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Contribution of Fisheries and Aquaculture to Food Security and Poverty Reduction: Assessing the Current Evidence

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Summary. — Following a precise evaluation protocol that was applied to a pool of 202 articles published between 2003 and 2014, this paper evaluates the existing evidence of how and to what extent capture fisheries and aquaculture contribute to improving nutrition, food security, and economic growth in developing and emergent countries. In doing so we evaluate the quality and scientific rigor of that evidence, identify the key conclusions that emerge from the literature, and assess whether these conclusions are consistent across the sources. The results of the assessment show that while some specific topics are consistently and rigorously documented, thus substantiating some of the claims found in the literature, other areas of research still lack the level of disaggregated data or an appropriate methodology to reach consistency and robust conclusions. More specifically, the analysis reveals that while fish contributes undeniably to nutrition and food security, the links between fisheries/aquaculture and poverty alleviation are complex and still unclear. In particular national and household level studies on fisheries' contributions to poverty alleviation lack good conceptual models and produce inconsistent results. For aquaculture, national and household studies tend to focus on export value chains and use diverse approaches. They suggest some degree of poverty alleviation and possibly other positive outcomes for adopters, but these outcomes also depend on the small-scale farming contexts and on whether adoption was emergent or due to development assistance interventions. Impacts of fish trade on food security and poverty alleviation are ambiguous and confounded by a focus on international trade and a lack of consistent methods. The influences of major drivers (decentralization, climate change, demographic transition) are still insufficiently documented and therefore poorly understood. Finally the evaluation reveals that evidence-based research and policy narratives are often disconnected, with some of the strongest and long-lasting policy narratives lacking any strong and rigorous evidence-based validation. Building on these different results, this paper identifies six key gaps facing policy-makers, development practitioners, and researchers.

Key words — poverty reduction, food security and nutrition, development, fisheries, aquaculture

1. INTRODUCTION

Food security and poverty reduction have been central to the world development agenda but the principal themes have evolved with the growing population, and changes in the world economy, technology, and state of the environment. Recent food security discourse stresses the need for multiple policy, economic and social actions addressing consumer demand, access, supply and nutrition (Grafton *et al.*, 2015). Within the global food production and distribution system, poverty reduction strategies have renewed the focus on the role of smallholders in agriculture, and identified the importance of upstream and downstream linkages, as well as non-farm activities (Hazell *et al.*, 2007).

Fish [1] matters to all these food security and poverty reduction themes—nutrition, supply (and its sustainability), demand, access, and the role of small-scale workers—but, in the capture fisheries and aquaculture sectors, not all these themes have been adequately addressed and assessed. A large part of the past and recent fish research has focused on managerial issues driven by ecological/conservation and efficiency/economic considerations. Despite new narratives that highlight the potential contributions of capture fisheries and aquaculture to food security and poverty reduction, little has been done to evaluate rigorously the evidence base for the actual contribution of the two sectors to food security and poverty reduction (see however HLPE, 2014; Béné *et al.*, 2015).

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With more focus on the nutritional value of food commodities, fish is acknowledged as a major nutrient-dense animal-source food for a significant proportion of the nutritionally vulnerable people, overshadowing that of most of terrestrial animal foods. In 2010, the quantity of fish produced was twice that of poultry and three times that of cattle (FAOSTAT and FISHSTAT). In 2010, of the 30 countries where fish contribute more than one-third of the total animal protein supply, 22 are Low Income and Food Deficient countries (LIFDCs) (Kawarazuka & Béné, 2011). Furthermore, in addition to animal protein, fish contain unique long-chain poly-unsaturated fatty acids (LC-PUFAs) and highly bioavailable essential micronutrients—vitamins D and B, minerals (calcium, phosphorus, iodine, zinc, iron, and selenium). These compounds, often not readily available elsewhere in diets, have beneficial effects for adult health and child cognitive development (HLPE, 2014).

In the world food regime, in addition to production, trade is a major factor. Fish products, from capture fisheries and aquaculture, presently account for about 10% of total agricultural exports, and the value of the global fish trade exceeds the value of international trade in all other animal source foods combined (World Bank, 2011). Low- and medium-income countries (LMICs) play a major role as they supply 50% of all fish exports by value and more than 60% by quantity (World Bank, 2011). In general, fish production contributes 0.5–2.5% of GDP globally but for countries such as Mauritania and Vietnam, the contribution is 10% or more (Allison, 2011), and, in some Pacific small island states dependent on fisheries, 25% of their GDP (Gillett, 2009b).

Despite the importance of fish to economic development and food provision, public debate in relation to fish is dominated by concerns over resources and environmental sustainability (e.g., Worm *et al.*, 2006; Pauly 2009). Capture fisheries are commonly presented as in "crisis" and with the future potential of fisheries as a food source jeopardized. Similarly, a strong historical dependence of aquaculture on marine ingredients derived from capture fisheries as key feeds is presented as a challenge for the sector. Discussions on steering fisheries beyond crisis sometimes invoke food security concerns (e.g., Srinivasan, Cheung, Watson, & Sumaila, 2010) but are more typically focused on finding ways to ensure that fisheries are governed to maximize their monetary value (e.g., Cunningham, Neiland, Arbuckle, & Bostock, 2009) while conserving charismatic species and habitats, such as sharks and coral reefs (Newton, Côté, Pilling, Jennings, & Dulvy 2007).

Some recent works in developing countries have challenged these views, however, highlighting the locally complex, diverse, and dynamic nature of capture fisheries and aquaculture, stressing their central role in providing food, income and employment, as well as a range of social and cultural values and benefits to the local populations (e.g., Neiland & Béné, 2004; Friend, Arthur, & Keskinen, 2009; Chuenpagdee 2011; Weeratunge *et al.*, 2014).

In addition, strong narratives and discourses highlighting the potential contribution of the fishery and aquaculture sectors to poverty reduction and food security are widely promoted—at least within the sector literature (see, e.g., Béné, Macfadyen, & Allison, 2007; Heck, Béné, & Reyes-Gaskin, 2007). Establishing whether these narratives can be supported by evidence is important to both international policy and science. For instance, it is widely stated that 90% of the households dependent on fish-related activities for their income live in LMICs, and the vast majority of the people who depend directly on fish as a major source of animal protein and micro-nutrient live in LIFDCs. But, while generally accepted, what is the strength of evidence to support such claims, and to what level of specificity can we claim that fish-related activities effectively play a role in economic development, food provision, and ultimately poverty alleviation and reducing malnutrition?

This paper evaluates the existing evidence of how and to what extent capture fisheries and aquaculture contribute to food security and poverty reduction. In doing so we evaluate the quality and scientific rigor of that evidence, identify the key conclusions that emerge from the literature, and assess whether these conclusions are consistent across the sources. This paper therefore differs fundamentally from a conventional literature review in the sense that its aim is not simply to conduct a review and synthesis of the existing literature, but to actually assess the scientific quality and consistency of that literature, and, where it exists, the reasons for inconsistencies.

For this, a scoping review was completed, following a precise evaluation protocol that was applied to more than 200 articles grouped into eight development themes (called "clusters") that relate to fish and its contribution to food security, nutrition, human health, economic growth, and poverty alleviation at both local and national levels. In addition the assessment considered four cross-cutting development issues: international trade, governance, scale, and gender, which are also often considered to be critical factors in relation to issues of food security and poverty alleviation. The scoping review will reveal a heterogeneous "landscape" in which certain clusters are characterized by high scientific quality and/or relatively consistent conclusions, while others show lower methodological rigor, or display more inconsistent or more inconclusive findings.

The paper is organized as follows. Section 2 presents the details of the methodology of the scoping review. Section 3 summarizes the main findings of the review, organized around the eight clusters and four cross-cutting issues. Section 4 draws on these results to identify areas where more research is required to "refine" our understanding of the ways fisheries and aquaculture effectively contribute to development and food security and offers some concluding remarks.

2. METHODS

The assessment is based on an in-depth evaluation of the existing evidence related to capture fisheries and aquaculture activities in LMICs and the ways the two sectors contribute to economic growth, food security, and nutrition. The aim was to compile and review existing literature; provide a rigorous assessment of the scientific quality of the evidence provided in this literature; and ensure that the assessment was completed in a rigorous, transparent, and consistent way. For this a protocol drawing on methodologies found in the domain of scoping review (e.g., Arksey & O'Malley, 2005; Levac, Colquhoun, & O'Brien, 2011)[2] was developed, building upon a three-step approach.

Step 1—Scanning and selection: Academic research documents, including journal articles, books and book chapters, government and international institution studies, reports, working papers, and other gray literature sources were scanned, using two research engines: ScienceDirect and Google Scholar. Five inclusion/exclusion criteria were applied: language (only English documents were retained), year of publication (only documents published in the last 12 years (2003–2014) were considered; academic quality (documents of non-scientific or non-academic nature—news-media

articles, blogs, etc. were excluded), geographic areas (the focus was on LMICs), and topical relevance (directly related to capture fisheries and aquaculture in relation to either poverty reduction, economic development, food security or a combination of these three). Based on these criteria 202 documents were retained.

Step 2—Individual scoring: Each of these documents was categorized based on the nature (primary/secondary—case study-review) and scale of the data (small/large data bases). The quality of the documents was then evaluated using a three-criterion assessment system (rigor, validity and reliability—see Table 1) developed from existing assessment frameworks including ESRC (2003), Petticrew and Roberts, (2006) and Gough (2007). Scores were allocated, based on these three criteria [3] (details of the scoring system are provided in Appendix 1).

Step 3—Thematic clustering: The 202 retained documents were then clustered thematically (see below) and the quality of evidence within each cluster evaluated by aggregating the individual papers' score, using three criteria:

1. Size of the body of evidence, using three categories: large >10 documents; 10 < medium < 5; and small <5.
2. Technical quality of the body of evidence, based on the criteria described in the top part of Table 2: "High" quality characterizes clusters in which two thirds or more of the documents demonstrate strong adherence to the three principles of rigor, validity and reliability, as assessed by their individual scores obtained through step 2. "Moderate" quality characterizes clusters in which between one third and two thirds of the documents are of a high quality. "Low" quality was associated with clusters in which more than two thirds of the studies in the cluster show significant deficiencies in adherence to the three principles of rigor, validity or reliability.
3. Consistency of the body of evidence was estimated based on the descriptors provided in the bottom part of Table 2: a "consistent" body of evidence is one that points systematically to similar conclusions in relation to a particular question. In contrast a "mixed/inconsistent" body of evidence (irrespective of the quality of the research) points toward diverging and sometimes opposed conclusions.

In addition to the 202 articles identified through step 1 of the protocol, several seminal papers published before the 2003–2014 window, but unanimously recognized as critical to various aspects of our question (such as Nadel-Klein & Davis, 1988 on gender, or Baland & Platteau, 1996 on governance in relation to natural resources), are also cited in this paper but are not included in the scoring of the different clusters.

3. FINDINGS

The literature was evaluated for eight thematic areas that relate firstly to the contribution of fish to food security, nutrition and health and then to capture fisheries and aquaculture and their contribution to national and household economies. The study also includes the four cross-cutting issues of international trade, governance, scale, and gender, usually recognized to directly impact access to and control over resources, and therefore assumed to influence the nature and distribution of benefits from capture fisheries and aquaculture. The eight clusters and four cross-cutting issues are listed in Table 3. [4] The rest of this section discusses the key messages that emerge from each of these clusters, highlighting where consensus, as well as inconsistencies and knowledge gaps have been identified.

(a) *Fish, food security and nutrition*

A growing literature which aims to document the contribution of fish to food security and nutrition is now available (e.g., Kawarazuka & Béné, 2011). This cluster of literature is relatively large and homogenous, made up of articles published essentially in nutrition and/or health journals (e.g., *Journal of Nutrition*, *Public Health Nutrition*). The large majority of these studies were assessed as being of a high quality, demonstrating adherence to the principles of rigor, validity, and reliability and showed strong consistency (Table 3, cluster 1.a).

The overall message that emerges from this literature is consistent and supports the well-established evidence of the high nutritional value of finfish (in particular small fish) in terms

Table 1. *Criteria used to assess the quality of the research at the article level*

Indicators	Criteria	Yes	Partial	No
Validity	• Are the findings substantiated by the data and has consideration been given to limitations of the methods that may have affected the results? • Are there issues in applying the method to some research question(s), i.e., was the methodology adequate for the research question?			
Rigor	• Is the context or setting adequately described? • Is (are) the research question(s) clear? • Is the method used appropriate to answer the research question(s)? • Is the method applied correctly? • Is there evidence that the data collection was rigorously conducted to ensure confidence in the findings?			
Reliability	• Is the data analysis rigorously conducted to ensure confidence in the findings? • Is the methodology adequately described to ensure confidence in the findings?			

Source: adapted from ESRC (2003) and Petticrew (2006).

Table 2. *Top: criteria for the quality of the body of evidence; bottom: consistency descriptors*

Quality of the body of evidence	Definition
High	Two thirds or more of single studies are assessed as being of a high quality, demonstrating adherence to the principles of rigor, validity and reliability
Moderate	Between one third and two thirds of the studies are high quality, as assessed according to the principles of rigor, validity and reliability
Low	More than two thirds of single studies are assessed as being of low quality, showing significant deficiencies in adherence to the principles of rigor, validity and reliability
Consistency	**Definition**
Consistent	A range of studies point to identical, or similar conclusions
Inconsistent	Different studies point to a range of conclusions. In some cases, one study will directly refute or contest the findings of another. In other cases, different designs or methods applied in different contexts may simply have produced results that contrast with those of another study

of essential nutrients and micronutrients—fatty acids, vitamins D, A and B, minerals (calcium, phosphorus, iodine, zinc, iron and selenium), and the potential effective contribution that fish can offer to address multiple micronutrient deficiencies of people in developing countries (Roos, Chamnan, Loeung, Jakobsen, and Thilsted, 2007; Karapanagiotidis, Yakupitiyage, Little, Bell, and Mente, 2010; Kawarazuka & Béné, 2011; Tacon & Metian, 2013). Some caveats are worth adding, however. First, the majority of these studies have been conducted in Asia (essentially Bangladesh and Cambodia) and the analyses often lack reference to broader diets. Far less is known about species consumed in other parts of the developing world, and especially in Africa (e.g., Kawarazuka, 2010a). Second, while fish intake will increase animal protein intake and perhaps also essential micronutrient and fat content of a person's diet, it does not necessarily mean that the nutritional status of that person will systematically improve or can always be measured (Kongsbak, Thilsted, & Wahed, 2008). Also, with some exceptions (e.g., Karapanagiotidis *et al.*, 2010; Belton & Thilsted, 2014) little emphasis has been placed on understanding the variability and importance of nutrients in fish produced in different contexts, i.e., capture compared to culture, or farmed under different conditions.

(b) *Fish consumption and nutritional links to health*

Closely linked to the research on the contribution of fish to nutrition, the second cluster of articles looks more specifically at the effect of fish consumption on human health, (e.g., Thilsted 2012), and fish consumption versus health risks (ciguatera, mercury and other toxins) (e.g., Molgó, Laurent, Pauillac, Chinain, & Yeeting, 2010; Hoekstra *et al.*, 2013). Here again the cluster is remarkably homogeneous in terms of type of research undertaken. Most of the documents are articles published in medical or food/health journals. The quality of the body of evidence is relatively high (Table 3, cluster 2), although it does not score as highly as the previous cluster due to the difficulty of simultaneously evaluating the opposing positive and negative effect of fish consumption.

On the one hand, there is a large and well-established body of evidence that fish consumption does provide protective effects on a wide range of health issues, including incidence of stroke (He, Song, Daviglus, *et al.*, 2004), high blood pressure, coronary heart disease (e.g., Larsen, Eilertsen, & Elvevoll, 2011) and, possibly, cancer (although the mechanisms through which these different effects occur are still poorly understood). On the other hand, the risks of

Table 3. *Quality of the body of evidence for the cluster*

Clusters / cross-cutting issues	Validity	Rigour	Reliability	Quality[a]	Size	Consistency
Cluster 1: Fish and nutrition	24/24 = 1	58/60 = 0.96	24/24 = 1	High	Large	Consistent
Cluster 2: Fish consumption and links to health	17/20 = 0.85	39/50 = 0.78	18/20 = 0.90	High	Large	Consistent
Cluster 3.a: Fisheries and related diseases	20/24 = 0.92	58/60 = 0.96	22/24 = 0.92	High	Large	Consistent
Cluster 3.b: Fisheries, health and safety risks	10/14 = 0.71	30/35 = 0.86	12/14 = 0.86	High	Medium	Consistent
Cluster 4: Fish consumption and poverty	16/20 = 0.80	40/50 = 0.80	16/20 = 0.80	High	Large	Inconsistent
Cluster 5: Impact of interactions on food security	9/12 = 0.75	26/30 = 0.86	10/12 = 0.83	Moderate	Small	Inconsistent
Cluster 6: Drivers of change	45/70 = 0.64	130/175 = 0.74	44/70 = 0.63	Moderate	Large	Inconsistent
Cluster 7.a: Fisheries and national economies	17/38 = 0.45	63/95 = 0.66	18/38 = 0.47	Low	Large	Inconsistent
Cluster 7.b: Fishing and household economy	31/46 = 0.67	92/115 = 0.80	30/46 = 0.65	Moderate	Large	Consistent
Cluster 8.a: Aquaculture and national economies	19/28 = 0.68	46/70 = 0.66	16/28 = 0.57	Moderate	Medium-large	Inconsistent
Cluster 8.b: Aquaculture at the farm gate	25/42 = 0.59	63/105 = 0.60	26/42 = 0.62	Moderate	Large	Mixed
Cross-cutting 1: Fish trade and food security	7/18 = 0.39	27/45 = 0.60	8/18 = 0.44	Low	Large	Inconsistent
Cross-cutting 2: Fish trade and poverty alleviation	26/46 = 0.56	80/115 = 0.70	20/46 = 0.44	Moderate	Large	Inconsistent
Cross-cutting 3: Governance	32/48 = 0.67	103/120 = 0.86	34/48 = 0.74	Moderate to high	Medium	Inconsistent
Cross-cutting 4: Fish and gender	11/22 = 0.5	28/55 = 0.5	7/22 = 0.3	Moderate	Large	Mixed

Notes: [a]Quality high = the three scores under validity, rigor, and reliability >0.75; moderate = at least one score <0.75; low = at least two scores <0.50.

intoxication/poisoning are still persistent at least in some part of the world (e.g., Pacific region) (Molgó *et al.*, 2010) where diseases such as ciguatera caused by the consumption of contaminated reef fish can have both acute and chronic effects. However, when considered together, experts tend to agree (e.g., FAO/WHO, 2011) that the positive effects of high fish consumption largely outweigh the potential negative effects associated with contamination risks (HLPE, 2014). A weakness of this literature is the lack of focus on nutritionally vulnerable groups such as pregnant women and children for whom micronutrient deficiencies and contaminant levels have greater significance than for the general population.

(c) *Health risks associated with capture fisheries and aquaculture activities*

The third cluster consists of articles documenting and assessing the potential occupational health risks associated with the fisheries and aquaculture sectors. These fall essentially into two categories. The first relates to the prevalent risk of communicable disease among fisherfolk (men and/or women involved in fishing or fish trading and processing), which includes high incidence of HIV and AIDS (e.g., Allison & Seeley, 2004) and, in inland fisheries, schistosomiasis (Parker *et al.*, 2012). The second group of articles focus on the physical risks associated with fishing and fish-processing work (e.g., Nag & Nag, 2007; Windle, Neis, Bornstein, Binkley, and Navarro, 2008). Because of the nature of the issues considered, a substantial number of these articles have been published in medical (or related) journals. The assessment shows that the quality of the body of evidence is relatively high—see Table 3 cluster 3.a and 3.b, essentially due to the rigor that usually characterizes this type of research.

There are a large number of consistent findings under the cluster that stress the very high exposure and vulnerability of fishing communities to a whole combination of (sometimes reinforcing) risks. Fishing is certainly among the most dangerous occupations in the world in terms of number of accidents involving loss of fingers or limbs, back injuries, permanent disabilities, and loss at sea (Perez-Labajos, Blanco, Azofra, Achutegui, and Eguía, 2009; Zytoon, 2012). Evidence has been established largely from statistics from developed countries fisheries (Perez-Labajos, 2008), and it is recognized that the situation in developing countries is likely to be even more daunting. In addition, for various social, cultural, and possibly economic reasons, fishing communities are also particularly exposed to risks related to water-borne diseases such as schistosomiasis and malaria, but also STDs and HIV/AIDS (e.g., Béné & Merten, 2008). Prevalence of these diseases is often higher in fishing communities than in the general adult population, and comparable or higher than for other known at-risk occupational groups, such as long-distance truck drivers and military personnel (Kissling *et al.*, 2005) [5].

(d) *Fish consumption and poverty*

The fourth cluster of articles explores the relation between fish consumption and poverty: do poor people consume more (or less) fish than better-off households, and if so which fish (e.g., Garaway, 2005)? Does aquaculture improve availability of fish and to whom (e.g., Murshed-e-Jahan, Ahmed, & Belton, 2010)? The large cluster of articles and reports retained for this part of the assessment is somewhat more heterogeneous than the clusters on nutrition and health discussed above. It includes literature reviews (but no systematic ones) and several individual analyses that often combine local case-studies and global data. The quality of evidence (Table 3, cluster 4) is slightly lower than in the clusters on nutrition but still remains relatively high. The main findings that emerge from the literature are however inconsistent and somewhat ambiguous.

On the one hand, the majority of the articles stress the importance of fish as a critical source of animal protein for the poor (Hortle, 2007; Aiga, Sadatoshi Matsuoka, Kuroiwa, & Yamamoto, 2009; Kawarazuka & Béné, 2010). It is estimated for instance that capture fisheries and aquaculture provide 3.0 billion people with almost 20% of their average per capita intake of animal protein, and a further 1.3 billion people with about 15% of their per capita intake (FAO, 2014; HLPE, 2014). There is also strong evidence that fish consumption is higher in small islands developing states and LIFDCs from tropical Asian and sub-Saharan Africa (FAO, 2012), suggesting that the adage "fish as a rich food for the poor" somehow reflects reality.

The importance of the nutritional contribution of fish is, however, often overstated in regard to its protein contribution—as in most cases the share of protein intake derived from plants (e.g., beans, peas, nuts) far exceeds animal protein in general, and fish-protein in particular (Kawarazuka & Béné, 2010)—often leading to overlooking fish micro-nutrient and essential fatty acid contributions.

At the household level, there is strong evidence that both fishing households and fish-farmers consume a higher proportion of fish than other households (e.g., Gomna & Rana, 2007; Dey *et al.*, 2005), but there is no evidence that the higher consumption results in higher nutritional status. In fact, the only study that rigorously demonstrates higher nutritional status in fish-farming households also suggests that this does not result from direct fish consumption of farmed fish but from the additional cash generated by the selling of fish, which allows households to purchase other types of nutrient-rich food (Aiga *et al.*, 2009).

(e) *Capture fisheries and aquaculture and the impact of their interactions on food security*

Another cluster relates to the question of the potential (positive and negative) interactions and synergies between capture fisheries and aquaculture and the outcomes of these interactions in relation to food security. The overall quality of the body of evidence is moderate to high (Table 3, cluster 5)—but the findings are mixed.

At the global level, the literature emphasizes the increasingly critical importance of aquaculture to fill the gap between fish demand and supply (e.g., Merino *et al.*, 2012). By supplying an increasing amount of fish on the world market, the aquaculture sector has not simply increased the availability of fish, it has also prevented prices from rising as they would have if only wild fisheries were to meet the general increase in demand (World Bank, 2013; Troell *et al.*, 2014), with the potential exception of forage fish, such as many small pelagic species, that serve as aquaculture and livestock feed. In addition to this direct effect on supply–demand, aquaculture also has an impact through competition and lower price, substituting wild caught fish. [6] At the same time, however, the growing importance of aquaculture is not without issues. Earlier criticisms regarding ecological (e.g., Naylor *et al.*, 2000) and social (van Mulekom *et al.*, 2006) sustainability have continued (e.g., Martinez-Porchas & Martinez-Cordova, 2012) despite considerable progress. Wild fish (especially small pelagic fish rich in fatty acids) used as fish meal/oil production to feed farmed fish is still identified as wholly problematic (e.g.,

Merino *et al.*, 2010; Merino *et al.*, 2012) and alternative interpretations ignored (e.g., Wijkstrom, 2009). Although competition between fish for direct human consumption and fish for animal feeding may exist (HLPE, 2014) its impacts on overall human nutrition remain contested, sparking a more nuanced debate (e.g., Cao *et al.*, 2015).

At the local/household level, case studies in Bangladesh highlight that farmed fish are usually grown larger and consumed filleted, and may therefore be of lower nutritional contribution than wild small indigenous fish which are generally consumed whole. There is also no clear evidence that an increased supply of farmed-fish (or conversely availability of wild fish) has a direct effect on micronutrient status of the producing households and/or consumers (Kawarazuka & Béné, 2011).

(f) *Major drivers of change*

Can fisheries and aquaculture play any role in sustaining food security in the future, with rising demands and increasing challenges affecting supply? Numerous and heterogeneous articles attempt to address the link between fisheries or aquaculture and food security within the wider context of global drivers including population growth, fisheries governance reform, and climate change (e.g., Allison, Perry, Badjeck, *et al.*, 2009; Rice & Garcia, 2011; Merino *et al.*, 2012; Troell *et al.*, 2014). While some articles are general literature reviews of varying nature and quality, others propose some form of scenario/projection analyses. The quality of the body of evidence for some of these analyses is high, but the overall scoring is relatively low, reflecting the poor level of rigor, validity, or reliability of some of other analyses (Table 3, cluster 6).

Due to the heterogeneity of the analyses assessed under this cluster, no clear message emerges. As a result, most of the attempts to estimate the effect of these global drivers remain highly hypothetical and rely on questionable assumptions and/or methods.

(i) *Population transition*

Fish is more expensive than staple grains, pulses, or vegetables, and it is contended that economic access, and thus consumption, improves with consumers' increasing wealth and income. Consumption of animal source foods, including fish, also increases with urbanization, which improves geographic access by offering bigger, better served markets than rural areas. Urban culture also changes food consumption patterns through influencing patterns of leisure and work, provision of fast food, and advertizing.

A medium-sized body of evidence addresses the relationship between population growth and fish supplies. Over the past 50 years per capita fish supplies have increased by more than 60%, reaching 18.9 kg per person per year in 2010 (Beveridge *et al.*, 2013). The expansion that occurred during the 1960s–1980s was largely due to increased capture fisheries landings, while that that took place since the 1990s is primarily attributable to aquaculture (FAO, 2014). The quality of supporting evidence, which largely uses FAO fish production data and UN population estimates, is high, the greatest discrepancy among papers being whether fish alone or fish and shellfish consumption were considered.

The quality of the small body of evidence that considered the impacts of consumer wealth and income on level of fish consumption is moderate: only about half produce evidence that is considered valid, rigorous, and reliable. Similarly the number of papers retained for consideration of the impacts of urbanization on fish consumption is very small and the overall quality of evidence moderate. As a consequence the conclusions about the nature of this relationship are inconsistent among the different studies.

(ii) *Climate change*

Climate change is now widely recognized to affect a range of environmental variables, including ocean currents, rainfall, temperatures, river flows, storm severity and frequency, harmful algal blooms, and ocean acidification (Feely, Doney, & Cooley, 2009; Fleming *et al.*, 2006). These in turn impact on production ecology, fishing, and aquaculture operations and dependent communities, as well as on food security and the wider economy (Cochrane, De Young, Soto, and Bahri, 2009; Merino *et al.*, 2012). A medium-sized body of evidence discusses the impacts of climate change on production ecology, capture fisheries, and aquaculture operations. Approximately equal numbers of papers were judged to be of high or moderate quality, based on rigor, validity, and reliability. The great majority of papers, however, were concerned with fisheries exclusively. Another group of papers was retained for their consideration of the impact of climate-induced changes on fisheries and/or aquaculture livelihoods, food security, and economies (e.g., Cinner *et al.*, 2012; Perry, Ommer, *et al.*, 2011; Allison *et al.*, 2009). However, the quality of evidence was somewhat weak, with just under 40% of papers demonstrating clear evidence for present and future impacts. The majority concluded that it is possible to meet future fish demand, despite climate change, provided fish resources are managed sustainably and reliance on fishmeal and fish oil by the aquaculture sector continues to decline.

(iii) *Value chains and the global economy*

There is a growing literature on value chains, extending the analysis beyond the technical assessment of efficiencies, and aimed at examining industry structures, the function of players and wealth distribution. Such analyses draw attention to the roles of different actors, including fishers and farmers, the state, NGOs, and certification schemes. These articles examine aquaculture and capture fisheries value chains in Southeast Asia and Africa (e.g., Thyresson, Crona, Nystrom, de la Torre-Castro, & Jiddawi, 2013; Loc, Bush, & Sinh, 2009; Ponte, 2008). All the articles considered for this assessment are based on primary data and the quality of the evidence is relatively high.

A number of messages emerge. First in terms of food waste and losses: fish is susceptible to high post-harvest losses, especially in small-scale fisheries. Consistent evidence demonstrates that these losses occur throughout the value chain and can be both quantitative and/or qualitative (i.e., economic and nutritional) (e.g., Kumolu-Johnson & Ndimele, 2011; Akande & Diei-Ouadi, 2010). Quantitative losses are more serious, and include fish discarded at sea and lost from the value chain through spoilage caused by insect infestation (often around 20%), poor handling, and contamination (Kelleher, 2005). Overall the literature suggests that discarding is lower in artisanal fisheries, in which locally developed post-harvest methods typically utilize a wide range of species, including low-quality fish (Akande & Diei-Ouadi, 2010).

Power asymmetries in the value chain are important, and the evidence suggests that, relative to other actors, small-scale producers often receive the least benefit (e.g., Ardjosoediro & Neven, 2008). The studies provide evidence of vertical integration, especially in export-oriented trade for both capture fisheries and aquaculture as a means to secure supplies. Of increasing importance is the setting and enforcement of capture fisheries and aquaculture standards.

Certification has been seen as a way of addressing power asymmetries within value chains, but the evidence suggests that the introduction of certification schemes plays out within a particular political and economic setting and is not necessarily leading to the inclusion of the smaller-scale operators (Thyresson *et al.*, 2013; Tran, Bailey, Wilson, and Phillips, 2013; Ponte, 2008).

(g) *Capture fisheries and poverty*

Recent estimates suggest that the potential direct value of the outputs from capture fisheries is about US $80–85 billion annually (World Bank & FAO, 2009) and, when processing and ancillary activities are considered, a total contribution to global economic output of between US $225 and $240 billion per year is suggested (Dyck & Sumaila, 2010). Whether this wealth can be generated sustainably, and whether/how it contributes to poverty alleviation, are critical concerns. There are two important strands in the literature that address this issue. The first considers how fisheries contribute to economic development at the national level (World Bank & FAO, 2009; Cunningham *et al.*, 2009). The second major strand focuses on the importance of fishing at the household and local level (e.g., Béné, 2006).

(i) *Capture fisheries and national economies*

The contribution of capture fisheries to national economies is generally examined through four different pathways (e.g., Allison, 2011): (1) generation of revenues to national accounts from access payments, exports, taxation and license fees; (2) economic rents, and more generally net economic benefits that can include consumer welfare and allow for shadow pricing; (3) wages and income received by those employed in the sector; and (4), effect of multipliers and economic linkages within the regional/national economy. The cluster is quite homogeneous in terms of the type of research undertaken, dominated by bio-economic modeling and the use of national and global data sets. Most of the documents are articles published in fisheries and economics journals. The quality of the body of evidence is relatively low, essentially due to the difficulty of providing evidence of how positive contributions at the national level can be linked to pro-poor outcomes at the local and household level (Table 3, cluster 7.a).

The evidence generated from studies using global and national data sets is usually employed to highlight the opportunities for governments to maximize wealth in the fisheries sector. Fisheries can in theory be a means to generate rents that can be extracted and used to address poverty (e.g., World Bank & FAO, 2009). While a consistent message is often advocated, the evidence is weak due to problems inherent to national and global data sets. Although opportunities for poverty reduction through utilization of rents, job and income opportunities are often discussed in the literature, these elements are rarely rigorously substantiated, and power dynamics in the creation and distribution of rent are often downplayed (e.g., Campling & Havice, 2014). Evidence for the actual practice of rent extraction and its reinvestment in the fisheries sector or in poverty alleviation interventions and resultant impacts is currently lacking.

In addition to the financial value of fisheries production, a number of authors have considered the employment contribution of fisheries to national economies (e.g., Teh & Sumaila, 2013). Within the context of developing countries, evidence suggests that in conditions of chronic unemployment or when there are limited alternatives to fishing, the level of employment in the fishery that maximizes the national revenue in the rest of the economy and that contributes most to the balance of trade is larger than the employment that maximizes resource rent (e.g., Wilson & Boncoeur, 2008). The evidence is that fisheries, in particular more labor-intensive ones, can also provide important additional seasonal employment, support agricultural livelihoods, and may also provide a "labor buffer" function as people can move in and out of fishing activity depending upon other opportunities (e.g., Jul Larsen, Kolding, Overa, Nielsen, and van Zwieten, 2003; Béné, Hersoug, & Allison, 2010). While the evidence is still weak, it suggests that fisheries can potentially provide employment opportunities for the poor, in particular in conditions in which capital and investment are lacking and in post-conflict and post-disaster conditions (Béné, Hersoug, & Allison, 2010).

Within the literature on fisheries and national economic development, the importance of multipliers and the role of fisheries as a driver of development has been argued but with little in the way of quantitative evidence of fisheries growth potential. Instead, much of the focus remains on high value products for export and increasing economic efficiency (e.g., Birthal & Joshi, 2009). The literature remains unclear how changes to increase efficiency and increase rents, including certification schemes, actually benefit the poor. As with the wider literature on economic growth and poverty, it is not the aggregate wealth that matters as much as the distribution of this wealth. As with all of this section, the lack of evidence suggests that it may be misleading to rely only on global figures to infer conclusions about impacts on poverty at the local level.

(ii) *Fishing and household economy*

What sorts of benefits are derived from fish and fishing, and are poor fishing people better-off than those who don't fish? How are these benefits realized? What is the evidence that these benefits can be enhanced? A large body of peer-reviewed work, as well as an extensive gray literature, is associated with this theme. It includes literature reviews and individual country analyses (some of which combine local case-studies and global data), and appears to be relatively homogeneous. The quality of the body of evidence can be considered moderately high (Table 3, cluster 7.b).

The assessment shows that a lack of precise information remains about the role of fisheries at the individual and household levels and the means by which poverty relates to fisheries. What has been established is that fishers are not always among the "the poorest of the poor" (Béné, 2003) and poverty can be both a consequence as well as a cause of resource degradation (Béné & Friend, 2011; Allison, Horemans, & Béné, 2006). People tend to be poor for reasons that extend beyond the fisheries sector, and tackling poverty among fishers will require more than sectoral interventions (Heck *et al.*, 2007; Allison *et al.*, 2013). At the same time, the retained literature (and wider gray literature) highlights the important roles that fisheries can play within household economies and the contributions that they can make to local livelihoods. The range of benefits that inland and marine capture can provide includes material benefits (through food—produced or purchased, income, and employment) and the support of wider household livelihood strategies, for example, through seasonal contributions and safety nets (Garaway, 2005; Béné *et al.*, 2007; Jentoft & Eide, 2011; Béné, Steel, Kambala, and Gordon, 2009). But benefits extend beyond these material/financial dimensions. Fisheries also have a role in supporting relationships and well-being within communities, often through reciprocal arrangements, access to fisheries, and collective action (e.g., Weeratunge *et al.*, 2014). Even larger, although less tangible, benefits arise from the nature of the activity and from the sense of personal or

collective identities and job satisfaction that can be derived from engaging in fishing activities (Pollnac, Pomeroy, & Harkes, 2001). The literature highlights, however, the extent to which these fisheries' contributions embedded within local cultural and social contexts are often downplayed in the wider debates on the role of fish and fisheries (Thorpe, Reid, van Anrooy, and Brugere, 2005).

The literature also demonstrates that, contrary to what is often assumed, fisheries are often locally regulated (e.g., Baland & Platteau, 1996). The evidence goes some way to demonstrating that while fisheries are often referred to as "open access", there are in fact often some institutional structures that regulate fishing activity at the local level that can serve to ensure that fisheries benefit poorer as well as wealthier households (e.g., Neiland, Madakan, & Béné, 2005; Tubtim & Hirsch, 2005). Altering the nature of these institutions, or of command over access to fisheries resources, can have significant effects on the resource-poor, poorer people in general, and indeed the wider community. Less evidence is available, however, to demonstrate whether development initiatives in relation to local-level resource management have been able to increase the pro-poor nature of these arrangements. A general weakness with this literature is that there are, as yet, no general models to explain the empirical evidence of these interventions, so the nature of these sets of evidence remains a series of individual local examples.

(h) *Aquaculture for poverty alleviation*

Aquaculture accounts for an increasing proportion of global fish supply, and is widely considered to have an important role in meeting increased future demand for fish (e.g., Beveridge *et al.*, 2013; Troell *et al.*, 2014). The diversity of aquaculture systems is one of the challenges to conclusive statements about how the sector impacts poverty, but what is recognized is that, as with capture fisheries, aquaculture generally contributes to poverty reduction directly and indirectly by providing food, income, and employment for both producers and other value chain actor households.

(i) *Aquaculture and national economies*

There is a medium to large body of literature discussing how export-orientated aquaculture benefits national economies and hence—in theory—contributes to poverty reduction through its contribution to export revenues and national economic growth. However the evidence is not necessarily strong (Table 3, cluster 8.a) due to problems inherent in the data sets used, including the relatively small fraction of GDP and export revenues from aquaculture in larger and more diverse economies; the aggregation of different types of aquaculture (with different sets of beneficiaries), and, as for capture fisheries, critical assumptions about how the benefits of trade are distributed.

Studies on the scale of domestic trade and its effect on income and/or employment multipliers are also generally lacking. Thus, how much and in what way aquaculture contributes to national economic development remains unclear. National-level data in countries such as Nigeria and Vietnam confirm that commercial aquaculture systems can generate considerable domestic and export revenue, respectively, and account for a significant share of national GDP. However, the lack of tangible evidence to substantiate the effects of derived tax revenues and foreign exchange earnings on the welfare of lower income households raises the question of whether the sector makes an effective contribution to poverty alleviation, especially in the light of a lack of inter-country comparisons acknowledging the variability of production systems in their different local/regional contexts. As a result, the quality of this body of evidence is relatively low.

Two forms of aquaculture development are identified: "immanent" systems, whereby aquaculture emerges in response to demand, and "interventionist" systems, in which external agencies support the promotion of predominantly small-scale subsistence aquaculture systems (Brummett, Gockowski, Pouomogne, and Muir, 2011; Belton & Little, 2011). The evidence presented suggests that these two forms do not necessarily have the same effective contributions to economic growth and poverty alleviation. Only a few critical studies have challenged the established view that donor support to small-scale subsistence aquaculture alleviates poverty, specifically in Sub-Saharan Africa (Muir, 1999), or even in countries such as Bangladesh, where small-holder aquaculture is widely practiced (Belton, Haque, & Little, 2012).

(ii) *Contribution of aquaculture at the farm gate*

There is a large body of work, including an extensive gray literature, associated with the contribution of aquaculture to household economies. The retention rate of articles with valid and robust empirical evidence bases was relatively low, however, compared to the overall number initially reviewed, as the vast majority lack disaggregated data on household wealth, income status, and standardised controls. Also, a large number of these studies were often of (too) small sample size and of (too) small time duration to ensure validity of findings. As a consequence the overall standard of the papers was classed as moderate (Table 3, cluster 8.b).

Commercial aquaculture has developed rapidly in a number of developing countries. Some systems, such as shrimp and *Pangasius* (i.e., catfish) industries across Asia, have had transformational impacts on households and communities supporting a wholesale escape from poverty rather than incremental declines (Little *et al.*, 2012). This result suggests that the trend within aquaculture toward increasingly intensive production systems does not necessarily threaten efforts to reduce poverty. Commercial fish culture systems have been shown to limit price increases of fish, leading to their increased consumption by both extremely and moderately poor consumers (Toufique & Belton, 2014). However, evidence also shows that intensification may come at the cost of increased risks of, for example, diseases, species introduction and environmental degradation, similar to intensification of any agricultural food production system (e.g., Subasinghe, Arthur, Bartley, *et al.*, 2010). Evidence also shows that commercial aquaculture development and intensification can lead to increased elite capture of resources that negatively affect access and entitlements of the poor (Toufique & Gregory, 2008). Thus, considering the relationship between the nature and scale of production and other key characteristics of aquaculture value chains becomes critical to understanding governance structures, including power and benefit sharing mechanisms, and thus eventually to understanding their impacts on poverty alleviation and sustainable economic development (Krause, Brugere, Diedrich, *et al.*, in press).

On the other side of the spectrum, much of the evidence produced by those promoting small-holder extensive aquaculture systems concerns the opportunities and technical requirements for expansion of aquaculture and to increasing production (e.g., De Silva, 2003). Only a few case studies evoke the possibility that income and employment created by aquaculture can benefit low-income households participating in specific, often rural, aquaculture activities in both Asia and Africa (e.g., Dey, Paraguas, Kambewa, & Pemsl, 2010; Haque, Little,

Barman, and Wahab, 2010; Jahan *et al.*, 2010; Irz, Stevenson, Tanoy, Villarante, and Morissens, 2007). This literature shows that the benefits to household livelihoods through aquaculture development can occur in a number of ways and be both seasonal and indirect. Income, employment generation, and increased fish consumption have been observed for both producers, others in the value chain, and the general population through purchase or gifting. However, the overall evidence from the literature indicates that it is usually better-off farmers who have the capability to adopt new practices and technologies and thus obtain the benefits (Belton *et al.*, 2011). The reasons for this include education, income, and access to credit and information, but also more structural issues, such as ownership or rental of land and water resources. Overall, it also appears that peri-urban fish-farmers are more likely to generate higher incomes, net returns, and longer term financial viability than similar producers in more remote rural areas. This illustrates the importance of access to urban markets for both the sale of fish as well as access to key inputs such as feed and fingerlings (Karim *et al.*, 2011; Brummett *et al.*, 2011; Saguin, 2014). However, the lack of rigorous analyses and differences in what constitutes "urban" makes it difficult to say if these findings are generic (Kassam, 2014).

A second, growing body of literature on small-scale aquaculture provides evidence that points to it as having a complex role in household and community livelihood strategies. Maximizing fish production is downplayed, and a greater emphasis is placed on the fish ponds that can play a variety of potential roles in enabling communities and households to respond to changing conditions, including spreading/minimizing risk, providing income, and supplying cultured fish for consumption (e.g., Bush & Kosy, 2007). This is reminiscent of the complex multiple roles that livestock play in household and community livelihood strategies (Randolph *et al.*, 2007).

(i) *International fish trade*

Two main threads of literature need to be considered under fish trade: one looking at the contribution to and impact on food security and the second (closely linked but distinct) on the contribution of fish trade to poverty alleviation and economic growth.

(i) *Fish trade and food security*

A series of peer-reviewed articles (representing just the visible part of a much larger pool of (gray) literature) discusses the contribution that international fish trade can make to food security in developing countries. Among the articles and reports that were reviewed, the vast majority rely on existing data (with a mix of local case studies and global data sets), suggesting that a lot of the debate on this issue is based on "recycling" data. None of these articles offers a methodology and a combination of data that allows apprehending the issue comprehensively and rigorously. As a consequence, the quality of evidence is low to moderate as shown in Table 3 cross-cutting 1. In particular, the validity and reliability scores are relatively low due to problems in the methods applied to answer these questions.

The conclusions drawn from the studies are also relatively inconsistent, reflecting essentially the lack of tangible evidence and the subsequent unsettled debate that characterizes current discussions on this issue. On the one hand, some of the analyses contend that international fish trade contributes to improve food security of developing countries through fish export revenues (e.g., Schmidt, 2003), on the other, others claim that international fish trade threatens food security at the local level (e.g., Kaczynski & Fluharty, 2002). None of the studies, however, manage to demonstrate correlation between fish export revenues and import of food or improvement in food security at national or local levels. A more recent series of papers refute this polarized vision and stress the need to capture both the local- and national-level dimensions of the issue (e.g., Béné, Lawton, & Allison, 2010). An ongoing challenge here is the reliability of national and intra-regional trade data in most of the developing world and the ubiquitous non-differentiation of tropical fish species in international trade classification (except for those species of commercial significance to the global North).

(ii) *Fish trade and poverty alleviation*

A closely related group of papers report on the contribution of export-oriented fish trade to national and local economic growth (e.g., Schmidt, 2003; Bostock, Greenhalgh, & Kleih, 2004). The quality of these papers was judged as moderate (see Table 3, cross-cutting 2) because of the high diversity in the scale of secondary and primary data that are used, making comparison difficult, and leading to some inconsistencies in the conclusions.

Thematically, the papers generally assume that exploiting rising demand in export markets is an unproblematic means of wealth generation (e.g., Bostock & Walmsley, 2009). The literature supporting this analysis is largely uncritical, relying largely on global data sets of foreign exchange earnings and/or revenues derived from fish trade rather than evidence of the effects of these revenues on the national economy of the countries or the livelihoods of their populations (Kaczynski & Fluharty, 2002; Geheb *et al.*, 2008). National-level studies focused on access arrangements to developing country resources by foreign fishing interests demonstrate a significant income for national governments, but, again, there is no evidence that this income is redistributed and that it has a specific impact on poverty (Mwika, 2006; Ponte, Raakjær, & Campling, 2007; Arthur, Mees, & Halls, 2010). Studies at the local level do highlight, however, that the social relations of fish trade, such as quasi-credit patron-client relations, are an important factor affecting the nature and distribution of benefits from capture fisheries and aquaculture alike (Thorpe & Bennett, 2004; Bush & Oosterveer, 2007; Ruddle, 2011; Kusumawati, Bush, & Visser, 2013). These papers draw on local examples to argue that the wealth generated through trade is not necessarily invested back into the fisheries sector or to the regions from where the fish resources are being grown or extracted (e.g., Béné, Hersoug, & Allison, 2010; Béné, Lawton, & Allison, 2010), and that increased trade leads to declines in production that simultaneously reduce the quantity and quality of fish while increasing their local market price (e.g., Kaczynski & Fluharty, 2002; Alder & Sumaila, 2004).

Domestic trade is significantly less well explored, as is export trade between developing countries. Yet, the contribution of domestic and regional fish trade is thought to be important (Béné *et al.*, 2010). Despite little evidence of the size of income and/or employment multipliers from capture fisheries and aquaculture, qualitative analysis points to a greater multiplier effect providing important opportunities for local and national market-driven development (Béné, 2006). With the rise of the middle class in developing economies, fish consumption practices are likely to shift with changing income, taste and values (Belton & Bush, 2013), and more sophisticated capacity for upgrading fish production. However, without a clearer picture of how many people in different economic classes are employed in production, processing and ancillary activities (e.g., Allison *et al.*, 2011), the impact of market growth and

innovations, such as the introduction of mobile phones (Jensen, 2007) and certification schemes (e.g., Vandergeest, 2007; Hatanaka, 2010), will remain unclear. The challenge remains to generate a more systematic analysis to demonstrate the link between trade and pro-poor outcomes.

(j) *Governance of capture fisheries and aquaculture*

Articles within this cluster explore how societies organize to provide and recognize access and entitlement to capture fisheries and aquaculture resources and to the net benefits from them. Questions are focused around the role states and other actors play and the efficacy of different institutional arrangements. The literature is large and extensive with many papers identifying governance as critical in creating the right conditions for capture fisheries and aquaculture to contribute to poverty alleviation. The quality of the body of evidence is moderate to high (Table 3, cross-cutting 3).

The literature shows that access to and distribution of the benefits from capture fisheries and aquaculture are typically mediated through a range of institutions[7], both public and private, which emerge from the continuous interactions between individuals and groups within a given social and cultural context. The combination of these actors, deliberating, designing and implementing rules, and contracts across levels makes up the governance system (see Bavinck *et al.*, 2005; Kooiman & Bavinck, 2005; Béné & Neiland, 2006).

Decentralized governance approaches, including co-management and community-based management, dominate the capture fisheries literature, with a variety of social and environmental objectives, institutional designs, and levels of community, state, and private sector participation (Wilson, Nielsen, & Degnbol, 2003; Evans, Cherrett, & Pemsl, 2011). The general conclusion is that no one size fits all. Performance is variable, with the number of reported successes outweighed by cases demonstrating ineffective state support, weak cooperation and free-riding (Béné & Neiland, 2004; Tubtim & Hirsch, 2005; Béné *et al.*, 2009; Evans *et al.*, 2011). The role of the state remains prominent, despite co-management and community-based management emerging initially as a response to critiques of state-led resource management. Greater private sector involvement is also evident, especially in the formation of marine protected areas and the development of "rights-based approaches" to capture fisheries (e.g., Allison *et al.*, 2013).

Aquaculture governance has focused predominantly on the technical upgrading of production to foster improved or "better" management standards designed to improve efficiency and reduce negative environmental and social impacts (Anh, Bush, Mol, and Kroeze, 2011; Krause *et al.*, in press). The literature describes successful technical implementation of different standards, but also includes critical reflections on the weak inclusion of small-holder producers, enclosure and the limitations of governing "off-farm" common resources sustainably and ethically (Vandergeest, 2007; Belton *et al.*, 2011; Bush *et al.*, 2013; Hatanaka, 2010).

How these institutional arrangements in both capture fisheries and aquaculture support poverty alleviation is divided along two main lines of argumentation within which a key difference is the way in which the issue of agency is considered. The first interpretation of individuals as economically rational actors leads to a focus on the design of improved property regimes, institutions, and standards as a means to increase efficiency and aggregate wealth. This approach identifies the observed outcomes as the result of poor policy and practice, highlighting a need to introduce new arrangements that focus on technical inputs—property rights in the case of capture fisheries and improved production standards in the case of aquaculture. The approach also notes that a focus on improved property rights reifies a particular interpretation of overfishing and overcapacity as commons problems (e.g., Sutinen, 2008). In both aquaculture and capture fisheries evidence for reform is presented primarily in terms of benefits to rights holders, environmental outcomes, and efficiency (e.g., Mansfield, 2004). However, the evidence of the effectiveness of these measures in terms of addressing poverty remains weak (Béné *et al.*, 2009).

A second body of work considers agency as a more complex issue and focuses on the individuals' capabilities and the structural dimensions of knowledge and power that shape governance institutions. This part of the literature presents evidence suggesting that institutional reform alone does not address the wider social, economic, and political context in which decisions over capture fisheries and aquaculture production are taken (Crosoer, van Sittert, & Ponte, 2006; Allison *et al.*, 2013). Instead, links between fisheries and poverty are presented in the context of wider processes of reform, determinants of access and control over resources, and of the durability of local institutions faced with rent-seeking behavior (Béné, 2003; Thorpe *et al.*, 2009; Béné *et al.*, 2010). Emphasis is instead given to issues of labor and self-determination and understanding how individuals, including the poor, are constrained by wider social, economic, and political relations. Although individual cases limit the ability to generalize findings, the literature highlights the structural dimensions of power and control that extend beyond the technical aspects of fish production and that can be strong determinants of poverty (Béné & Friend, 2011).

(k) *Fish and gender*

Gender is a relational concept that considers the roles, responsibilities, and relationships between men and women and their changing dynamics in social, economic, cultural, and institutional contexts (Williams, 2008). Within the papers retained in this cluster, a large proportion included literature reviews, the rest entailing primary data-based research, or a combination of both. When assessed against the principles of rigor, validity, and reliability, the quality of the body of evidence for these analyses turned out to be moderate, essentially due to the presence of good analyses mixed with lower quality studies (Table 3, cross-cutting 4).

The assessment reveals a lack of disaggregated data and analyses that could enable comprehensive gender analysis. Instead most of the studies focus on women in capture fisheries: their roles, their lack of access to the natural resource, lack of credit, and lack of participation in governance and management (e.g., Tindall & Holvoet, 2008). A number of narratives relating to the issue of gender in capture fisheries emerge from this literature, essentially centered on gendered division of fisheries and household labor, household income, and household security as well as HIV/Aids (Williams & Choo, 2002; Ntombi Ngwenya, Keta Mosepele, & Magole, 2012). Evidence to support these narratives is weak or too location-specific, however, to be generalized. While some of these papers highlight differences between men and women beyond simple divisions of labor (e.g., Weeratunge & Snyder, 2010), there is little research as to why these differences occur and what the underlying gender issues are. In hindsight, relevant literature in the social sciences may have been overlooked as the word "women" was not used in searches, but additionally, several studies with stronger gender

conceptual basis were conducted before the period of the present evidence review, e.g., Nadel-Klein & Davis, 1988). In fact, the evidence is strongest with regard to the role of women in economic and/or socio-cultural spheres, rather than on the gender dynamics (i.e., the cultural roots of these gender divisions). Nevertheless, all these papers demonstrate convincingly that women's roles and their contribution in capture fisheries either go unrecorded or are undervalued, and remain largely invisible in national statistics (Bennett, 2005).

4. GAP ANALYSIS AND CONCLUSION

The aim of this paper was to evaluate the evidence in the published literature on the contribution of fisheries and aquaculture to food (and nutritional) security and poverty reduction, with an emphasis on developing countries. The objective was to evaluate the quality and scientific rigor of that evidence, identify the key conclusions that emerge from the literature, and assess the consistency of these conclusions across the sources.

The review revealed a heterogeneous landscape in which particular clusters of research were judged as being of good scientific quality, demonstrating a high degree of rigor, validity and reliability. This is particularly the case for papers related to aspects of nutrition and health (top part of Table 3). In contrast, some other clusters are characterized by relatively lower levels of rigor, validity, and reliability. These include analyses related to the contribution of capture fisheries or aquaculture sectors to food security or economic development at global or macro-levels. One potential explanation for this may be the lack of a consensus on underlying concepts or of one single, universal indicator relevant to measure the contribution of a particular sector.

Partially connected, but independent from the question of quality and rigor in the research, the assessment revealed that certain clusters are also characterized by relatively consistent conclusions whereas others display more inconsistent or more inconclusive findings. For example, a cluster displaying consistent findings is that assessing the contribution of capture fishing activities to household economy. Although the quality of that cluster is only moderate, the papers all converge toward the same conclusion, namely that fishing is usually a critical element in the economy of the households engaged in the sector, even when this is only on a seasonal or part-time basis. In contrast, some clusters display relatively rigorous analyses, yet fail to provide consistent or conclusive findings. The question of whether decentralized forms of governance arrangements lead to pro-poor outcomes is a good example. Presently, the outcomes are too locale-specific to allow any strong generalization.

Building on these different results, this paper identified six key gaps facing policy-makers, development practitioners, and researchers. Policy-makers and development practitioners seek consistency of results to advise their actions, whereas researchers can help resolve inconsistencies and reduce uncertainties. Comparing the results of the evidence review with implementation actions, two important conclusions emerge.

The first (and perhaps more important) gap revealed by the review is that key components of capture fisheries and aquaculture currently are not accounted for in national statistics, and/or the available figures are inaccurate. In particular, in developing countries, few rigorous socio-economic analyses have been conducted on the impact of various commercial fishing and aquaculture activities on low-income households.

The second gap that requires attention relates to gender relations and health and safety within the fisheries sector. This social and equity issue likely has major food security and poverty implications, and partly relates to the first gap wherein women and many in small-scale operations are underrepresented in statistics.

Of more general concern, the third gap is that poverty is not clearly conceptualized, articulated, or measured in fisheries and aquaculture studies. Addressing fisheries (management) issues in a developing country context, for instance, is not the same as addressing poverty *per se* in fishing communities, and fisheries research would greatly benefit from drawing on the wider knowledge on the nature of poverty that is discussed in the broader development literature.

A consequence of this gap, and a major weakness identified by this review is the lack of concrete evidence of how fish production, trade, and consumption translate into developmental benefits and their distribution, and ultimately reduce poverty. Despite a clear recognition in the literature that poverty reduction is not attributable to aggregate fish production alone, these metrics remain (surprisingly) dominant, including in the rhetoric of many international institutions. This scoping review suggests that a greater emphasis and more evidence are required on the distributional aspects of benefits, recognizing differentiated access and entitlement to fish resources across a range of scales. Evidence of such distributional aspects at regional and national scales remains scant. In contrast, a wealth of evidence of the benefits from capture fisheries and aquaculture exists at the local level.

Thus, the first conclusion of this review is that local-specific case studies could be given more credence at the international level. Arguably these studies are better able to capture the complex and multi-dimensional nature of the pathway through which fisheries and aquaculture effectively contribute to poverty alleviation, economic growth, and food and nutrition security, and the distributional aspect of these contributions. Fine grained studies such as these would need to be designed to enable comparisons across cases and to build cross-scale analyses of the contribution of fisheries and aquaculture to poverty alleviation, food security, and improved nutritional quality, spanning both national and household levels. The challenge however is to remain true to the socio-ecological nuances found in particular places (case study analysis), while simultaneously drawing upon comparative lessons from other places, and setting them all within the context of global drivers (and their differentiated effects). In short, there is a need to develop methods that capture complex relational interplay, and not resort to simplistic cause and effect [8].

Acknowledging the extremely rapid growth of aquaculture, the fourth gap identified relates to the causal relationships—either positive or negative—between aquaculture development and food security, economic growth, and impacts on poor people. In aquaculture many questions remain concerning who benefits, and at what costs to whom. Such research should be feasible as the sector is concentrated around a limited number of fish species and products compared to capture fisheries.

The fifth gap is in the well-studied area of nutrition where problems persist in demonstrating the impact of fish availability on micronutrient status or other functional outcomes (e.g., cognition, infections, growth, and development). More studies are needed on how fish contribute to the diets of the poor, as part of their food strategies.

The sixth gap relates to the urgent need for more studies in capture fisheries to explore the local-level impacts of global

drivers on food security (e.g., urbanization, climate change). For example, the lack of reliable data on small-scale fisheries complicates the uncertainty induced by climate change on the dynamics of local fish stocks. As a result, most of the attempts to estimate the effect of these global drivers are still highly hypothetical and rely on questionable assumptions and/or methods.

Finally, the second conclusion from the review arises from observations on the influence and uptake of the information in the literature and in policy. The review shows a tendency for domains of research with the most consistent and rigorous science (e.g., nutrition and health) to be least effective in influencing policy agendas in the development community. International food security experts and decision-makers seem unaware of the potential that fish can play in the fight against malnutrition (HLPE, 2014; Béné, Barange, Subasinghe, *et al.*, 2015). The problem is particularly pronounced in the current debate on how to make food systems more nutrition sensitive, i.e., how to change and improve food systems in order to advance nutrition (Allison, Delaporte, & Hellebrandt de Silva, 2013, p 45).

In contrast, areas of research such as those documenting the link between fisheries/aquaculture and national economies, or fish and international trade and food security appear to be among those that are systematically advocated by national or international institutions and development agencies, to "promote" fisheries/aquaculture in relation to development—even if the quality of the science characterizing these clusters appear to be lower, the results less consistent, or the evidence more difficult to establish. As such policy narratives and discourses preferably used by these institutions were not necessarily based on, or reflect, the quality of the existing evidence but rather other criteria such as the scale at which these processes are documented. Clearly global estimates carry more weight than local ones when it comes to influencing policy. This disconnect between evidence/science and policy narratives may not be specific to fisheries and aquaculture, but was noticeable through this evidence-based review.

NOTES

1. "Fish" in this article includes finfish, crustaceans, molluscs, miscellaneous aquatic animals, but excludes aquatic plants and algae.

2. The reason for adopting a scoping review approach is that this specific types of review allows presenting and synthesizing the evidence published in the literature (as in a conventional literature review) but in a way that allows evaluating the quality of this evidence based on a transparent and replicable protocol. Adopting a scoping review protocol therefore also fulfills the objective of a systematic review, in the sense that the criteria for eligibility to include/exclude documents are pre-determined and transparent and the evaluation of the quality of the articles reviewed is not based on the expert's subjective opinion (as in a conventional analytical literature review), but based on a set of standardized, quantifiable, and replicable scores. The work presented here cannot be considered as a systematic review *sensu stricto* however, because the scope of the question considered (contribution of fisheries and aquaculture to poverty alleviation, economic growth and food security and health) is too wide and broad to allow for the focused assessment that is generally expected from a systematic review. Instead it falls into the category of scoping review.

3. The quality scores refer specifically to the empirical research evidence that addresses the relationship between poverty or food-security issues and fisheries or aquaculture. It is not, therefore, a judgment on the value or quality of the paper in a wider academic sense. We recognize that papers of low value in demonstrating empirical relationships among key variables may provide value in other ways, such as in developing new analytical frameworks and methodologies, revealing emerging policy issues, building theory or raising new research questions.

4. The articles included in each of these eight clusters and four cross-cutting issues are listed in Appendix 2. While most of the 202 articles are used in one cluster and/or one cross-cutting issue only, several of the articles are referred to in more than one cluster and/or cross-cutting issue. Full details of publications are in the reference list.

5. Few such health risks have been identified in aquaculture, in part because the risks either do not exist, are smaller or are different, but also because there has been little research.

6. The result of such effects on the price of wild fish has already been documented for several species such as salmon and shrimp (Béné, Cadren, & Lantz, 2000; Knapp, Roheim, & Anderson, 2007) (a potential exception is again with forage fish, whose derived demand has increased due to aquaculture, leading to either relative price increases or stabilization of relative prices).

7. We refer here to "institutions" as the rules (both formal and informal) and organizations that are used to structure and influence patterns of interaction and behaviors within society.

8. Value chain analysis offers one such approach, providing an opportunity to move beyond aggregate trade statistics to explore relations among economic actors, and influence of market dynamics, public and private regulation and commercial strategy on global production and consumption practices.

9. With the exception of the second question under the validity criterion "Are there problems in applying the method to some research question (s)?" for which a "No" answer would score 1.

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APPENDIX 1. DETAILS OF THE SCORING SYSTEM USED TO ASSESS THE ARTICLES INCLUDED EACH CLUSTER

Each article was evaluated using the 9 questions presented in Table 1: two questions related to the validity level of the article; 5 questions related to the level of scientific rigor; and 2 questions related to the reliability level of the study. For each question the answer was coded according to a "Yes/Partially/No" entry code system. Only a "Yes" answer would score 1 point [9]. The total score of each article would then be equal to the total number of Yes for the 9 questions, over the maximum total possible.

These individual scores are then aggregated at the cluster level by summing up the articles' individual scores by criterion. For instance, the aggregated score for the 11 articles includes in the *Fish contribution to nutrition and health* cluster is as follows:

Criteria	Score
Validity	$22/22 = 1$
Rigor	$53/55 = 0.96$
Reliability	$22/22 = 1$
Quality	High
Size	Large
Consistency	Consistent

This score indicates that the 11 articles all scored "Yes" to the first question related to the validity criterion and "No" to the second question (thus $11 \times 2 = 22$ out of 22 points possible for validity), but that 2 articles out of the 11 did not score Yes to one of the 5 questions related to the rigor criterion (thus $4 \times 11 + (11-2) = 53$ out of 55 points possible for rigor) and scored Yes to the 2 questions related to the reliability criterion (thus $11 \times 2 = 22$ out of 22 points possible for reliability).

The overall quality was estimated to be "High" based on the very high scores (100%, 96% and 100%) obtained by the cluster on the three criteria of validity, rigor and reliability. Eleven articles also means that the size of the body of evidence was considered "large" (because $N > 10$). The overall findings of the body of evidence were evaluated to be "consistent" because for that particular theme, the 11 articles were all leading to the same conclusion, namely that fish do contribute to nutrition and health.

APPENDIX 2. LIST OF ARTICLES USED IN THE SCOPING REVIEW, DETAILED BY CLUSTERS AND CROSS-CUTTING ISSUES. FULL REFERENCE PROVIDED IN THE REFERENCE LIST

Clusters and cross-cutting issues	Articles list
Fish and nutrition	Bonham *et al.* (2009), Kawarazuka (2010b), Kawarazuka and Béné (2011), Karapanagiotidis, Yakupitiyage, Little, Bell, and Mente (2010), Kongsbak *et al.* (2008), Larsen *et al.* (2011), Lund (2013), Tacon and Metian (2013), Roos, Islam, and Thilsted (2003), Roos, Chamnan, Loeung, Jakobsen, and Thilsted (2007), Roos *et al.* (2007), Thilsted (2012)
Fish consumption and links to health	Allison *et al.* (2013), Domingo (2007), He *et al.* (2004), HLPE (2014), Hoekstra *et al.* (2013), Lund (2013), Molgó *et al.* (2010), Sidh (2013), WHO-FAO (2011), Zatsick and Mayket (2007), Zheng *et al.* (2012)
Fisheries and related diseases	Allison and Seeley (2004), Béné and Merten (2008), Entz, Prachuabmoh, van Griensven, and Soskolne (2001), Kissling *et al.* (2005), Howard, Zhou, and Omlin (2007), Lautze *et al.* (2007), Lungu and Husken (2010), McPherson (2008), Mojola (2011), Ngwenya and Mosepele (2007), Parker *et al.* (2012), Seeley and Allison (2005)
Fisheries, health and safety risks	FAO (2000), Jeebhay *et al.* (2008), Kaplan and Kite-Powell (2000), Matheson *et al.* (2001), Nag and Nag (2007), Perez-Labajos *et al.* (2009), Windle, Neis, Bornstein, Binkley, and Navarro (2008)
Fish consumption and poverty	Aiga *et al.* (2009), Allison and Seeley (2004), Béné *et al.* (2009), Bose and Dey (2007), Garaway (2005), Geheb *et al.* (2008), Gomna and Rana (2007), Heck *et al.* (2007), Hortle (2007), HLPE (2014), Kawarazuka and Béné (2010), Murshed-e-Jahan *et al.* (2010)
Impact of interactions on food security	Kawarazuka and Béné (2010), Kawarazuka and Béné (2011), HLPE (2014); Merino *et al.* (2012), Tacon and Metian (2009), Wijkstrom (2009)
Drivers of change	Ahmed (2008), Akande & Diei-Ouadi (2010), Ardjosoediro and Neven(2008), Aswani and Furusawa (2007), Bell *et al.* (2009), Béné *et al.* (2007), Beveridge *et al.* (2013), Bolorunduro, Adesehinwa, and Ayanda (2005), Chiwaul, Jamu, Chawez, and Nagoli (2012), Garcia and Rosenberg (2010), Gordon, Pulis, and Owusu-Adjei (2011), Gustavsson, Cederberg, Sonesson, van Otterdijk, and Meybeck (2011), Hap, Un, Yagi, Nakajima, and Matsui (2012), Ibengwe and Kristofferson (2012), Kabahenda, Omony, and Hüsken (2009), Kumolu-Johnson and Ndimele (2011), Loc, Bush, Sinh, and Khiem (2010), Macfadyen *et al.* (2012), Merino *et al.* (2012), Nowsad Alam (2010), Ponte (2008), Purvis (2002), Rice and Garcia (2011), Smith, Roheim, Crowder, *et al.* (2010), Srinivasan *et al.* (2010), Thyresson *et al.* (2013), Tran *et al.* (2013)
Fisheries and national economies	Alder and Sumaila (2004), Allison (2011), Béné *et al.* (2007); Béné *et al.* (2010); Bostock and Walmsley (2009), Carneiro (2011), Campbell, Whittingham, and Townsley (2006), Cunningham *et al.* (2009), Dyck and Sumaila (2010), Gillett (2009a), Hall and Andrew (2010), Heck *et al.* (2007), Hersoug (2011), Jul Larsen *et al.* (2003), Kaczynski and Fluharty (2002), Love (2010); Teh & Sumaila (2013), Thorpe *et al.* (2009), Wilson and Boncoeur (2008)
Fishing and household economy	Allison (2011); Allison & Ellis (2001); Béné (2003), Béné *et al.* (2007), Béné *et al.* (2009), Garaway (2005), Garaway (2006), Geheb *et al.* (2008), Heck *et al.* (2007), Jentoft, Onyango, and Islam (2010), Kawarazuka and Béné (2010), Meusch, Yhoung-Are, Friend, and Funge-Smith (2003), Pollnac *et al.* (2001), Salmi (2005), Sarch (2001), Smith, Lorenzen, and Nguyen Khoa (2005), Thorpe *et al.* (2005), Tubtim and Hirsch (2005), Weeratunge *et al.* (2014)
Aquaculture and national economies	Ahmed and Lorica (2002); Allison (2011); Belton and Little (2011), Belton *et al.* (2012), Brummett *et al.* (2011), Bush, Khiem, and Le Xuan Sinh (2009), Chimatiro, Hummel, and Sholz (1999), Goss, Burch, and Rickson (2000), Kaliba *et al.* (2007), Kassam (2014), Lewis (2007), Little *et al.*, (2012), Rivera-Ferre (2009)

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Appendix 2 (*continued*)

Aquaculture at the farm gate	ACIAR (2010), Amilhat, Lorenzen, Morales, Yakupitiyage, and Little (2009), Balgah and Buchenrieder (2010), Brummett (2011), Brummett *et al.* (2011), De Silva (2003), Dey *et al.* (2010), Faruque (2007), Garaway *et al.* (2006), Haque *et al.* (2010), Irz, Stevenson, Tanoy, Villarante, and Morissens (2007), Jahan *et al.* (2010), Jahan and Pemsl (2011), Huong and Cuong (2012), Karim *et al.* (2011), Kassam, Subasinghe, and Philips (2011), Kassam (2014), Morales (2007), Pant, Barman, Murshed-E-Jahanb, Belton, and Beveridge (2014), Parker (2008), Stevenson and Irz (2009), Toufique and Gregory (2008)
International fish trade and food security	Alder and Sumaila (2004), Allison (2011); Allison *et al.* (2013), Béné *et al.* (2010); FAO (2003), Kent (1997), Kurien (2004), Rivera-Ferre (2009), Smith *et al.* (2010)
Fish trade and poverty alleviation	Alder and Sumaila (2004), Allison (2011), Arthur *et al.* (2010), Belton and Bush (2013); Béné *et al.* (2010); Bostock *et al.* (2004), Bostock and Walmsley (2009), Bush and Oosterveer (2007), Geheb *et al.* (2008), Hansen and Trifković (2014), Hatanaka (2010), Kaczynski and Fluharty (2002), Kent (1997), Kurien (2004), Kusumawati *et al.* (2013), Mwika (2006), Ponte *et al.* (2007), Ruddle (2011), Thorpe and Bennett (2004), Vandergeest (2007), Walker (2002), Wierowski & Hall (2008), Wilkings (2012)
Governance	Allison and Ellis (2001), Allison *et al.* (2011), Allison *et al.* (2013), Bavnick *et al.* (2005), Belton, Little, and Grady (2009), Belton *et al.* (2012), Béné (2003), Béné *et al.* (2009), Béné and Neiland (2004), Béné and Neiland (2006); Béné *et al.* (2010); Bush *et al.* (2013), Crosoer *et al.* (2006), Evans *et al.* (2011) Garaway (2006), Hatanaka (2010), Jonell, Phillips, Rönnbäck, and Troell (2013), Mansfield (2004), Ponte (2008), Sarch (2001): Thorpe *et al.* (2009); Tubtim and Hirsch (2005), Vandergeest (2007)
Fish and gender	Bennett (2005), Geheb *et al.* (2008), Matthews, Bechtel, Britton, Morrison, and McClennen (2012), Ntombi Ngwenya *et al.* (2012), Medard, Sobo, Ngatunga, and Chirwa (2001), Tarisesei and Novaczek (2004), Tindall and Holvoet (2008), Weeratunge and Snyder (2010), Weeratunge *et al.* (2014) Williams (2008), Williams and Choo (2002)