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Abstract

This paper introduces a special issue of Aquaculture that brings together the largest collection of research on aquaculture value chains compiled to date, comprising 19 individual papers and this introductory review. The introduction identifies five themes emerging from research on aquaculture value chains in the special issue, namely: multi-polarity, diversity and scale, dynamics of transformation, performance and equity, and technical and institutional innovation. Contrary to much research to date, the papers addressing these themes show how the expansion of aquaculture has resulted highly diverse configurations of production for consumption in the global South. Collectively, the papers highlight the need for greater attention to neglected value chain segments and categories of actor, modes of production, regulation, and innovation, and patterns of access to benefits. The papers synthesized also affirm the need for more rigorous and diverse future value chain research to illuminate the aquaculture sector's ongoing development, and contribute to the sustainable expansion as an increasingly important component of the global food system.

Keywords: value chains; development; governance; trade; global South; innovation; sustainability

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1. Introduction

This special issue brings together a diverse set of papers to reinvigorate value chain analysis as an analytical tool for understanding the development and sustainability of aquaculture. This effort is timely because, despite growing academic attention to both aquaculture and the supply chains that facilitate production, trade and consumption of farmed fish, most literature to date has emphasized a narrow range of issues and geographies (Belton and Bush 2014). As a result, research has failed to keep pace with the growth and transformation of aquaculture value chains and, arguably, even to ask many of the right questions. As aquaculture emerges from relative obscurity to become an enduring and important feature of the global food system, and conventional narratives on the form and consequences of its development are increasingly challenged (e.g. Belton et al. 2018), the creation and synthesis of new knowledge and perspectives on aquaculture value chains is increasingly important.

This special issue addresses this challenge by bringing together the largest collection of research on aquaculture value chains ever assembled. Together, these 19 papers speak to five key themes that also serve as an agenda for orienting future research. These are summarized as follows:

1. A shift away from an emphasis on unidirectional South-North flows of aquaculture trade driven by Northern 'lead firms', to a growing '*multi-polarity*' (see Pieterse, 2017) driven by competing producers, traders and consumers across, within, and between Southern and Northern countries.
2. The growing *diversity and scale* of production and trade, that does not conform to the 'traditional, small-scale' / 'modern, industrial' binary implicit in much of the literature.
3. The *dynamics of transformation*, referring to changes in value chain structure and actor practices across all value chain nodes, in response to systemic changes in the global food system (e.g. urbanization and associated diet change) (Reardon et al. 2012, Reardon et al. 2018; Troell et al. 2014).
4. The *performance and equity* of value chains, related to the complex mix of positive, negative, and indeterminate outcomes for people and environments incorporated into, excluded from, or located in the vicinity of, key value chain nodes.
5. The extent and means by which processes of *technical and institutional innovation* can foster better chain performance, whether in terms of technical efficiency, productivity and profitability, or environmental impact and social equity.

Together, papers addressing these emergent themes reflect the diversity of methodological and disciplinary approaches that fall under the banner of value chain analysis, and provide a nuanced and current analysis of many aspects of global aquaculture production, trade and consumption.

A key conclusion of this special issue is that scholarship and policy on global aquaculture production needs to place considerably more attention on species and markets in the global South, in particular the emergence and characteristics of domestic value chains in Asia and Africa. We argue that only by taking a truly 'global' approach to value chain analysis that incorporates domestic as well as international flows of farmed fish, a clearer understanding of whether and how aquaculture can meet the estimated forecast of 93 million tonnes of production by 2030 in a sustainable manner (up from 74 million in 2014, Kobayashi et al. 2015).

This paper is arranged as follows. The following section reviews the literature on value chains, with aquaculture value chains as a subset of these. We then summarize the main findings of the special issue, elaborating on the five themes outlined above. We conclude by setting out an agenda for future research on aquaculture value chains.

2. Contextualizing aquaculture value chain research

Since the early 1990s, value chains have gained traction as both an analytical framework and an object of empirical study among academics and practitioners from a wide array of disciplines and fields. We identify three major ways in which value chains have been conceptualized in this body of work.

First, value chains are seen as a form of industrial organization that enables the procurement and transformation of inputs into outputs (Porter 1985), as well as their distribution utilization at other sites of production or consumption. Viewed in this way, value chains are often analyzed in terms of their structure (geographical location of actors, their size, and the degree of concentration among them, at each node in the chain), conduct (actor behavior throughout each stage of a production process), and performance (e.g. process efficiency, product quality, or social, economic or environmental outcomes) (e.g. Reardon et al 2012).

Second, value chains are as seen as global networks that govern coordination within and between transnational firms and other actors to facilitate international production, trade and consumption of goods and services. These networks may be influenced by 'extra-chain' actors such as non-governmental organizations (NGOs) or governments, and the standards and regulation that they impose (Gereffi and Korzeniewicz, 1994; Ponte and Sturgeon, 2014; Yeung and Coe 2015;

Nadvi, 2008; Bush et al. 2015). The emphasis on global (as opposed to local, national or regional) processes in this strand of literature stems in part from the emergence of value chain analysis during a period of rapid economic globalization during the 1990s, and a focus on large 'lead firms' responsible for structuring relations of production within chains.

Third, value chains are as seen as sites for achieving normative goals, such as poverty alleviation or gender equality; either through technical support for process and skills 'upgrading' at key nodes, or efforts to enhance market access and terms of trade or incorporation' for producers, workers and other related value chain actors (e.g. Kaplinsky and Morris, 2001). The rise of value chain oriented development projects is characteristic of what Bernstein and Oya (2014) dub the 'markets plus' approach to development, reflecting the 'post-Washington consensus' position that the appropriate role of the state and actors such as NGOs is to facilitate private sector action.

Research on aquaculture value chains emerged as a field of enquiry in the late-2000's, paralleling growing interest in the sector among social scientists. Aquaculture value chain studies often implicitly incorporate concerns with value chain structure, most commonly expressed through mapping exercises (e.g. Asiedu et al, 2016), as well as the conduct of value chain actors (e.g. Pomeroy et al, 2017; Eltholth et al, 2015), and the performance of chains and classes of actor within them (e.g. Lim, 2016). However, few aquaculture value chain studies explicitly operationalize structure, conduct and performance as their core analytical framework, nor address all three simultaneously.

The bulk of aquaculture value chain research to date has addressed questions arising from the 'global value chain' (GVC) literature (the second 'strand' identified above), and has focused primarily on transnational chains supplying shrimp, salmon and (Vietnamese) pangasius to Northern export markets (see Belton and Bush 2014). Taking value chain governance as a key concern, research in this tradition has focused on how lead firm coordination sets the conditions for product specification and market access market (e.g. Bush and Oosterveer 2007; Loc et al 2010; Tran et al. 2013; Ponte et al. 2014). The role played by private voluntary (often NGO-led) standards in setting norms for production, trade and consumption through (certified) codes of conduct, and the implications of such standards for smaller producers, feature centrally in this body of work (e.g. Anh et al. 2011a; Belton et al. 2011; Islam 2008; Tran et al. 2013; Bush et al. 2013; Trifković 2014). Other research in the GVC tradition has focused on the spatial organization of support services, divisions of labour, and the creation, location and capture of value along transnational aquaculture supply chains (e.g. Lebel et al. 2002; Anh et al. 2011b; Jespersen et al. 2014).

Value chains also form a central component of donor-supported aquaculture development projects. Such efforts reflect the expectation that deeper market integration for smaller producers

and market-driven innovation can contribute to poverty alleviation, food security and sustainability goals (see, for example, Macfadyen et al. 2012). The scope of aquaculture value chain development interventions (and associated literature) - once predominantly focused on the transfer of technology (e.g. Olson and Criddle 2008; Bostock 2011) and upgrading the position of smallholder producers (e.g. Khiem et al, 2011) - has increasingly widened to include questions of market compliance, benefit sharing and gendered approaches to livelihoods and nutrition (Velu et al. 2009; El Sayed et al. 2015).

Overall, research and policy have both tended to represent social and economic relations within value chains as technical problems amenable to resolution by expert intervention (Li, 2005). Relatively little attention has been paid to 'immanent' processes of aquaculture value chain development (Belton and Little, 2011), whereby value chain actors have responded to changing conditions of demand, technology and infrastructure in a largely unplanned, undirected and un-(externally) coordinated fashion. As papers in this special issue illustrate, paying closer and more deliberate attention to immanent forms of aquaculture development, as well as on the structure, conduct and performance of value chains, researchers will avoid falling back on some of the false assumptions that have pervaded the literature to date.

3. Key Themes

This section examines each of the five themes listed above, drawing on content from articles submitted to this special issue, and supporting literature.

3.1 Multi-polar geographies of aquaculture

The shape of globalisation is changing. Whereas in the 1990s the global South accounted for 35% of the world's GDP, it now accounts for 50% and is set to increase this share to 60% by 2030 (Pieterse 2017). Consumption is also forecast to increase dramatically in these countries over the same period, with hundreds of millions of people reaching consumption levels currently associated with median incomes in advanced economies (Hellebrandt and Mauro 2015). Food production in particular will increase to meet rising demand from both absolute population growth and relative increases in middle-class demand (e.g. Popkin 2014; Tschirley et al. 2015). As a result, food production and consumption will become increasingly concentrated in the global South - in terms of volume and value, and levels of Southern domestic and South-South cross-border investment and trade.

As the papers in this special issue highlight, the global shape of aquaculture production, trade and consumption reflects these changes. Instead of focusing on the core group of species that make up North-South trade, contributors to the special issue have turned their attention to the extent and structure of the industry *within* the global South. This does not imply certain aquaculture value chains or value chain segments will not remain global – production has expanded to 200 countries and territories (FAO 2016) and trade in feed ingredients (including, but not limited to, fish meal, fish oil, meat and bone meal and soy) remains highly international (Tacon and Metian 2015). Instead, as highlighted by nearly every paper in this special issue, it means that aquaculture production, trade and consumption is far more diverse than a ‘uni’ or ‘bi’-polar North-South trade, driven by lead firms in the European Union and United States. The industry is instead ‘multi-polar’ - reflecting a diffusion of sources of demand and sites of production, with predominantly Asian economies driving a South-South mode of economic globalisation (see Horner 2016; Pieterse 2017).

Multi-polarity also reflects the plurality of social and regulatory drivers that shape the structure and governance of value chains (Ponte 2014). For aquaculture, such drivers include the diversity of species, categories of producers and the values and qualities that structure production, trade and consumption. While several papers in this special issue address the North-South trade of these species (Bush 2018; Pham et al. 2018; Little et al. 2018), others highlight the importance emerging South-South trade. For instance, the trade in pangasius produced in Andhra Pradesh with other parts of India and South Asia (Belton et al. 2018) and the appreciation for Filipino *tambak*-produced shrimp in East Asian markets (Miahle et al. 2018). Other papers focus on the contribution of a variety of freshwater species to domestic markets in South and Southeast East Asia (e.g. Hernandez et al, 2018) and (filling a previous gap in the literature) Africa (Kominski 2018; Kassam and Dorward 2018).

Finally, multi-polarity is also observed in the diffusion of regulatory drivers shaping aquaculture that go beyond lead firms setting product specifications and contracts for suppliers. As highlighted by Little et al. (2018) and Miahle et al. (2018) in this issue, categories of values and qualities originating from markets in the global North often do not correspond with the social conditions of production in the global South. As a consequence, market-based forms of governance based on Northern norms are losing leverage with the rise of alternative markets emerging such as China, as well as Southern domestic markets, which are demanding alternative values to those currently included in international eco-certification. This raises questions about what norms will hold the greatest influence over aquaculture production in future.

3.2 Diversity and scale

Aquaculture is characterised by its extreme diversity of species, culture systems and scale of production. Research and development policy has, however, commonly simplified these this diversity in two directions. First, as small-scale rural culture systems (including rice fields and homestead and community ponds) that contribute directly to the livelihoods and food security of producing households (e.g. Bondad-Reantaso and Subasinghe, 2013). Second, as ‘intensive’, ‘large scale’ and ‘export orientated’ production that contributes to national incomes, but compromises local livelihoods and food security, due to a combination of industrial concentration, displacement, environmental degradation, competition for resources and focus on production of high value species for export and wealthy urban consumers (e.g. Nayak and Berkes, 2011; Golden et al., 2016). The papers in this special issue highlight how simplified narratives of who benefits/loses and how are outdated in at least two ways.

First, the polarised focus on small vs. large scale production needs to be replaced with more nuanced, representative categories, based on ownership structure of farms and relations of production. Gonzales et al.’s (2018) analysis of Chile’s blue mussel farming sector shows how large firms, typically with multiple located farms dominate farm output, but coexist with micro and small farms owned by individuals and companies which constitute 80% of registered producers and exhibit higher mean levels of productivity. Belton et al. (2018) identify a similar dualistic farm size structure in Myanmar, with a ‘new’ class of small-medium commercial farms emerging in spite of regulatory constraints, in a policy environment that historically favoured industrial-scale farms. These studies point to the potential for domestically oriented production to confound assumptions that ownership will inevitably concentrate over time (cf. Khiem et al. 2011; Lam 2013; Asche et al. 2013). Instead a mosaic of production systems co-exist across a spectrum of intensification that some have argued is likely to endure in the face of consolidation and standardisation (Belton and Little 2014). As argued in the paper by Little et al. (2018), this observation is important as it shows that the push for sustainable intensification of aquaculture can be more inclusive than often assumed.

Second, access to benefits derived from aquaculture is also highly variegated and often indirect. Belton et al. (2018) outline how, in contrast to large extensive farms that tend to be operated by absentee owners, small and medium commercial farms are locally owned and managed, providing significant opportunities for wage labourers. Yi et al. (2018) and Sanguin (2018) also highlight the importance of wage labour, but also outline various other ways in which access to aquaculture value chains is mediated, including credit, technology, tenure, and patronage. But the most dramatic case of alternative forms of access is illustrated by Miahle et al. (2018) in their study of shrimp *tambaks* in Manila Bay. They describe a highly organised system

through which gleaners (*mangangapa*) from local communities access ponds after harvest to collect aquatic organisms, providing a livelihood to a highly marginalized group in these coastal areas.

3.3 A quiet revolution

Four papers in this special issue (Hernandez et al. 2018; Belton 2017; Saguin 2018; Belton, 2018) provide strong evidence for an urban domestic-market-driven “quiet revolution” as one of the defining characteristics of Asian aquaculture development. In doing so these papers provide a counterpoint to the ‘export bias’ in much of the GVC inspired aquaculture literature. This is underlined by Hernandez et al. who note that while Bangladesh is famed for its export oriented shrimp production (see Kais and Islam, 2018 in this issue), 94% of the country’s aquaculture production is destined for domestic consumption. Saguin makes a similar case for the Philippines, as do Kominsky et al. (2018) for Zambia and Kassam and Dorward (2018) for Ghana.

Although each of these countries possess unique histories, geographies, political economies and agrarian structures that have influenced the specific configurations of aquaculture value chains (in terms, for example, of farm size, concentration of ownership at different nodes – c.f. Mahile et al. 2018), drivers, processes and outcomes of transformation share common features across countries. We identify seven key trends.

First, urbanisation has stimulated demand for fish as wages have risen and diets have diversified, at the same time as capture fisheries landings per capita have declined. Aquaculture has emerged in response to the opportunities created. As reported by Saguin (2018), urban areas also stimulate aquaculture by serving as sources of inputs and investment capital.

Second, the growth of farmed fish supply has been made possible by, and contributed to, the proliferation of non-farm enterprises throughout the value chain (many, though by no means all of them, small and medium scale enterprises). These provide essential inputs, logistics, trade, and other services to the farm segment of the chain (see Belton et al. 2018 and Hernandez et al 2018), creating considerable demand for labour in clusters with high concentrations of these businesses.

Third, farms and the businesses supporting them have emerged in a largely ‘immanent’ or ‘unplanned’ way (see Belton and Little 2011), but have been supported by the provision of public infrastructure (e.g. roads, waterways, irrigation, wholesale markets). The most effective forms of intentional external intervention have been public investments during the nascent stages of aquaculture value chain development in the 1970s and 1980s, most notably (though not restricted to) the establishment of hatcheries (e.g. Hernandez et al. 2018, Gonzales et al, 2018). Government

policies governing land use have also exercised significant influence over aquaculture development (both facilitating and inhibiting), most notably in Myanmar (Belton et al. 2018) and Andhra Pradesh (Belton et al. 2017).

Fourth, all value chains have undergone rapid technological change in all segments as they have modernized. This has been due both to spontaneous experimentation and invention by value chain actors, and induced innovation in response to greater competition as a function of shrinking margins. Evidence for such innovation includes the growing use of pelleted feeds, and strategies such as deepening ponds, stocking fingerlings at ever larger sizes, and integration with poultry (Belton et al, 2018). Off-farm, innovations such as the production and use of ice and insulated boxes have extended the length of time for which harvested fish can be kept fresh or live, contributing to the lengthening of value chains downstream (Belton et al, 2018; Belton et al. 2017). Upstream in the chain, aeration systems and modification of boats for transport of fingerling have extended the distance between hatcheries and farms (by more than 1200 km from West Bengal to Andhra Pradesh in the Indian case), enabling a specialized division of labour to emerge between different locations (Belton et al, 2017; Belton et al, 2018).

Fifth, structural changes have occurred throughout the chain as farms and related firms have proliferated and become more specialized (as individual enterprises) and diversified (in aggregate). Occasionally (such as in the case of Indian pangasius) they have become more concentrated in certain nodes, or vertically integrated across them. Dynamic processes of continuous innovation and technological change are omnipresent in most aquaculture value chains, reflecting in part their relatively 'immature' status in comparison to longer established components of the food system. This is apparent in Yi et al's (2018) study of Indonesian shrimp, Kominsky et al. (2018) and Kassam and Dorward's (2018) studies of Zambia and Ghana, and Asche et al.'s (2018) study of Norwegian salmon.

Sixth, product differentiation has occurred over time in line with the product cycle, as species become commoditized, prices have fallen, and new 'niche' species have been introduced as alternatives, ultimately undergoing commoditization themselves (Hernandez et al, 2018). In all cases, this process (along with improved production and logistical efficiencies that occur with commoditization and modernization) has resulted in farmed fish becoming accessible to greater numbers of low income consumers (see Dorward and Kassam 2018; Saguin 2018; Belton et al. 2018).

Seventh, in all cases, development pathways are forged in the context of pre-existing relations of class, power and gender that structure access to productive resources (land, capital,

technology), but have also contributed to the reworking of these relations, sometimes deepening existing inequalities, sometimes attenuating them (e.g. Belton et al, 2016; Belton 2017). These political-economic dimensions, though present in all the cases addressed by papers in this special issue, and tackled by Kruijssen et al. (2018) and Saguin (2018), require more explicit recognition, attention and integration into future aquaculture value chain research.

3.4 Value chain performance and equity

The themes addressed in the three preceding sub-sections focus primarily on value chain structure and actor conduct, but deal less directly with how chains perform, in terms of outcomes for those incorporated into or remaining outside of them.

These latter questions are a key concern identified by Kruijssen et al. (2018) in their review of literature on women's involvement in aquaculture value chains, covering gender division of labour, distribution of benefits, access and control over assets and resources, social norms, and power relations and governance. The review reveals that men and women are not necessarily able to participate in aquaculture value chains in the same ways, and the benefits of doing so may not be evenly distributed between them. Downstream nodes of aquaculture value chains are shown to have different gendered patterns of employment than the production nodes, with women typically much better represented in the latter, in low paid and insecure work. The challenge for women to balance (unpaid) domestic work with economic responsibilities is also underscored. The review also draws attention to a general lack of high quality and consistent gender disaggregated data on employment, incomes and wages in aquaculture value chains. This lack of data impedes gender analysis and the development of gender sensitive policies.

The distribution of economic benefits arising from participation in aquaculture value chains is central to Kassam and Dorward's (2018) paper. This estimates local economic multipliers generated in Ghana's rural non-farm economy by different types of aquaculture (medium scale cage culture, versus small-scale pond farming), accounting for both employment and incomes generated on-farm and via 'production linkages' that create demand for products and services above and below the farm in the chain. Their results show that indirect impacts of aquaculture on poverty, primarily through farm employment and pond digging, are greater than direct gains obtained by farmers. The paper's analysis also complicates an emerging narrative that suggests commercial small and medium enterprises have greater indirect impacts on poverty than small-scale producers (e.g. Belton et al, 2011), by indicating that well managed small-scale pond farms,

best referred to as ‘commercial micro enterprises’ create a larger multiplier effect than either commercial cage farms or low input subsistence ponds.

The questions of how short-term climate shocks and long-term climate change interact with food supply chains linking producing and consuming areas, is an emerging issue with important implications for food security (Reardon and Zilberman, 2018). Kais and Islam’s (2018) study evaluates how shrimp producers in Bangladesh, located at the bottom of a buyer-driven commodity chain have responded to increasing climate vulnerability, and explores whether their adaptation and coping strategies build resilience. They document the impacts of a wide variety of climatic conditions and phenomena - including cyclones and storm surges, increasing temperatures, drought, heavy rainfall, and salinity ingress and sea-level rise - on shrimp farming, and adaptive responses to these challenges on the farm, and in farming households. Some coping strategies adopted on farm such as deepening ponds or raising dykes can be considered adaptive. However, many strategies deployed by households to cope with climate induced shocks (e.g. meal skipping, borrowing informally or selling productive assets) appear to be instances of maladaptation, that facilitate survival in the short term, but undermine resilience over the long run.

Murshed-e-Jahan et al.’s (2018) paper is the only one in the collection to address the effects of interventions intended to improve the performance of aquaculture value chains (in this case, for carp, in Bangladesh and Nepal). The study assesses the impact of the ‘participatory market chain approach’ (PMCA) value chain development methodology. PMCA aims to foster pro-poor innovations in value chains by systematically engaging value chain actors and institutions external to the chain in identifying and assessing market opportunities, and developing commercial, technical and institutional innovations to meet them. The paper combines qualitative and quantitative monitoring techniques to offer a multi-faceted picture of how impact was generated and distributed through the intervention process over the life of the project, drawing on the perceptions of project participants. This calls attention to the role of diverse methodologies in studying different facets of value chains.

3.5 Governing innovation

For the aquaculture industry to make an ongoing and sustainable contribution to food security the industry will need to continue to innovate across multiple ‘sites’ and through multiple modes of innovation. But as demonstrated by Joffre et al (2018), research on aquaculture innovation has to date overwhelmingly focused on technology transfer and standardisation at the farm-level; as illustrated by Samerwong et al. (2018) in Thailand and Kassam and Dorward (2018) in Ghana.

Instead, Joffre et al argue for systems and value chain approaches to innovation management that foster ‘multi-directional’ interactions between producers, SMEs and government (see also Jahan et al. 2018). These approaches redirects the focus of research and policy from a collective pre-occupation with the farm (as illustrated by Mialhe et al. 2018) to take better account of the social, economic and political context within which production takes place, as illustrated by Little et al.’s (2018) approach for understanding innovation for sustainable intensification.

Innovation management for aquaculture can also take much inspiration from other agro-food sectors. Asche et al. (2018), for example, argue that as aquaculture value chains modernize they will become increasingly comparable with those in other agro-industrial sectors. The Norwegian salmon industry, they argue, could make considerable efficiency gains by taking lessons from the industrial organisation chicken value chains. They also note that the tendency toward vertical integration and economies of scale in both salmon and chicken production have led to considerable consolidation among processing and marketing firms. But as noted by Bush (2018), it is not clear that all aquaculture sectors will tend towards vertical integration given the different production risk profiles. The capacity of many SMEs in the South to take up new innovations, while expanding, remains dependent on greater coordination by chain actors with, amongst others, the state (a relationship that the Norwegian salmon industry has benefited from for the last three decades, see Asche et al. 1999). Returning to Joffre et al., the modes of interaction needed innovation, and not technology transfer alone, therefore appear central for success across the entire value chain.

Finally, integrated approaches to innovation raise questions around the role of certification (either international certification or national Better Management Practices, see Samerwong et al. 2018; Kassam and Dorward 2018) as ‘hands off’ modes of governance to incentivise supplier upgrading (see for e.g. Guðmundsson and Wessells 2000). As Pham et al. (2018) outline, it remains unclear to what extent price signals from certification are transmitted down chains from buyers to producers. Furthermore, certification may be more successful where producers are provided assistance to upgrade through greater degrees of ‘developmental’ coordination with both buyers and government (Bush 2018; Ivarsson and Alvstam, 2010). While such approaches have been integrated into some North-South value chains, in the form of so called ‘aquaculture improvement projects’ (see Pekdemir 2016), it remains to be seen whether or how similar modes of support will emerge in the context of domestic and South-South trade. Alternatively, as argued by Samerwong et al. (2018) more inclusive forms of upgrading may ultimately be achieved through national, state-controlled standards. But to be successful, these national standards need to gain greater credibility amongst both producers and (global and domestic) buyers (see Samerwong et al. 2017).

4 New frontiers for aquaculture value chain analysis

The papers in this special issue offer a state of the art insight to how a value chain approach is being applied to understand the development and sustainability of aquaculture. The papers collectively offer an improved understanding of the organisation and drivers underpinning the ongoing development of aquaculture as the fastest growing food sector in the world. They do so by bringing together a diverse set of approaches that together make visible the structure, performance and conduct of actors embedded in aquaculture value chains.

The overall conclusion drawn from this collection is that the aquaculture industry is undergoing a 'quiet revolution' based on the expansion of production, trade and consumption in the global South. The papers are, as such, a start at furthering our understanding of 90% of global production that has hitherto only attracted 10% of scholarly attention (Belton and Bush 2014). Recognising the multi-polarity of aquaculture value chains means research has to go beyond issues of marginalization and governance so prevalent in the global value chain literatures. Instead research should focus on neglected categories of chain actors, modes of production and regulation that affect the formation of value, sector wide innovation, access to fish and environmental sustainability. Doing so will not only provide a clearer understanding of what shape and function these chains take, but also assist in the design of public and private development interventions aimed at the further expansion or regulation of aquaculture.

It is also clear that a diversity of theoretical, methodological and disciplinary approaches coalesce under the label of value chain analysis. This makes value chain analysis well suited to not only to address the diversity and rapid expansion of the industry, but also provide integrated analyses of the sector's contribution to food security, poverty alleviation and social and environmental sustainability. Continued efforts should be made to bring these dimensions together through value chain research, highlighting the synergies and trade-offs needed to make the sector's future expansion sustainable.

Despite covering considerable ground, there are also some conspicuous gaps in the analysis presented in this special issue. To address these, we identify eight new directions for aquaculture value chain research.

First and foremost, none of the papers in this special issue focus on China. This is not only conspicuous because China is the largest producer in the world, but also one of the major processors of seafood products - both for their own domestic market and export. As the China state and Chinese companies continue to increase their influence around the world, the country's

role in global aquaculture value chains will only become more important. This opens up considerable opportunity for research to understand what effect China will have on all facets of the aquaculture industry in any of the dimensions

Second, consumption has received little attention beyond macro-level analysis of trade flows. As argued for other food sectors (see Spaargaren et al. 2013), there is much to be gained from analyzing consumption as a set of social practices. Doing so can reveal more about changing demand for fish than the literature currently focused on food safety and marketing. For example, research can address how aquaculture species are being incorporated into fish based and/or fish dependent cuisines that have traditionally relied on fish harvested from wild stocks, and the substitution of farmed fish into rural, urban and even luxury forms of fish consumption (e.g. Fabinyi 2012). Studies can also address how more diversified demand for aquaculture products can be promoted, and how these changing practices can be translated into new systems of provision all the way up value chains to producers.

Third, more attention is needed on the wellbeing of actors operating at different aquaculture value chain nodes and on the dynamics of agrarian change associated with value chain development and transformation. Building on the review Kruijssen et al. (2018), for instance, there is clear need for better understanding how gendered relations throughout the value chain affect the terms and value of employment, which turn affect the familial and reproductive expectations of those working in the industry (e.g. Resurreccion and Sajor 2010). As argued elsewhere (see Bush et al. 2017), doing so can extend the attention of policy and research beyond the important, but still narrow interpretation of social sustainability in terms of unfree labour alone. Linking accounts of value chain transformation to Bernstein's (2010) four key questions of agrarian political economy (who has what, who does what, who gets what, and what do they do with it?), also has the potential to yield deeper and more finely nuanced interpretations of which groups gain or lose from the process of aquaculture development and why.

Fourth, research is also needed on the blending or mixing of what have until now been considered opposable categories, practices and regulation over aquaculture production and trade. There is considerable amount of research that points out clear 'frictions' between modernized value chains and locally embedded social practices (see for example Miahle et al. 2018). But less work has gone into understanding how the modernities of food safety, labour and sustainability transparency, can be blended or mixed with existing practices. Building on Little et al (2018), what opportunities are there then for 'mixed modernities' (Spaargaren et al. 2005) in aquaculture value chains that, for instance, allow for expanded notions of sustainable and ethical aquaculture production? In short,

can modernized mixtures in aquaculture value chains contribute to improved production efficiencies that benefit the environment and people?

Fifth, disruptive digital platforms (e.g. Ali Baba and Amazon) and technologies (e.g. blockchain) are entering into seafood trade and logistics. As digital platforms seek to virtualize value chains, creating direct links between producers and consumers, the performance, structure and conduct of value chains is set to change dramatically. It is unclear, however, who will ultimately benefit from these shifts, nor whether they can foster markets for sustainable aquaculture products. Some argue that these systems will democratize food systems to the benefit of small holders, while others argue they will lead to centralized control and modes of 'platform capitalism' (see Srnicek 2017). Meanwhile, blockchain based technologies offer the prospect of enhanced traceability and transparency throughout supply chains, and thus have significant potential to transform sustainability governance, food safety regulation and consumer access to information, in ways that are only just beginning unfold. Aquaculture scholars would do well to keep a close eye on these rapidly developing systems.

Sixth, there is a growing understanding of the role of landscape approaches for mitigating the impacts of aquaculture production, as an alternative to existing approaches to certification and regulation. While work to date on landscape models has focused largely on the collective organisation of farmers and zoning, attention to the potential role of international and domestic buyers is also growing. For example, what role can buyer contracts and consumer values play in supporting the capability of producers to organize beyond the level of the farm? Can buyers smooth out supply risk by organizing product sourcing from certified 'areas' rather than farms? What role can states play in mitigating production risks emanating beyond the farms? And how can new surveillance technologies be used to build up real-time landscape monitoring?

Seventh, the so called 'circular economy' is emerging as a key principle for the efficient use and reuse of material (waste) flows through value chains (see for e.g. Strazza et al. 2015). One conspicuous gap that requires considerably more attention is the use of aquaculture related wastes and byproduct recovery. Aquaculture processors are already investing heavily in the technology and knowhow necessary to create further value these 'secondary' value chains, to the extent that the output of food fish may become of secondary importance by value in some cases (see for example Newton and Little 2017; Stevens et al. 2018). To date, virtually no work has been done on the volume, value, structure, performance or conduct of these secondary chains.

Finally, this special issue argues for a move beyond simplifications and biases in research that have privileged narratives of North-South trade and small vs. large scale production. These

biases have created a blind spot that the papers in this special issue have collectively begun to address. The challenge is then clear. Future value chain related research must be more rigorous, broader in geographical and theoretical scope, and more firmly grounded in the empirical realities of an increasingly complex and multi-polar world if it is to yield insights that can inform more effective policy and practice, and by doing so ultimately contribute to shaping a more sustainable and equitable, truly global aquaculture industry.

ACCEPTED MANUSCRIPT

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Highlights

- Synthesis of five core themes on aquaculture value chain research
- Aquaculture value chains not as global as commonly thought
- Diverse configurations of aquaculture production, trade and consumption in global South
- Diverse approaches and methodologies for aquaculture value chain research available
- Research focus needed on value chains in context of wider global food system