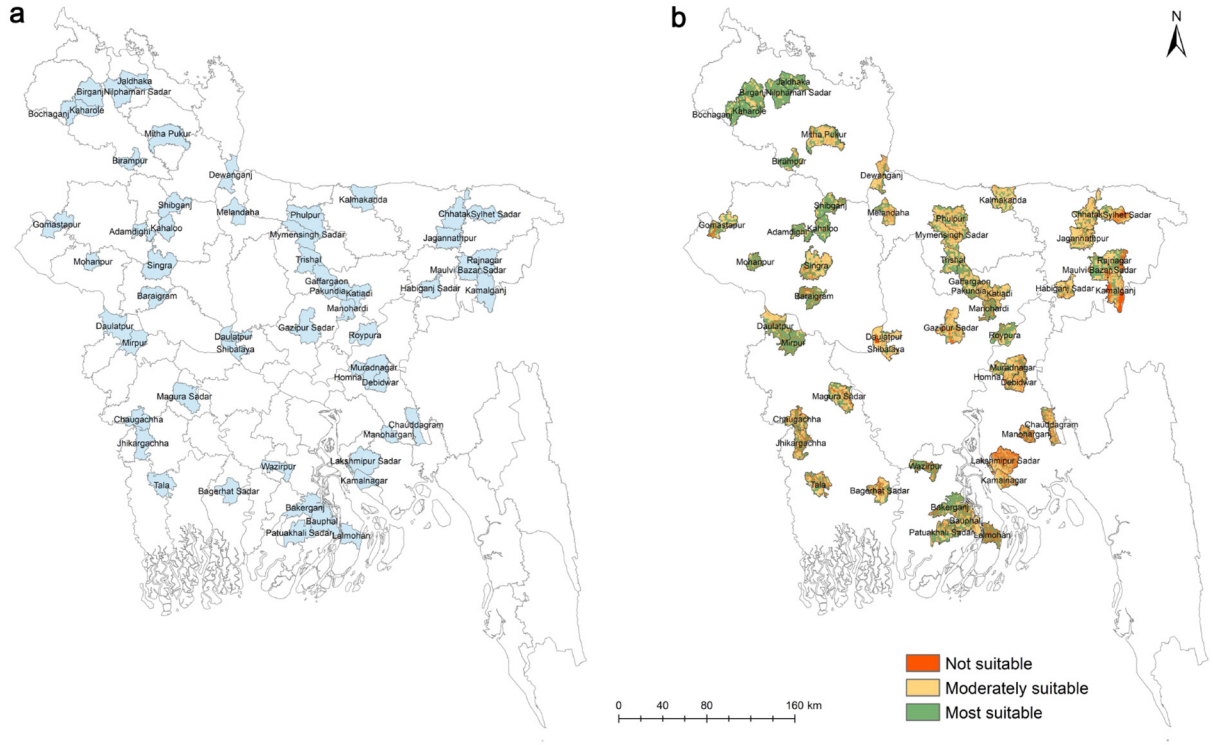

FIGURE 1
Location of study areas (upazilas) **(a)** and their suitability for aquaculture **(b)**.

Offices (see above). Subsequently, through in-person visits in these blocks/unions, we registered all available carp farmers identified. Once all such producers were identified/registered, we moved to another randomly selected area until we drafted lists of 130–150 carp producers in each upazila. These lists collectively covered 8,066 carp producers across all of the 54 study upazilas.

Third, we randomly selected carp producers in each upazila. We aimed at interviewing 84 producers in each upazila. Overall, we interviewed 84 producers in 46 of the 54 upazilas, while in the remaining eight upazilas we interviewed 83, 85 or 86 carp producers. The final total sample contained 4,540 respondents. Supplementary Table 2 (Supplementary material) outlines sample distribution across upazilas.

2.4 Data collection

The survey (see Section 2.1) was translated in Bengali and digitized in tablets for in-person data collection using well-trained enumerators (see Section 3). The digitisation and data collection were undertaken using the *SurveyCTO* platform (www.surveycto.com) by Development Research Initiative (dRI), in close cooperation with the research team. The dRI enumerators and supervisors were trained with the active supervision of the research team over the duration of 3 days (13–15 November 2021). Subsequently, the enumerators conducted pilot surveys for 2 days (16–17 November 2021) with aquaculture producers in some of the selected study areas to become further acquainted with the protocol. The piloting was also essential for identifying questions with problematic framing (e.g., in terms of clarity or sensitivity) and ensuring that the ranges/answers in the questions for categorical values were sensible. Some individual questions and response options were revised slightly to reflect the insights gathered from the piloting through iterative discussions between the enumerators, supervisors and the research team.

The full household survey was conducted between 18th November 2021 and 28th February 2022. Each survey lasted 60–120 min depending on the answers of the respondents. Surveys tended to last longer for households operating multiple ponds.

Prospective respondents were informed that they were selected randomly and were assured that participation in the survey was optional and voluntary, as well as that they could refrain from answering any questions at any point. They were also informed that all information will be confidential and will be used for research purposes only. Enumerators were instructed to provide further information as to the nature of these research purposes (e.g., use of highly anonymised data for research publications, inclusion of anonymised survey answers to online research databases) to those participants that inquired. Furthermore, participants were assured that they will not be directly disadvantaged or benefit financially or in any other form. Surveys commenced only after the prospective respondents consented to participate.

Multiple quality assurance mechanisms were implemented during the digitisation of the survey, the training of enumerators/supervisors and survey implementation to

ensure high and consistent data quality. Section 3 provides a comprehensive explanation of these quality assurance mechanisms.

2.5 Data processing and preliminary analysis

Initial data cleaning was performed within the *SurveyCTO* platform (Section 2.4), and subsequently in Microsoft Excel. The dataset was then coded and processed using R version 4.3.2, with additional manual checks and corrections conducted in Excel to ensure accuracy and consistency. Furthermore, we conducted preliminary analysis to understand the patterns of some of the main variables that can be used in different applications (Section 4–5).

First, we estimate the variation in key production variables across households using kernel density estimates. We conduct this analysis for six variables, including household income (USD/yr), aquaculture income (USD/yr), aquaculture cost (USD/yr), aquaculture area (ha), purchase of food items (USD/yr), and aquaculture production (kg/yr). All variables were log-transformed using the *log1p* function of R version 4.3.2 to account for skewed distributions. The density distribution analysis was performed using R-package *ggplot2*.

Second, we quantify the prevalence of major aquaculture species across the surveyed households. We estimate the prevalence of major species categories (i.e., carps, tilapia, catfish, snakehead, small indigenous species, koi, and prawn), as well as carp species. Furthermore, we estimate the diversity of fish species cultivated by households. We visualize these patterns through bar chart constructed using R-package *ggplot2*.

Third, we estimate two major demographic variables, namely age of the household head and household size. We visualize the demographic patterns through bar charts generated using *geom_bar* function of R version 4.3.2.

2.6 Ethical approval

The protocol of the study, including the method of informed consent, survey questions, sampling and data handling was approved by the Institutional Review Board of the Institute of Health Economics (IHE-IRB), which is approved by the U.S. Department of Health and Human Services Federalwide Assurance (No. FWA00026031).

3 Dataset validation

Sampling and non-sampling errors can compromise data quality in large-scale farm-level surveys such as the one outlined in this Data Report (Gasparatos et al., 2018; Waha et al., 2016). In the context of the dataset presented here, these errors can compromise the robust identification of technology adoption and performance at the farm level, and ultimately the design of development interventions to improve farm performance and sustainability. The research team was conscious of these risks. From the onset of the study we implemented various quality assurance procedures to reduce these errors to the extent possible.

Sampling errors generally arise from the unrepresentativeness of the sample. During the initial stages of research design we identified that the main sources of sampling errors in our study would mostly be associated with the selection of: (a) study areas with unusual, unrepresentative, and/or very homogenous carp production systems, and (b) individual respondents (i.e., aquaculture producers) with unrepresentative carp production systems compared to the prevailing systems in their respective study area.

Risks associated with study area selection could likely occur by (a) selecting study areas with low/no carp production, (b) selecting study areas in few localities within Bangladesh (e.g., select upazilas only in some divisions or districts for convenience reasons), and/or (c) selecting study areas that collectively fail to capture the diversity of carp production systems in Bangladesh. Such study area selection decisions could individually or collectively lead to a skewed understanding of the national landscape of carp production systems.

To reduce the risks stemming from flawed study area selection we followed the multi-stage process outlined in Section 2.2 that consisted of expert consultations, GIS-based aquaculture suitability analysis and triangulation (to the extent possible) with secondary data compiled by the Department of Fisheries of the Bangladesh Ministry of Fisheries and Livestock (DoF, 2022). By superimposing the upazilas identified through the expert consultation (Figure 1a) with the aquaculture suitability map generated by the research team we ensured that none of the selected upazilas falls completely within areas of low aquaculture suitability (Figure 1b). This multi-stage approach allowed us to avoid selecting study areas with unrepresentative carp production, and particularly areas that individually lack significant carp production or areas that collectively fail to capture the diversity of carp production systems in Bangladesh. By relying on multiple data sources and a large number of experts we reduced to the extent possible: (a) biases that could emerge from reliance on the perspectives of just a few experts, and (b) inaccuracies due to the incompleteness of some datasets.

Risks associated with respondent selection could occur through biases in producer identification and/or lack of proper randomization during respondent selection in each study area. We expected that such types of errors are likely to occur due to the lack of comprehensive, consistent and spatially-explicit datasets about carp aquaculture in Bangladesh (e.g., see Section 1 and 2.2).

To reduce risks associated with respondent identification and selection, we followed a multi-stage process. The respondent selection process relied on a randomized selection from carp producer lists developed by the research team (Section 2.3). This aimed at minimizing (to the extent possible) biases and errors introduced by non-randomized sampling methods (e.g., convenience sampling) or by using outdated producers' lists. To ensure a relatively large and balanced pool of respondents, we randomly selected approximately 84 respondents in each study upazila, from more extensive lists of 130–150 producers that were developed by the research team for this project (see more details in Section 2.3). We must note here that we did not identify every carp producer in each study upazilas. Conducting such a

complete census of all carp producers in the study areas, was both outside the scope of the study and would have been prohibitively resource intensive. However, we must also acknowledge that despite our best efforts there is some likelihood that randomization was not conducted perfectly in all upazilas, possibly inserting some selection biases. Unfortunately, this cannot be formally tested considering the lack of comprehensive and cohesive carp producers' lists, as explained throughout this paper. However, we believe that the final sample offers a good representation of the carp aquaculture sector in Bangladesh when taking into consideration the preliminary analysis of the patterns of major variables (Section 4), the insights gained from the expert workshops Rossignoli et al. (2023b), and the findings of other aquaculture studies in the country (Henriksson et al., 2018; Hossain et al., 2022; Jahan et al., 2015).

Non-sampling errors refer to all other errors that can arise during data collection, which can cause the collected data to differ from their true values (Phung et al., 2015). Such errors typically occur if (a) data collection deviates from the established study protocol, and (b) responses are biased or fail to capture/report properly the required information (e.g., recollection errors) (Phung et al., 2015). During the initial stages of research design, we identified that the main sources of non-sampling errors would mostly be associated with non-response errors and measurement errors (Waha et al., 2016). We expected that such types of non-sampling errors could likely occur for two reasons. First, was the large enumerator team needed for data collection considering the study's extensive geographical scope (entire Bangladesh) and large sample size (>4,500 surveys) that were necessary to avoid the possible sampling errors mentioned above. Second, was the large amount of information captured in the survey and the long recollection periods for some of the key questions.

To reduce non-sampling errors, we developed and adhered to a robust and comprehensive protocol for the design and implementation of the household survey. Specific actions were to:

a) select experienced research and data collection teams;
b) design and digitize carefully the questionnaire to ensure the accurate capture of the characteristics and performance of carp producers, and assist respondent recollection;
c) train enumerators to adhere properly to the study protocol;
d) revise iteratively the questionnaire prior to survey implementation using the insights generated from training and piloting;
e) check daily all collected surveys for completeness and quality, and provide timely and constant feedback to enumerators.

Finally, we must acknowledge that it is not possible to formally test the representativeness of the selected sample or externally verify the dataset due to the lack of spatially disaggregated national statistics about the main areas of carp production in Bangladesh, as well as the number, output, and characteristics of carp aquaculture producers. However, we see consistency in the findings of the analysis of the dataset analysis and the expert insights elicited during the expert workshops. In particular, a recent characterization study using the dataset to identify differentiation in the production models within the sample (Dompreh et al., 2025) found the same production models qualitatively identified by the experts during the workshop (Rossignoli et al., 2023b).

4 Patterns for major variables

Figure 2 visualizes patterns for some of the main production and outcome variables in the dataset, which can be used for different types of applications (Section 5). The log-transformed density distributions reveal substantial variability for all variables. On average (indicated by red lines in each panel), households reported an annual income of 6,869 USD/yr, with aquaculture output contributing 3,755 USD/yr and aquaculture inputs incurring average costs of 2,180 USD/yr. These three income and cost variables exhibit right-skewed distributions, with most households concentrated around lower to mid-income levels and the long distribution tails indicating a smaller number of high-income or high-cost producers. Aquaculture production was on average 2,540 kg/year, with a similarly skewed distribution indicating that a few producers have substantially higher fish output than the majority of producers. The average production area was 0.57 ha, with the distribution showing a steep drop-off, underscoring the substantially higher prevalence of small-scale producers in the sample, and the carp aquaculture sector more broadly. Finally, food purchases were relatively uniform across producers, averaging at 318 USD/yr, and displaying a compact density curve. Collectively, these log-normal shaped distributions imply the significant heterogeneity among carp producers in the sample, justifying the relevance of our dataset that can be used to characterize fully the different carp production models in the country (Section 5).

Supplementary Figure 2 (Supplementary material) summarizes the prevalence of different fish species in the sample. Beyond the many different carp species (see below), many producers cultivated tilapia (*Oreochromis niloticus*: 43.3%) and different catfish species (*Clarias batrachus*; *Pangasius pangasius*; *Wallago attu; Mystus tengara*: 21.8%) (Supplementary Figure 2a, Supplementary material). The most prevalent carp species were rohu (*Labeo rohita*: 91.8%), silver carp (*Hypophthalmichthys molitrix*: 67.9%), mrigal (*Cirrhinus mrigala*: 61.8%) and catla (*Catla catla*: 60.8%) (Supplementary Figure 2b, Supplementary material). More importantly, practically all producers (~99.8%) adopt polyculture models (Supplementary Figure 2c, Supplementary material). More than 80% of producers cultivate between three and six fish species, with aquaculture systems combining four (32.4%) and five (24.0%) species being the most prevalent (Supplementary Figure 2c, Supplementary material).

Supplementary Figure 3 (Supplementary material) summarizes some of the main demographic characteristics of the surveyed households. Most household heads are middled aged (41–50 years; average age is 48.0 years) and most households contain >5 members (average household size is 5.1 people).

5 Dataset applications

As outlined in Section 1 small-scale carp aquaculture is a particularly important aquatic food system in many low- and middle-income countries (especially of Asia). The dataset described here can have different applications in Bangladesh and beyond.

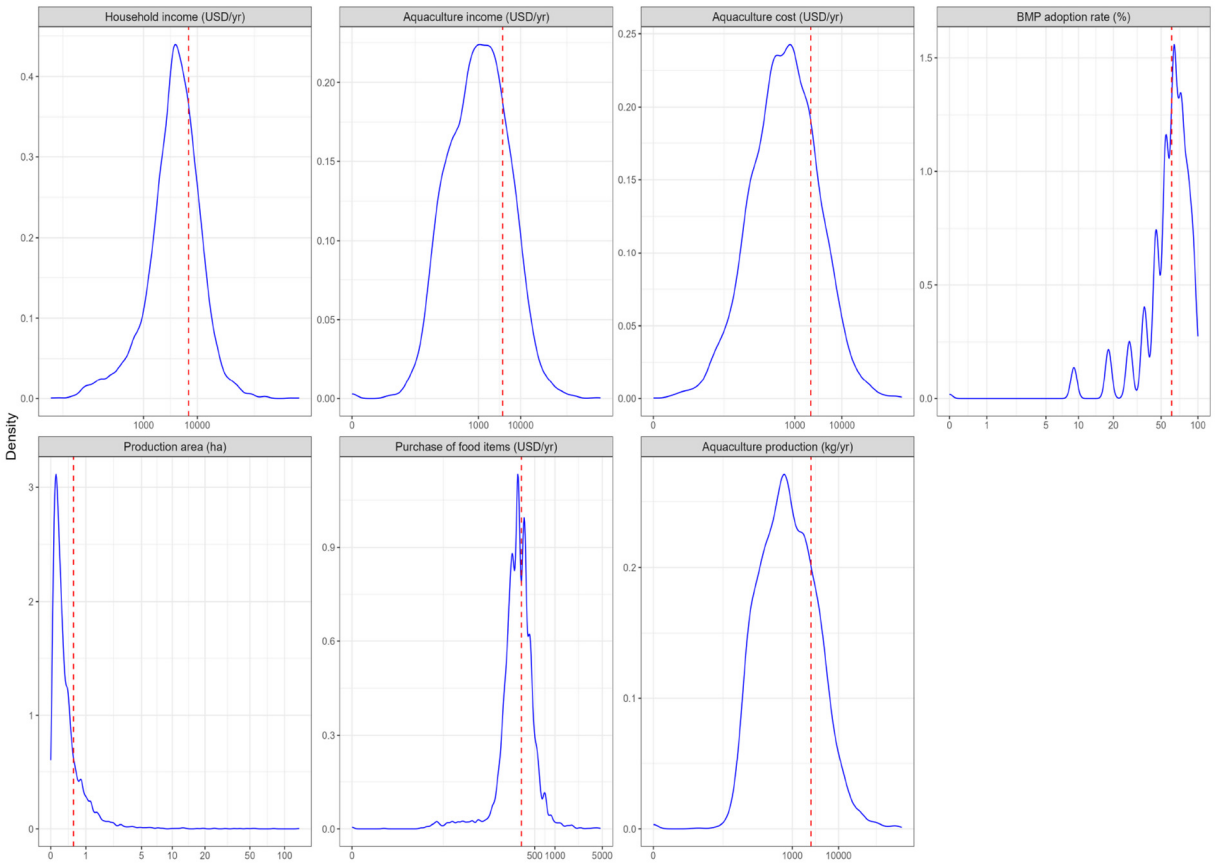

FIGURE 2
Distribution of major production variables.

First, it can be used to explore the heterogeneity and differentiation of carp, and small-scale more broadly small-scale aquaculture production systems in Bangladesh, in terms of their comparative characteristics and performance. The main variables that can be used to describe the aquaculture systems are included in Module C and D, which contain comprehensive information in terms of fish/crops/livestock species and output, agriculture/aquaculture inputs, aquaculture management practices, intensification levels, and market orientation, among others. Variables in Modules C, D, F, G and H can be used to develop different performance indicators related to income (on-farm income in Module C-D; off-farm income in Module H), multi-dimensional poverty (Module G), food security (Module H), and environmental performance (Module C). Regarding the latter, Module C contains comprehensive information about aquaculture inputs and outputs that can be used to develop inventories for Life Cycle Assessments (LCA) to estimate nutrient use efficiency or environmental impacts such as acidification, eutrophication, and ecotoxicity.

Second, and related to the previous point, the dataset can be used to understand in more depth which factors affect the performance of these aquatic food systems. These factors can be very diverse, spanning multiple domains: technical (e.g., adoption of BMPs), demographic (e.g., household structure), capacity (e.g., education, access to extension services), geography/infrastructure (e.g., access to infrastructure), economic (e.g., access to credit, asset base) or institutional (e.g., participation in producer groups). Related variables can be found in different parts of the dataset: technical (mainly Module C), demographic (mainly Module A), capacity (mainly Module A and F), geography/infrastructure (mainly Modules A and C), economic (mainly Modules C, E, F), institutional (mainly Module E). Such studies can focus solely on Bangladesh or be used in multi-country assessments if combined with similar datasets from other countries.

Third, large-scale integrated modeling studies are increasingly exploring food system transformation and food system vulnerability to climate change and livelihood shocks. However, such models do not usually have good quality data for their aquatic food system components compared to land-based agricultural systems and fisheries. Our dataset contains diverse variables that can help populate such modeling components, depending on the focus of the modeling exercise. Of particular relevance could be variables related to the production characteristics (Module C-D), impacts (Module C, D, F, G and H), and vulnerability to climate change and livelihood shocks (Module I–J).

6 Conclusion

This Data Note describes a unique dataset that can be used to describe the characteristics and assess the performance of carp aquaculture systems in Bangladesh. Considering the large number

of samples (n = 4,540) and it wide geographical coverage (54 upazilas across the entire country), the dataset essentially provides a snapshot of the current state of the carp aquaculture sector in Bangladesh. As the sector is very dynamic and experiences fast change, this information can be used to develop a national benchmark of this critical aquatic food system. This can offer a robust evidence base to both design future interventions and/or assess the performance of future interventions in the study areas. Although the actual data are essentially applicable only in studies focusing solely on Bangladesh, the findings of studies using this dataset can have wider implications considering the global importance of small-scale carp aquaculture, especially in Asian countries.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: Harvard Dataverse: https://doi.org/10.7910/DVN/R01ZTM.

Ethics statement

The studies involving humans were approved by Institutional Review Board of the Institute of Health Economics (IHE-IRB), Bangladesh. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AG: Methodology, Supervision, Writing – original draft, Validation, Investigation, Conceptualization. ED: Methodology, Conceptualization, Validation, Investigation, Data curation, Writing – review & editing, Formal analysis. QW: Formal analysis, Investigation, Visualization, Data curation, Validation, Writing – review & editing, Methodology. RD: Project administration, Writing – review & editing, Conceptualization, Supervision. BB: Resources, Writing – review & editing, Project administration, Conceptualization, Methodology. JS: Writing – review & editing, Methodology, Validation, Data curation. CR: Project administration, Supervision, Writing – review & editing, Conceptualization, Funding acquisition, Resources.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1646381/full#supplementary-material

References

Alkire, S., and Santos, M. E. (2014). Measuring acute poverty in the developing world: robustness and scope of the multidimensional poverty index. *World Dev.* 59, 251–274. doi: 10.1016/j.worlddev.01.026

Béné, C., Arthur, R., Norbury, H., Allison, E. H., Beveridge, M., Bush, S., et al. (2016). Contribution of fisheries and aquaculture to food security and poverty reduction: assessing the current evidence. *World Dev.* 79, 177-196. doi: 10.1016/j.worlddev.11.007

Dam Lam, R., Barman, B. K., Lozano Lazo, D. P., Khatun, Z., Parvin, L., Choudhury, A., et al. (2022). Sustainability impacts of ecosystem approaches to small-scale aquaculture in Bangladesh. *Sustainability Sci.* 17, 295–313. doi: 10.1007/s11625-021-01076-w

DoF, R. R. (2022). *Yearbook of Fisheries Statistics of Bangladesh, 2020-21. Department of Fisheries*. Bangladesh: Ministry of Fisheries and Livestock, 138.

Dompreh, E., Wang, Q., Su, J., Dam Lam, R., Barman, B. K., Rossignioli, C., et al. (2025). Differentiated characteristics, sustainability performance and preferences among small-scale aquaculture producers: implications for sustainable intensification. *Sustainability Sci*. doi: 10.1007/s11625-025-01703-w

FAO (2022). *The State of World Fisheries and Aquaculture 2022.* Rome: FAO.

FAO (2024). *The State of World Fisheries and Aquaculture 2024.* Rome: FAO.

Gasparatos, A., Dompreh, E. B., Wang, Q., Dam Lam, R., Barman, B., Su, J., Rossignoli, C. (2024). Survey of production characteristics and performance of small-scale carp aquaculture systems in Bangladesh. *Res. Squ.* doi: 10.21203/rs.3.rs-4429734/v1

Gasparatos, A., Von Maltitz, G. P., Johnson, F. X., Romeu-Dalmau, C., Jumbe, C. B. L., Ochieng, C., et al. (2018). Survey of local impacts of biofuel crop production and adoption of ethanol stoves in Southern Africa. *Sci. Data* 5:180186. doi: 10.1038/sdata.2018.186

Henriksson, P. J. G., Belton, B., Jahan, K. M., and Rico, A. (2018). Measuring the potential for sustainable intensification of aquaculture in Bangladesh using life cycle assessment. *Proc. Natl Acad. Sci.* 115, 2958–2963. doi: 10.1073/pnas.1716530115

Henriksson, P. J. G., Troell, M., Banks, L. K., Belton, B., Beveridge, M. C. M., Klinger, D. H., et al. (2021). Interventions for improving the productivity and environmental performance of global aquaculture for future food security. One *Earth* 4, 1220–1232. doi: 10.1016/j.oneear.08.009

Hossain, Md. E., Khan, Md. A., Saha, S. M., Dey, M. M. (2022). Economic assessment of freshwater carp polyculture in Bangladesh: profit sensitivity, economies of scale and liquidity. *Aquaculture* 548:737552. doi: 10.1016/j.aquaculture.2021.737552

Jahan, K. M., Belton, B., Ali, H., Dhar, G. C., and Ara, I. (2015). *Aquaculture Technologies in Bangladesh: An Assessment of Technical and Economic Performance and Producer Behavior.* Penang: World Fish.

Karim, M., Keus, H. J., Ullah, M. H., Kassam, L., Phillips, M., and Beveridge, M. (2016). Investing in carp seed quality improvements in homestead aquaculture: lessons from Bangladesh. *Aquaculture* 453, 19–30. doi: 10.1016/j.aquaculture.2015.11.027

Morgan, M., Terry, G., Rajaratnam, S., and Pant, J. (2017). Socio-cultural dynamics shaping the potential of aquaculture to deliver development outcomes. *Rev. Aquacult.* 9, 317–325. doi: 10.1111/raq.12137

Naylor, R. L., Hardy, R. W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H., et al. (2021). A 20-year retrospective review of global aquaculture. *Nature* 591, 551–563. doi: 10.1038/s41586-021-03308-6

Phung, T. D., Hardeweg, B., Praneetvatakul, S., and Waibel, H. (2015). Non-sampling error and data quality: what can we learn from surveys to collect data for vulnerability measurements? *World Dev.* 71, 25–35. doi: 10.1016/j.worlddev.11.008

Rossignoli, C., Dam Lam, R., Dompreh, E., and Gasparatos, A. (2023a). *Survey of production characteristics and performance of small-scale carp aquaculture systems in Bangladesh. Harvard Dataverse.* doi: 10.7910/DVN/R01ZTM

Rossignoli, C. M., Lozano Lazo, D. P., Barman, B. K., Dompreh, E. B., Manyise, T., Wang, Q., et al. (2023b). Multi-stakeholder perception analysis of the status, characteristics, and factors affecting small-scale carp aquaculture systems in Bangladesh. *Front. Sustainable Food Syst.* 7:1121434. doi: 10.3389/fsufs.2023.1121434

Short, R. E., Gelcich, S., Little, D. C., Micheli, F., Allison, E. H., Basurto, X., et al. (2021). Harnessing the diversity of small-scale actors is key to the future of aquatic food systems. *Nat. Food* 2, 733–741. doi: 10.1038/s43016-021-00363-0

Waha, K., Zipf, B., Kurukulasuriya, P., and Hassan, R. M. (2016). An agricultural survey for more than 9,500 African households. *Sci. Data* 3:160020. doi: 10.1038/sdata.2016.20

Wang, Q., Rossignoli, C. M., Dompreh, E. B., Su, J., Ali, S. A., Karim, M., et al. (2023). Sustainable intensification of small-scale aquaculture production in Myanmar through diversification and better management practices. *Environ. Res. Lett.* 18:15002. doi: 10.1088/1748-9326/acab16

Wang, Q., Rossignoli, C. M., Dompreh, E. B., Su, J., Griffiths, D., Htoo, K. K., et al. (2024). Diversification strategies have a stabilizing effect for income and food availability during livelihood shocks: evidence from small-scale aquaculture-agriculture systems in Myanmar during the COVID-19 pandemic. *Agric. Syst.* 217:103935. doi: 10.1016/j.agsy.2024.103935

WFP (2008). *Food Consumption Analysis: Calculation and Use of the Food Consumption Score in Food Security Analysis [Technical Guidance Sheet]*. Rome: United Nations World Food Programme.

Zhang, W., Belton, B., Edwards, P., Henriksson, P. J. G., Little, D. C., Newton, R., et al. (2022) Aquaculture will continue to depend more on land than sea. *Nature* 603, E2–E4. doi: 10.1038/s41586-021-04331-3