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Auburn University, United States

*CORRESPONDENCE

Aisa O. Manlosa

✉ a.o.manlosa@luc.leidenuniv.nl

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Social capital strengthens agency among fish farmers: Small scale aquaculture in Bulacan, Philippines

Aisa O. Manlosa^{1,2*}, Julia Albrecht³ and Maraja Riechers³

¹Social Sciences Department, Leibniz Centre for Tropical Marine Research (ZMT), Bremen, Germany,

²Faculty of Governance and Global Affairs – Leiden University College (LUC), Leiden University, The

Hague, Netherlands, ³Faculty of Sustainability, Social-ecological Systems Institute, Leuphana
University Lüneburg, Lüneburg, Germany

Using a case study approach focusing on Bulacan, Philippines, we examined three types of social capital (i.e. bonding, bridging, and linking) accessed by small scale aquaculture producers through fish farmers associations. The aim was to determine whether and how types of social capital contribute to promoting human agency among small scale aquaculture producers in the context of their livelihoods. Here, agency is considered an important part of sustainable livelihoods and is defined as people's ability to choose in ways that align with their values and goals, and to act to realise their goals. Agency was analysed in relation to livelihood preconditions, processes, power, and possibilities. The premise of this paper is that types of social capital from fish farmers' associations distinctly contribute to expanding and strengthening the agency of small scale aquaculture producers. The study found that all three types of social capital contributed to enhancing the resources that producers draw on for their livelihoods. The bonding and bridging types helped producers cope with various livelihood challenges by enabling access to mutual assistance and collective efforts for problem solving. The types of social capital were less effective in addressing issues of asymmetrical power relations which adversely affected livelihoods. All three types and particularly linking social capital contributed to expanding livelihood possibilities and enabling producers to explore new avenues for improving livelihoods, enhancing agency. The findings point to the distinct contributions and complementarity of different types of social capital to the exercise of agency in livelihoods. Attending to the different types of social capital and understanding how they are most beneficial in specific contexts as well as where they are insufficient, can improve priority-setting, targeting, and design for initiatives that seek to work with fish farmers organisations and other types of community-based organisations for livelihood improvements.

KEYWORDS

community-based organisations (CBO's), institutions, livelihoods, marine social science, networks, rural development, sustainable development, sustainability

Introduction

Aquaculture, if grown sustainably, is considered to have great potential to nourish the world's growing population. As of 2020, aquaculture contributed 49.2 percent to the global production of aquatic animals (FAO, 2022). In particular, small scale aquaculture supports food security, nutrition, income-generation, and the sustenance of community life for many households in the Global South (Kawarazuka and Béné 2010; Belton, 2013; Tigchelaar et al., 2022). In areas where fish production from capture fisheries has either stagnated or fallen, fish production from aquaculture has partially helped stabilise prices and maintain fish consumption (Belton et al., 2014). Small scale aquaculture has provided former farming households with an alternative livelihood to transition to in some areas with increased incidence of saline water intrusion (Manlosa et al., 2021). Moreover, it stimulates local economies by creating entrepreneurial and employment opportunities through the establishment of ancillary enterprises for inputs such as fingerlings, feeds, and other materials and equipment for production. Thus, small scale aquaculture holds significant potential to contribute to realising the Sustainable Development Goals (SDGs) (Thilsted et al., 2016) particularly in key geographies of the Global South such as Southeast Asia, South Asia, and Africa.

However, small scale aquaculture is also confronted with social and ecological challenges which can compromise its potential to alleviate poverty, realise food security and nutrition, and foster environmental stewardship (e.g. Mwanja and Nyandat, 2013; Manlosa et al., 2021). Tropical coastal areas where brackish water aquaculture is often situated is prone to hazards such as typhoons and flooding (e.g. Engelhard et al., 2022). Flooding can cause collapse of earthen fish ponds which can be expensive to repair. It can also wash away farmed fish leaving households with less or none to harvest. Water pollution from various sources threatens the viability of small scale production (Manlosa et al., 2021). With less capital owned and limited access to financing (Avadi et al., 2022) relative to large scale producers, small scale aquaculture producers¹ have fewer resources for coping and are vulnerable to the impacts of these environmental stressors. In addition, small scale aquaculture producers are often embedded in market arrangements in which they are price-takers, with little opportunities to negotiate prices to their advantage. Such arrangements in the value chain lead to small scale producers receiving the least economic benefit from the fish they produce (Bjorndal et al., 2014).

Given the important role of small scale aquaculture in achieving desirable sustainability outcomes and the challenges it faces, suitable and effective support needs to be put in place that can help address the challenges confronting the sector (Tigchelaar et al., 2022). Community-based fish farmers' associations are among the key institutional structures typically established at the local scale to support small scale aquaculture producers (Galappaththi and Berkes, 2014). The social capital derived from membership in

community-based associations contribute to the livelihoods of small scale aquaculture producers in various ways.

Since early 2000s, the concept of social capital has been extensively studied within the development sector (Pretty and Ward, 2001; Adler and Kwon, 2002). More recently, social capital has been examined in the context of aquaculture particularly in relation to post-disaster recovery (Marin et al., 2015), profit (Duy et al., 2022), resilience (Kriegel et al., 2022), and entrepreneurship (Mozumdar and Islam, 2022). Existing research details the contribution of social capital to local livelihoods including how it influences people's uptake of innovation and how it influences livelihood outcomes (Donkor and Mearns, 2018). Others critique the concept and outline pitfalls in its application (Inaba, 2013). The key contribution of our study is in refracting the concept of social capital into its constitutive types (i.e. bonding, bridging and linking) and connecting it explicitly with the concept of human agency in the context of small scale aquaculture. To the best of the our knowledge, this is the first study that explicitly views livelihoods as an area for expanding human agency and examines the connections between *types of social capital* and the *pillars for expanding human agency* in the context of small scale aquaculture livelihoods.

Before proceeding, a few clarifications for the concepts we are working with. Here we define agency as the capacity of individuals or of groups to make choices on the basis of their values (Brown and Westaway, 2011), to act on those choices to realise their goals (Kabeer, 1999), and to be active agents writing history through their daily lived experiences (McLaughlin and Dietz, 2008). Agency is an important basis for sustainable livelihoods (Clay, 2018; Lawless et al., 2019), and an important outcome of it (Brocklesby and Fisher, 2003; Manlosa, 2022). When local livelihoods deteriorate or are lost due to a combination of environmental and social factors, it is not only material production that is eroded but also the human agency that is enabled by people's livelihoods. Along these lines, a sustainable livelihood is not only one where material outcomes meet people's needs for a healthy and flourishing life, and one that is able to bounce back after shocks, stresses, and perturbations, it is also one that enables and expands the human agency of those who undertake it (Manlosa, 2022). Sustainable livelihoods therefore support people's agentic roles in various areas of life such as self-determination, participation in community life, and political involvement. At the same time, it is itself a generative area where the exercise of agency is vital.

The premise of this paper is that expanding and strengthening the agency of small scale aquaculture producers is vital to addressing different sustainability challenges facing the sector (*sensu* Westley et al., 2013), and that fish farmers' associations can contribute to this outcome in distinct ways. Thus, we examine the contributions of fish farmers' associations to expanding agency in the livelihoods of small scale aquaculture producers through the concept of social capital. The concepts of human agency and social capital are distinct, but they do involve some overlap. For instance, both concepts are concerned with actions. We briefly distinguish the two concepts here. On one hand, human agency is involved in the creation and emergence of social capital. It occurs when people, on the basis of their reasoning, choices, and values take the initiative

¹ The terms small scale aquaculture producers and fish farmers are used interchangeably in this manuscript and refer to the same group.

to establish relationships with other people. On the other hand, and as argued in this paper, social capital can contribute to strengthening human agency. But while human agency pertains to a generative individual capacity, social capital is essentially concerned with relationships and is therefore irreducibly about the connections between individuals and groups. They can be mutually reinforcing when individual capacity (agency) enables relationships (social capital) and when relationships enhance individual capacity.

We used a qualitative empirical case study approach focusing on the province of Bulacan in the Central Luzon region of the Philippines where aquaculture is an important food production sector. For the period 2005–2020, the Philippines was the eleventh major producer of aquatic animals through aquaculture. As of 2020, aquaculture production reached 854 thousand tonnes for aquatic animals (FAO, 2022). According to Primavera (1995), the Philippine government sponsored a fishpond boom from the 1950s to the 1960s. A shrimp boom started in the 1980s aided by the availability of hatchery-produced seeds and imported feeds, and public and private sector financing. The giant tiger prawn *Penaeus monodon* emerged as an important cash crop intended mainly for urban and export markets (Primavera, 1995). The same shrimp boom and the bust that followed also occurred in the study area we focus on. Presently, milkfish is the most important aquaculture commodity in our case study in terms of production volume; it is then followed by prawn (Manlosa et al., 2021). Milkfish is widely consumed particularly in the northern part of the Philippines, and is typically destined for local and regional markets.

The primary aim of our study is to establish a better understanding of the mechanisms through which types of social capital from fish farmers' associations contribute to expanding human agency of aquaculture producers in the context of small scale aquaculture livelihoods. In particular, the objectives of the study are to: (1) investigate the types of social capital that small scale aquaculture producers access through fish farmers associations; (2) examine how the different types of social capital contribute to the four pillars of human agency in livelihoods (i.e. preconditions, processes, power, and possibilities); and (3) outline action areas for strengthening the effectiveness of fish farmers' associations in promoting the agency of small scale aquaculture producers. The concepts used in this study are discussed in the following section.

Conceptual framework

For decades, livelihood research has been an important focus and topic within the broader development and environment discourse (Chambers, 1987; Chambers, 2011; Scoones, 2015), and more recently, within sustainability and social-ecological systems research (Manlosa, 2022). This is because people's livelihoods, including its processes and outcomes, have a direct influence on people's well-being and the environment. Sustainable livelihoods have been defined as those that can cope and recover from stresses and shocks, and enhance people's capabilities and assets without undermining the natural resources on which livelihoods are based (Scoones, 1998). Livelihoods are the primary means through which

households and individuals support themselves and secure their well-being (see Box 1 for definitions of key terms). Small scale aquaculture livelihoods are important for the availability and accessibility of aquatic food (e.g. fish, crustaceans) which are sources of proteins and nutrients (Tigheelaar et al., 2022). Income from small scale aquaculture enables households to meet needs not only for food, but also those related to maintaining homes, sending children to school, and accessing health care, among others. In addition to the material benefits generated from such livelihoods, there are intangible social and cultural benefits involved such as the reproduction of social relationships in communities (van Dijk, 2011), the sharing of knowledge and practices, mutual assistance in social networks, and the cultivation of a sense of self-efficacy when people achieve desired outcomes through their livelihoods.

Human agency has been a central focus in the sustainable livelihoods thinking in the 1980s (Clay, 2018). However, as applications of the concept of sustainable livelihoods became more instrumental and materialist in orientation (Sakdapolrak, 2014), the concept of agency has received less attention with the exception of feminist streams of livelihood scholarship where the centrality of human agency continues to be foregrounded (Kabeer, 1999; Lawless et al., 2019). The re-centering of human agency is argued to revitalise the concept of livelihoods and to strengthen the contribution of livelihood research to broader sustainability discourses (Manlosa, 2022). While an agency-centered framing of livelihoods has been applied in a number of studies, its application in the aquaculture sector is relatively new and needed.

Human agency encompasses people's ability to genuinely choose in a way that aligns with their values and goals, and includes the capacity to act to realise those goals (Kabeer, 1999; Brown and Westaway, 2011). It is a concept that is at the heart of

BOX 1 Glossary of terms.

- Social capital** – networks that link different actors together, facilitate the exchange of resources, and enable collective action to achieve shared goals.
- Bonding social capital** – closed networks of people with similar socio-economic backgrounds.
- Bridging social capital** – networks of external groups that organise to achieve shared goals.
- Linking social capital** – connections between the civic community and more influential private and public actors.
- Livelihoods** – the primary means through which households and individuals support themselves and secure their well-being.
- Agency** – a key basis and outcome of sustainable livelihoods. The capacity of individuals or of groups to make choices on the basis of their values, to act on those choices to realise their goals, and to be active agents writing history through their daily lived experiences.
- Preconditions** – the capital assets or resources that serve as the building blocks of livelihoods.
- Processes** – social-ecological feedbacks and dynamics within livelihood cycles.
- Power** – socio-cultural and political contexts including the institutions and power relations within which local livelihoods are embedded.
- Possibilities** – whether present livelihoods are expanding the possibilities and opportunities available to households and individuals. Concerned with what present livelihood benefits mean for people's future options.

empowerment, freedom, and people's capacity to be active agents who are able to influence and write history, in their own lives and in the society to which they belong (McLaughlin and Dietz, 2008). Agency is an important basis as well as a key outcome of sustainable livelihoods (Manlosa, 2022). When agency is constrained or diminished, people may still be able to undertake livelihoods, but the choices underpinning their actions are either narrow or non-existent. The lack of agency results in unfreedom and the erosion of people's well-being. Selling off one's agricultural land to work as a low-wage labourer as a result of forces beyond an individual's control, selling one's produce at very low prices which producers cannot influence nor negotiate, and having no control over the decision-making of one's income are examples of livelihoods characterised by constrained agency. These are often associated with poverty and diminished human well-being through a series of negative effects on people's ability to provide for themselves.

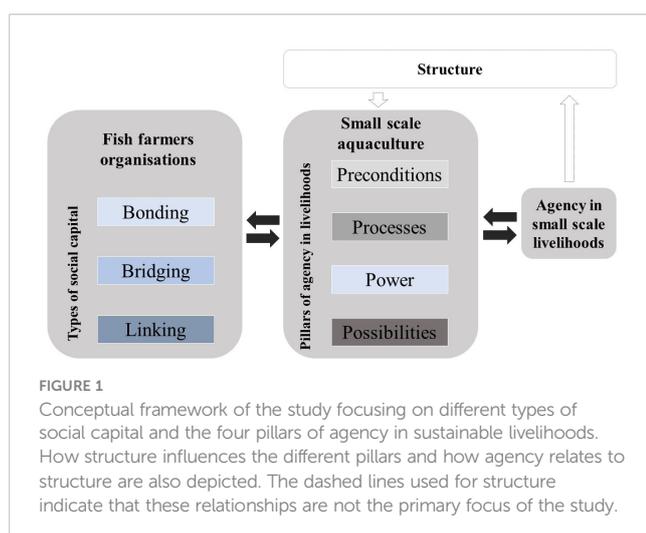
Human agency is multi-faceted and can thus be examined from multiple perspectives (e.g. Kabeer, 1999; Brown and Westaway, 2011). In sustainability discourse, agency has been examined in terms of people's participation in political processes and whether they are able to influence decision-making processes (e.g. Westley et al., 2011). However, as Chappell (2018) explains in the context of food systems, it is difficult for small scale producers to participate in political and decision-making processes when meeting fundamental needs such as food and income is a challenge. This study is therefore premised on a conceptualisation of livelihoods as an important area for expanding human agency (Manlosa, 2022). The fundamental argument here is that people's agency, or their power to choose, to decide, to act, and to be active agents who are able to shape the course and outcome of their lives, are influenced and enabled by their livelihoods along with broader scale and structural factors. The challenges that people face in their livelihoods, whether experienced as a direct impact of environmental change, or as an outcome of broader decisions, policies, and social systems, impact on human agency.

This study drew on the first author's previous work that operationalised the concept of agency in livelihood research using four pillars namely *preconditions*, *processes*, *power*, and *possibilities*

(Manlosa, 2022) (Figure 1). Preconditions refer to the capital assets and resources which serve as the building blocks of livelihoods. In the absence of access to certain capital assets and resources, certain livelihoods are closed off as options. Preconditions and its effects on livelihoods can be measured in a cross-sectional manner which allows for capturing relationships at a single point in time. However, people's access to capital assets and resources are dynamic. A more dynamic approach to studying capital assets and resources such as the socially embedded conceptualisation of van Dijk (2011) is more suitable for capturing flux in livelihood preconditions. Processes refer to social-ecological feedbacks and dynamics within livelihood cycles. For instance, environmental changes such as decreased soil fertility or decreased water availability in farming livelihoods can trigger coping strategies such as selling assets to generate money. This can eventually erode capital assets and resources and weaken the basis of livelihoods and what households are able to do in the next production cycle. The third pillar which is power, broadly refers to the socio-cultural and political contexts including the institutions and the power relations within which livelihoods are embedded. Power relations on the basis of intersecting axes of social differentiation such as gender, class, religion, age, ethnicity, ableism, among others, influence patterns of access to and control over resources, who is able to decide on what, whose influence prevails, who is able to participate in which activities, how tasks and responsibilities are allocated and negotiated, and how livelihood benefits are distributed. Power relations are therefore deep drivers of livelihood outcomes and these are upheld by societal structures, institutions, norms, and deeply embedded world views. The fourth pillar which is possibilities, goes beyond questions of livelihood productivity, and interrogates whether present livelihoods are expanding the possibilities and opportunities available to households and individuals. This pillar is therefore, not only concerned with present benefits from livelihoods, but about what present benefits mean for people's future options. Livelihoods that expand possibilities are those that generate earnings, expand knowledge, strengthen skills, and foster connections that make other livelihood trajectories an option, whether due to a need to adopt to conditions that make present livelihoods untenable, or because a livelihood change is desired. Taken together, these pillars provide a basis for analysing the extent to which people are able to define their goals in the context of their livelihoods and to act upon them.

The identification of the four pillars raise questions concerning the way agency relates to structure. Here, preconditions, processes, power, and possibilities in the context of livelihoods are directly or indirectly influenced by structure such as institutions. Our framework therefore does not separate agency from structure but takes the view that both can influence the other. While the two are distinct and irreducible, they are also interrelated in that certain structures can enable or constrain agency, just as agency can induce structural changes. Karp (1986, 131) describes it as "...structure is an emergent property of action at the same time that action presupposes structure as a necessary condition for its production."

Our study also draws on the concept of social capital (Figure 1). Several definitions of social capital exist. For instance, Bourdieu



(1986) defines social capital as “the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalised relationships of mutual acquaintance and recognition” (p. 21). Bourdieu’s concept of social capital contains two elements: social structures and the exchange of resources. Social structures such as networks or organisations connect individuals. By connecting individuals, these structures enable the exchange of material (e.g., money) and non-material resources (e.g., trust). Putnam (1995), on the other hand, defines social capital as the “features of social organisation such as networks, norms and social trust that facilitate coordination and cooperation for mutual benefit” (p. 67). According to Putnam’s definition, the three main elements of social capital are networks that enable the exchange of resources, norms of reciprocity, and *trust* in the reliability of others. Drawing on these definitions, social capital in this study is defined as the networks that link different actors together, facilitate the exchange of resources, and enable collective action to achieve shared goals. Research distinguishes between *bonding*, *bridging*, and *linking* social capital. Bonding social capital refers to closed networks of people with a similar socio-economic background (e.g., family members, close friends, neighbors) (Claridge, 2018). Bridging social capital refers to networks of external groups that organise to achieve shared goals (Pelling and High, 2005). Linking social capital refers to building connections between the civic community and more influential private and public actors (Woolcock, 2001; Szreter and Woolcock, 2004).

We unpack the different types of social capital accessed by small scale aquaculture producers through fish farmers organisations and investigate whether and how they contribute to the pillars of agency namely preconditions, processes, power and possibilities in the livelihoods of aquaculture producers. The next section provides a background on methods.

Methods

Background on case study

The Central Luzon Region is an important area for aquaculture production in the Philippines. It generates some of the highest economic value from aquaculture production in the country (Philippine Statistics Authority, 2020). The province of Bulacan is situated in this region. Our study area focuses on three adjacent municipalities in Bulacan, namely: Paombong, Hagonoy, and Malolos. All three municipalities have brackish water aquaculture production primarily through earthen fish ponds, although marine fish cages have also started to contribute to the overall production. Milkfish and prawn are the most important species in terms of production volume and economic value, but tilapia and mudcrabs are also produced. Both small scale and large scale aquaculture production operate in the area and produce these species, but given our objectives, this study focuses only on small scale aquaculture production.

The rise of aquaculture in the area began when saline water intrusion started to negatively affect rice farms in the coastal areas

(Manlosa et al., 2021). This led rice farmers to initially shift to fish farming at certain points in the year when salinity was highest. Over time, the high demand for aquaculture goods from proximate urban areas (Saguin, 2018), its profitability, the emergence of ancillary industries which gave producers access to fingerlings, feeds, information, technology, and markets, and environmental change which rendered rice farming unviable led to the establishment of aquaculture as an important aquatic food sector in the case study (Manlosa et al., 2021). According to the Bulacan Provincial Fisheries report, as of 2017, there were 1,018 brackish water fish farmers in the three municipalities operating over an estimated area of 8,926 hectares.

Although there is no formal classification of the scale of production in the study area, local fish farmers and government representatives described small scale aquaculture as one that covers 1 to 10 hectares of land. Small scale aquaculture production² is typically done in backyards. Most small scale producers source their fingerlings from local nurseries, particularly in the town called Paombong. Nursery operators, in turn, source out fry from Indonesian suppliers. Since most ponds combine a number of species such as milkfish and prawn in a single pond, newly stocked fingerlings are sometimes kept in a small enclosure when they are first introduced into the pond to reduce predation by larger species (Figure 2). They are then released from the enclosure at a later time when they are deemed large enough. Among small scale producers particularly those growing milkfish, locally grown algae is used as feed during the early stages of stocking and growing. It is then supplemented with industrially produced synthetic feed nearer to the harvest season in order to accelerate fish growth. Large scale aquaculture ranges from tens to over a thousand hectares of either owned or leased land. Large scale producers similarly source fingerlings from local nursery operators but typically buy from multiple operators to supply their higher needs. They rely on synthetic feed from stocking until the harvest period.

Aquaculture goods are typically sold in local fish markets which are ran by middlemen. Producers bring their goods to the middlemen who set the price. The middlemen, in turn, run auction processes in which goods are sold to the highest bidder. Local vendors, regional traders, and some large scale exporters typically buy fish from the middlemen.

Various sustainability challenges confront the aquaculture sector in the case study. These include water pollution from various sources including large-scale and intensive aquaculture, and domestic and industrial sources leading to higher incidences of fish kills due to changes in biochemical oxygen demand (BOD) and dissolved oxygen (DO). The area is also regularly exposed to typhoons and flooding which pose risk to people’s livelihoods and income. Land scarcity is increasingly becoming an issue with increased competition for land from locals who want to expand their aquaculture production, new investors from nearby urban areas looking to engage in aquaculture (e.g. Saguin, 2018), and real estate investors who are keen on building new residential and

² No data was collected for stocking densities and length of grow-out period for both small scale and large scale production.



FIGURE 2
Brackish water earthen fish pond in Bulacan, Philippines.

commercial areas. This increased demand for land had led to a steep increase in the price of land leased for aquaculture, effectively pricing out some of the small scale aquaculture producers and limiting their capacities to expand.

In this context, fish farmers' associations are multi-functional, community-level organisations which connect small scale aquaculture producers to one another, and to state actors. The establishment of such organisations throughout the country was stipulated in the Philippine Fisheries Code which is the country's national law on aquatic food production passed in 1998. In the study area, the Central Luzon regional office of the Bureau of Fisheries and Aquatic Resources sought to increase the relevance and efficacy of their livelihood assistance and service delivery. With this aim, the bureau moved towards working more closely with local government units, Municipal Agriculture Offices (MAOs), and local associations to improve targeting of livelihood needs of small scale aquatic food producers and to design livelihood assistance projects to address identified needs (Manlosa et al., 2021). This meant that when aquaculture producers became members of fish farmers' groups, they could specify and communicate to association leaders the type of livelihood assistance they wish to receive. Leaders then pass on the requested livelihood assistance to government actors. This arrangement incentivised membership in associations and thus contributed to the establishment of more fish farmers' organisations in the recent years.

Fish farmers' associations elect their group leaders and function with autonomy in that they are able to self-determine their aims and objectives for organising. They are able to determine and organise their activities and discussions in line with their group's interests. Typically, fish farmers' associations are registered with the government. While they are able to self-organise, many of the activities that members of fish farmers organisations participate in, are organised by the government including trainings, and municipal or higher level meetings (see Manlosa et al., 2021 for details on institutions and community-based organisations in the case study).

Democratic processes within the fish farmers' organisations are supported by the Bureau of Fisheries and Aquatic Resources which is the government office primarily responsible for capacitating local

small scale producers to organise, connect with various actors, and gain a better understanding of the office's operations for more effective collaborations. The regional office of the bureau which operates within the broad scope of Central Luzon established a satellite office in the municipality of Hagonoy where government staff from the regional office regularly visit. The regional staff are further supported by Fisheries and Livelihood Development Technicians (FLDTs) who conduct regular visits to communities to interact with local small scale producers and liaise with local government representatives, ensuring sustained communication and collaboration. In addition, the bureau regularly organises and finances meetings among representatives of fish farmers organisations from different municipalities and provinces within the region to stimulate exchange and collaborations beyond the local level. Notwithstanding such support for democratic processes, members of fish farmers organisations also exercise caution in navigating interactions with government actors particularly politicians from the local government units whose support may be needed for projects and initiatives but whose interests may run contrary to that of the smallholder producers.

Data collection and analysis

This study used qualitative data from in-depth interviews conducted from November 2019 to March 2020. A total of 67 interviews were conducted with stakeholders in the aquatic food sector including government actors, market actors, fishers, and small scale aquaculture producers which had the broader aim of generating understanding of the coastal social-ecological changes that have happened in the area in the past decades and how institutions also changed in the process. This was further supplemented by a focus group discussion, and participant observation of organisations' and people's activities (e.g. organisation meetings, meetings with government actors, aquaculture harvesting, selling in fish markets) to gain an in-depth understanding of the case study.

Of the total number of interviews, a smaller subset of 36 interviews which focused on the contributions of fish farmers' associations to the agency of aquaculture producers were selected and analysed. The selected interviews included aquaculture producers from different fisherfolk organisations (n=13), middlemen from local fish markets (n=12), and representatives of relevant government offices and councils (n=11). The interviews were selected using non-random purposive sampling which means that the interviewees were selected on the basis of their involvement in small scale aquaculture. Specifically, the selection applied snowball sampling in which interviewees were identified and invited to participate based on information and recommendation from earlier interviewees.

Prior to each interview, the aim and objectives of the study were explained and consent of the interviewee was sought. The rights of the interviewee to anonymity, to decline to answer some questions when desired, and to withdraw from the interview at any point were emphasised. The interviews were conducted by the first author in Tagalog (also called Filipino). Following consent, each interview

was recorded using a voice recorder, and was transcribed into English. The resulting transcripts were given alpha-numeric identifying codes to maintain the anonymity of interviewees, as agreed on, prior to the start of the interview. More information on the study area and data collection can be found in a previous publication (Manlosa et al., 2021).

A qualitative content analysis was employed to analyse the interviews. This is a particularly suitable method as it analyses the informational content of qualitative data and identifies patterns in responses (Forman and Damschroder, 2007). All 67 interviews were first coded inductively to capture emerging themes and general case study information. Then, using the smaller subset of 36 interviews, we analysed the different types of social capitals in fish farmers associations. Following the definitions for different types of social capital provided in the previous section, for bonding social capital, we looked for linkages and connections between those with similar socio-economic backgrounds and close social relationships. In the study area, this included relationships between neighbours and relatives. For bridging social capital, we mainly looked at networks of external groups that organised to achieve shared goals. In the case study, this included collaborative connections between different fish farmers organisations. Finally, we looked at linking social capital which refers to connections between the civic community and more influential private and public actors. Contextually, this included connections between fish farmers' associations and government actors particularly the local government units at the municipality level and the Central Luzon office of the Bureau of Fisheries and Aquatic Resources. We then thematically examined whether and how these different types of social capital contributed to expanding human agency in small scale aquaculture livelihoods by contributing to improved preconditions of livelihoods, improved processes such that livelihood challenges are addressed through virtuous coping strategies rather than maladaptive strategies, improved capacities to navigate or change asymmetric power relations including the socio-political structures that undergird these relations, and improved possibilities or expanded options, opportunities, or benefits from their current livelihoods.

Findings

The three types of social capital (i.e. bonding, bridging, and linking) were all observed in fish farmers' associations in the case study. These types of social capital were enabled by the multi-functionality of fish farmers' associations and their diverse activities. Fish farmers' associations were multi-functional in the sense that *de facto*, they served multiple purposes. For instance, they were the primary means through which small scale aquaculture producers were connected with government offices. Such connections, in turn, enabled producers to access various forms of livelihood assistance (e.g. free fingerlings, free trainings). Associations also functioned as platforms for collective discussions of livelihood problems and opportunities, as focal points for responding to various collective action problems, and as support systems for fish farmers during times of crisis and personal difficulties.

Aquaculture producers accessed *bonding* social capital when fish farmers' associations connected and enhanced social cohesion among neighbours who similarly depended on small scale aquaculture for their livelihoods. *Bridging* social capital emerged from collaborative initiatives among members of different fish farmers associations to address shared challenges such as accessing livelihood inputs (e.g. fingerlings, feed) and strengthening their market position. Fish farmers' associations also provided *linking* social capital by fostering a collective identity, recognition, and legitimacy, which opened opportunities for formal partnerships with government actors particularly the municipal local government units and the Bureau of Fisheries and Aquatic Resources. In the following sub-sections, we detail whether and how the different types of social capitals contributed to the four pillars of agency in sustainable livelihoods.

Social capital and livelihood preconditions

Preconditions refer to the capital assets and resources that provide the basis for sustainable livelihoods. In the case study, the three types of social capital (i.e. bonding, bridging, and linking) contributed to enhancing livelihood preconditions of small scale aquaculture producers albeit in differing ways.

Fish farmers associations were established in a bottom-up manner on various grounds. Some groups were formed based on a shared residential location, that is, amongst members who reside together in one neighbourhood. Several fish farmers' associations in the area therefore consisted of members who shared similar livelihoods and were neighbours. An example is an association called KAPISAN which was named after the barangays³ where the members reside: Kapitangan, Pinalagdan, San Isidro, Sto. Niño, San Roque, and Sta. Rosario. Membership in the same association among neighbours enhanced the bonding type of social capital by stimulating further interactions, fostering livelihood-focused discussions, and creating new or strengthening existing relationships. One of the ways in which members strengthened their connections was through conducting regular meetings in the home of one of the members, sharing meals or snacks, and allocating time for informal conversations. Group members took turn hosting meetings. The bonding social capital between neighbours contributed to enhancing livelihood preconditions through sharing of various types of needed resources, including information resource. Such sharing occurred, for instance, when a fish farmer visited a neighbour to ask questions, during chance encounters in the neighbourhood, or during association meetings. The information shared related mostly to prices of aquaculture goods, and where to source better quality or better priced livelihood inputs. *"I pick up information through informal conversations. We help one another. I adopt the good things that I pick from the conversations. There are technicalities involved in running a fishpond. I just ask others when there is something I don't understand and I know that they know more than I do. For instance, I hear about a respected person here. I would ask for the person's number and ask my question. From there, a relationship is built."* (Female nursery operator in Paombong)

Fish farmers' associations provided bridging social capital by connecting small scale aquaculture producers from different

associations and from different locations of the case study. Such bridging connections were common because members of different associations could regularly meet through events organised at the municipality level by government actors. Bridging social capital contributed to enhancing livelihood preconditions also through informal sharing of information. This was facilitated by the establishment of online communication channels. One member of an association explained how fish farmers developed a Facebook group chat for posting livelihood-related questions such as where to buy affordable and good quality feed, or where to access fingerlings when aquaculture producers want to explore other fingerling providers. Open communication channels helped with communicating needs as well as enabling others to help and respond to expressed needs. But in addition to enhancing access to information, bridging social capital also provided opportunities to increase access to physical capital. For instance, small scale aquaculture producers were able to borrow an electric pump (used to drain fish ponds) from a different association when the pump owned by their association broke down or was used by another member. During the Covid-19 pandemic in the year 2020, when access to local fish markets was disrupted, a vehicle provided by a member of an association enabled a group of small scale producers to explore markets in farther cities and municipalities and sell their goods elsewhere.

Linking social capital between fish farmers' associations and government actors facilitated access to a wider range of livelihood preconditions. By registering with government actors, fish farmers' associations were able to communicate the type of assistance they needed from government actors. The type of assistance preferred, was in turn, determined through discussions among association members. Some of the assistance included direct access to fingerlings, provision of boats, capacity development for fish processing (e.g. deboning, smoking, packaging, selling of value-added products), access to government-managed cold storage and processing facilities, and access to low-interest financial loans for individual producers as well as financial grants for groups. The first author had accompanied small scale aquaculture producers in the cold storage facility of the Bureau of Fisheries and Aquatic Resources where the producers made ice free of charge. The ice was then transported to a fish market and was used to cool the goods in smallholder producers' ice boxes.

Social capital and livelihood processes

Livelihood processes refer to the dynamics involving livelihood challenges and coping strategies, and how ways of coping can either diminish or maintain the capital asset and resource base on which a livelihood depends for subsequent production cycles. For small scale aquaculture producers in the case study, the most critical livelihood challenges were driven by environmental challenges namely water pollution and flooding. Both required aquaculture producers to implement strategies to cope with fish kills, fish being

washed away by flood, and damaged fish ponds. Households typically had to cope with livelihood challenges on their own, without adequate safety nets such as insurances or government support. With limited access to low interest and formal financing services, fish farmers typically accessed finance through informal channels such as the fish market middlemen. However, those arrangements then locked fish farmers into selling their produce to the middlemen to which they are indebted. *"You are lent money on the condition that you will bring your fish to the middleman who lends you the money."* (Small scale aquaculture producer in Paombong)

During periods of sudden and severe disruptions to livelihoods such as those experienced during the first Covid-19 pandemic lockdown in 2020, bonding social capital helped people cope by enabling food sharing at a time when opportunities to earn disappeared, and access to markets were limited. *"People in our neighbourhood will not leave you without assistance. Mutual help is never gone. Even if you don't speak, if they know you are in need, they will help."* (Male resident in Paombong) In one case, a fish farmers association which regularly collected monetary contributions from its members to fund its activities, used the funds to purchase and distribute food to families in their neighbourhood who were struggling due to livelihood disruptions and decreased earnings. The bonding social capital among neighbours and relatives also helped them cope with reduced access to fish markets. When established fish markets in the area limited their operations to comply with lockdown rules, aquatic food producers were able to sell some of their produce to neighbours and relatives either by hawking or by posting the goods for sale on social media. This enabled producers to gain some earning and local residents to access food.

Bridging social capital, here referring to the connections between different fish farmers' associations, also aided producers in navigating the challenges they faced in their livelihoods. In the 2010s, fish farmers as well as capture fishers were negatively affected by worsening water pollution. Fishes in earthen ponds died and various aquatic species in estuaries disappeared. Bridging social capital enabled fish farmers and fishers from different organisations to report the concern to their local government unit and to collectively demand for a public hearing with the aim of addressing the worsening water pollution. Pollution was widely perceived to have been caused by intensive and large scale aquaculture producers who excessively used commercial feeds and disposed water to streams and estuaries without proper treatment. However, the impact of the public hearing remained limited and did not result in the regulation of intensive aquaculture nor in any concrete pollution mitigation measure. At the community level, bridging social capital was perceived as helpful in changing producers' pond preparation practices to address water pollution at a lower scale. Those who attended trainings on environmentally-friendly pond preparation practices shared their newly acquired knowledge and advocated for a change in practice with fish farmers from other associations. This helped shift pond preparation practice from the use of the highly toxic sodium cyanide (used to kill off organisms in the pond before restocking) to the government-prescribed teaseed powder which is milder and

3 A barangay is the smallest political jurisdiction in the Philippines.

considered more environmentally-friendly. *“I would explain to my friend that the chemical she is using, for example sodium cyanide, is harmful to the environment and will have side effects which can affect the people who will be eating the produce from these fish ponds. These side effects may have long term effects for these people. We have learned these things in the trainings that we attended.”* (Small scale aquaculture producer in Paombong)

Social capital and power

There were several asymmetric power relations in the case study which have an important impact on the sustainability of aquaculture as a livelihood. On one hand, there was power asymmetry between small scale aquaculture producers and intensive large scale aquaculture producers. The latter were widely perceived by the former as being one of the main sources of water pollution due to their feeding practices, often involving excessive use of synthetic fertilisers, and the lack of water treatment mechanisms. In an interview, an intensive large scale producer described their practice of using a machine to scrape sludge from the bottom of their aquaculture cage at the end of the harvest season and dumping the sludge to adjacent water bodies. Most intensive producers rear milkfish and prawn which are sold at a large scale, either for export or for equally lucrative regional markets.

As described above, despite efforts from fish farmers' associations to utilise their linking social capital through discussions with local government units and the Bureau of Fisheries and Aquatic Resources, water pollution from large scale intensive aquaculture remains unaddressed. Some of the politicians elected to serve in local government units were also involved in intensive production or were related to large scale producers. Small scale producers therefore perceived politicians' involvement in intensive production as well as rich producers' influence over political processes as one of the reasons for inaction. Effectively enforced rules on the use of commercial fertiliser and proper treatment and disposal of polluted water from intensive fish ponds is still missing. Thus, linking capital has been insufficient to mitigate the influence and power of large scale aquaculture producers over government decisions and inaction on water pollution. *“I can't remember how many resolutions we passed about this. We are only told it is noted, but without any action.”* (Small scale aquaculture producer in Paombong)

Another important power asymmetry was observed in the relationship between small scale aquaculture producers and middlemen in fish markets who set prices and buying arrangements. Linking social capital played the most significant role in indirectly addressing this power asymmetry. Through their connections with government actors, small scale producers received administrative support and guidance for organising into a cooperative. Linking social capital with government actors also opened doors to connect with other markets beyond the fish farmers' own localities, which in turn gave them a chance to experience and learn from other market arrangements outside of the middlemen-dominated market institution they had been used to. From 2020 to 2022, the partnership between fish farmers'

associations and government actors enabled the former to access training for fish processing and value-adding which led a fish farmers' cooperative to launch new products (e.g. marinated and smoked milkfish). Exploring other market avenues outside of established fish markets in their localities and diversifying the products they could bring to the market helped fish farmers experiment and start to explore options for reducing dependence on dominant middlemen-centred market arrangement.

Social capital and possibilities

Possibilities refer to the opportunities that open up to fish farmers in the context of their livelihoods and is tightly linked with agency. Among the different types of social capital, linking capital was most significant in terms of enabling fish farmers to find and take advantage of new livelihood opportunities. Through linking social capital, members of fish farmers' associations were able to access capital assets and resources that they otherwise would not have been able to access on their own or through the two other types of social capital. Fish farmers' membership in associations and the government's recognition and partnership with those associations enabled the former to access low-interest loans instead of relying on market middlemen for financing. The loans enabled fish farmers to further invest in their livelihoods. Moreover, the multiple benefits that fish farmers accessed through the government including education (e.g. through various trainings and field schools), capacity development (e.g. for fish processing), cold and storage facilities, and grants (e.g. for live fish storage for transport) enabled different associations to establish one new integrated group in 2018 called Nagkakaisang Samahan ng mga Mangingisda ng Paombong which can be translated to United Association of Fisherfolks of Paombong (NASAMAPA). NASAMAPA has since been able to establish itself as a cooperative. It has started to be involved in processing some local produce from its members, and selling the market products at higher prices because of value addition. These changes are opening new practices and possibilities for the local fish farmers.

Discussion

This study highlighted how bonding, bridging, and linking social capitals from fish farmers' associations contribute to promoting agency in the context of small scale aquaculture livelihoods. In summary, all three types of social capital contributed to improving livelihood preconditions among fish farmers, albeit it was the linking type that was most helpful in enabling access to large physical assets such as cold storage and fish processing facilities, and financial services. This was particularly important in a smallholder aquaculture context where producers were unable to afford costly physical assets. In terms of livelihood processes, bonding social capital provided support in times of crisis such as the Covid-19 pandemic and bridging social capital was particularly helpful in inducing collective action to address water pollution although the results of this action were limited. Linking

social capital helped fish farmers navigate asymmetric power relations in their livelihoods, particularly in markets through enhancing livelihood preconditions and by enabling fish farmers to explore other market avenues. However, linking social capital was insufficient to address water pollution from intensive aquaculture. Linking social capital played a significant role in opening new possibilities for fish farmers. This was made possible by cohesive relations aided by bonding social capital, and collective action aided by bridging social capital. In a nutshell, different types of social capital matter for strengthening agency among small scale aquaculture producers in the context of their livelihoods. This is consistent with the findings of Slijper et al. (2022) who studied how different combinations of bonding, bridging, and linking social capital are related to social processes such as adaptation and transformation. Here, the types of social capital differed in contribution to the four pillars of agency in the context of aquaculture livelihoods, and linking social capital emerged to be the most significant across all four pillars. However, all three types can also be mutually reinforcing, such as when the bonding and bridging types create the conditions that enable effective partnership with government actors (linking type).

In this section, we discuss the results in terms of the insights they contribute to (i) examining the link between social capital and human agency, (ii) addressing the importance of power in social capital research, and (iii) discussing how benefits from fish farmers' associations not only in the case study but also in comparable areas can be further strengthened and supported. We then conclude with how these insights on social capital in small scale aquaculture matter for achieving sustainability in the aquaculture sector.

Different types of social capital benefit small scale aquaculture

While livelihoods may not be the most common arena in which human agency is typically examined and its expansion is pursued, livelihoods particularly of small scale producers are a vital basis for human agency (e.g. Chen et al., 2020). Within their livelihoods, people are able to actively pursue and realise goals in a way that advances their well-being and shapes the future they value and aspire to (Manlosa, 2022). When livelihoods are secure and sustainable, people are enabled to engage in generative discussions and collective actions in broader social and political spheres to address emerging challenges (Blythe, 2015). Thus, the goal of expanding human agency or empowerment in a sense, among traditionally marginalised groups such as small scale food producers can be examined and situated within livelihood research and practice, just as it is already situated in broader social movements and political analyses (Kabeer, 1999).

Our study demonstrates the vital role of social capital in promoting human agency in the context of small scale aquaculture livelihoods (see also Ramirez-Sanchez and Pinkerton 2009; de la Lama et al., 2018; Kriegl et al., 2022). By differentiating between types of social capital and refracting agency into four constitutive pillars, we were able to highlight areas in which a type of social capital made a significant contribution relative to others. A key reflection from this

work is the importance of classifying and characterising the type of social capital that is being examined in a research. Given the turn towards network analysis in social capital research (e.g. García-Amado et al., 2012; Abbasi et al., 2014; Díez-Vial and Montoro-Sánchez, 2014), in such an analysis, unpacking the type of social capital an individual or group possesses can generate insights into the type of resources and benefits that are accessible through that linkage as well as those that remain inaccessible. It also provides insights into which opportunities are made possible by social capital, and which limitations are present. For instance, we found that the valuable spontaneous sharing of information about livelihoods was enabled by bonding social capital, similar to the findings of Slijper et al., 2022. Local small scale aquaculture producers were the best sources of information as they are better informed about the multiple facets of production, the challenges that are viscerally encountered day-to-day, solutions that work and those that do not, and are better embedded in relevant networks of input providers and buyers. Bonding social capital was also evidently effective in providing aid in times of crisis such as the food system disruptions experienced during the Covid-19 lockdowns. Strengths of the bonding social capital include the relative ease of maintaining it due to its embeddedness in people's proximity and day-to-day actions that sustain social relations, its effectiveness at channeling context-specific information, and the rapidity with which it is activated to respond to various needs. However, bonding social capital also falls short in relation to addressing larger scale needs (e.g. costly assets) and systemic issues (e.g. asymmetric power relations). This implies that bonding social capital can be drawn on as an initial basis for collective action, but it needs to be complemented with other types of social capital to address broader issues. On the other hand, linking social capital enables access to 'big-ticket' assets that a group of relatives or neighbours with high bonding social capital are unable to provide. The question of which type of social capital will be most significant for a livelihood will depend on context and place-based challenges. However, our study does highlight that fish farmers' diverse connections with different individuals and groups benefit different facets of their livelihoods (Slijper et al., 2022). In a similar vein, Triyanti et al. (2017) emphasise the importance of paying attention to the particular patterns that social capital presents itself and that depending on these patterns, social capital can also lead to less effective interventions and less inclusive processes in the governance of aquaculture as was demonstrated in the case of Demak, Indonesia. They therefore call attention not only to the diversity of social capital, but also its quality particularly in so far as inclusiveness is concerned.

Power needs to be addressed in social capital research

Because social capital concerns relational connections between people, it essentially comes into contact with politics and power relations (Jacobs and Cramer, 2017; Carmen et al., 2022). However, examinations of power relations in the context of examining social capital particularly in aquaculture settings seems scarce (Carmen et al., 2022). In the case study presented, fish farmers' demand for action on water pollution remains unheeded for a number of

reasons including, a strong influence of large-scale intensive aquaculture producers over the local politicians who preside over rule-making processes (Manlosa et al., 2021). This is similar to the findings of Andriesse and Lee (2021) who also examined how formation of associations are interlinked with local and central state politics in the Philippine context. This raises the question about limitations of social capital both in the aquaculture sector and elsewhere. Under what conditions is social capital, particularly of the linking type which tends to involve differences in status and power, beneficial (e.g. Slijper et al., 2022)? Conversely, under what conditions is its potential to deliver solutions stifled due to broader social and power relations (e.g. McDougall and Banjade, 2015; Carmen et al., 2022)? Can bonding and bridging social capital from fish farmers' organisations mitigate disadvantages when linking social capital does not deliver on needed and desired solutions (e.g. environmental protection) and how? How asymmetric power relations shape the opportunities and limitations provided by social capital, particularly the linking type need to be examined particularly in a context where diverse actors and diverse interests are involved such as in aquaculture. Along these lines, Andriesse and Lee (2021) underscore how multi-scale politics and associated power relations in the Philippines can obstruct the functionings and efficacy of associations. They therefore highlight the necessity of integrating politics when analysing local associations. Triyanti et al. (2017) showed how social capital can lead to exclusion of social groups in the context of Demak, Indonesia where members of mangrove groups who have strong linking social capital with government monopolised access to resources for mangrove protection leading to the protection of only areas where mangrove groups were present, and eventually eroding the effectiveness of broader coastal protection efforts.

Broader institutional changes are needed to better support fish farmers' organisations

Fish farmers' organisations enable resource-sharing, the amplification of voices among small scale producers, and path-building towards a desired future. Key features of such organisations are their embeddedness in specific places and the social relations within those places, as well as the legitimacy that facilitates recognition and partnership with government actors. Such organisations are at once informal and formal, allowing cohesive social bonds and cooperation based on mutual interest and trust to emerge, while also enabling access to formal institutional spaces.

Governance of aquaculture development at the national scale is often situated within broader fisheries or farming institutions that address issues of food production at a broader scale. This is the case in the Philippines where aquaculture is assigned under the Bureau of Fisheries and Aquatic Resources, which is in turn, under the jurisdiction of the higher level Department of Agriculture (Manlosa et al., 2021). While this may offer a potentially fruitful opportunity for cross-fertilisation of knowledge, approaches, and programs, it may also lead to overlooking key issues for small scale aquaculture. Thus, despite well-functioning fish farmers' associations and strong linking social

capital with government as with the Bureau of Fisheries and Aquatic Resources in this case, the broader institution may be insufficient for addressing the range of challenges in the aquaculture sector (see Box 2 for actionable recommendations). This limits what linking social capital can actually achieve. Moreover, the devolution of aquaculture governance to local government units as in the case study (Manlosa et al., 2021), also means that local rule-making can be more easily influenced by powerful local players such as large scale aquaculture producers. For instance, despite the presence of bridging social capital which facilitated collective demand to address water pollution from large-scale, intensive aquaculture, and despite linking social capital with government, no action towards mitigating water pollution has yet been taken. Thus, even when bridging social capital helps amplify people's voices and there is linking social capital that brings the issues to the local government's attention, positive change is not realised. A separate and dedicated focused government institution in areas where aquaculture is an important sector, and checks and balances within local governments to prevent undue influence of powerful, industrial actors are needed (Hasan et al., 2020) to ensure that linking social capital can provide the kind of support and response needed by small scale fish farmers. To amplify the benefits fish farmers organisations derive from linking social capital with government, government actors need to invest in further developing leadership capacity in fish farmers associations, strengthening associations' communication and information system with internal members and external actors, and enhancing the organisations' participation in production and trade initiatives, and policymaking beyond the local level (Hasan et al., 2020). Additionally, in concrete actionable terms, government actors particularly the Bureau of Fisheries and Aquatic Resources can

BOX 2 Recommendations for actors.

Local scale

- Expand linking social capital of fish farmers organisations beyond the government actors in their immediate localities through:
 - Connecting local with environmental groups (e.g. non-government organisations) to support efforts of fish farmers organisations to mitigate pollution from intensive aquaculture.
 - Strengthening links between fish farmers organisations and the local research sector to facilitate research on environmental and socio-political challenges in the sector.

Regional scale

- Where there is a lack of effective action by local government units to act on issues such as water pollution, institutions must be put in place to remedy the gap. For instance, relevant higher level government actors such as the Bureau of Fisheries and Aquatic Resources (BFAR) may then take a more proactive role.
- Government actors like BFAR can support fish farmers organisations in further diversifying their linking capital through facilitating connections with relevant actors beyond the local level.

National scale

- Representation of a national association of smallholder fish farmers organisations in national departmental level meetings and workshops, and other capacity-building events organised by research organisations and universities.

empower small scale aquaculture producers to act on the persistent problem of water pollution through similar initiatives for community-based water quality assessments such as those implemented in the southern part of the Philippines (Deutsch et al., 2005). This can be done by training producers to collect and analyse water quality samples for parameters such as water turbidity and dissolved oxygen in the area. Such an initiative can provide evidence and establish trends on water pollution, making the impacts of polluters more visible and providing impetus for regulation and action.

Conclusion

Fish farmers' associations provide vital support to small scale aquaculture producers. This support is realised through the different types of social capital that the organisations provide to their members. As social capital contributes to the agency of small scale producers, it plays a key role in empowering producers to collectively address sustainability issues and deliver on environmental conservation, food security and nutrition, and poverty reduction. Thus, the formation of fish farmers' associations and the inclusion of these community-based organisations in new sustainability-oriented decision-making processes, initiatives, and programs should be pursued. However, social capital should not be treated as a panacea. As the study demonstrates, different types of social capital provide different contributions to livelihood, and the opportunities and benefits that are accessed by producers through social capital depend on the broader institutions in which the social relations are embedded. Thus, strengthening social capital to promote the achievement of sustainability outcomes in aquaculture and other sectors needs to be coupled with examinations of the institutions in which social capital is embedded, and of institutional changes where these are found necessary.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of the Social Sciences

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Author contributions

AM conceptualised the study, collected data, analysed the data, and wrote the manuscript. JA conceptualised the study, analysed the data, and co-wrote sections of the manuscript. MR conceptualised the study and co-developed sections of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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