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Fish for food and nutrition security in Ghana: Challenges and opportunities

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ABSTRACT

Fish is an important dietary source of micronutrients, particularly in low-and middle-income countries. In Ghana, effective management of fish and the fisheries is essential for food, economic and nutrition security and is critical towards achieving many of the UN Sustainable Development Goals especially those pertaining to hunger, poverty, gender equality and life under water. Ghana has experienced significant economic growth in the last few decades, but increasing inequality, uncertainties in fish availability and unsustainable management of the fisheries are challenging local food and nutrition security. This literature review examines and evaluates the role of fish and fisheries in supporting FNS in Ghana, and highlights the lack of focus on fish in the literature with regard to regional food security and fisheries governance. Our review highlights the importance of ensuring the viability of small fish populations to enhance micronutrient availability and counteract micronutrient deficiencies in Ghana. Additionally, strengthening women's role in decision making and promoting female education and empowerment in the fisheries sector is an important strategy towards enhancing FNS in the region.

1. Introduction

World hunger is on the rise, affecting an estimated 821 million people worldwide (FAO, 2019a). The significance of this global challenge is highlighted in the United Nations Sustainable Development Goals (SDGs), where goal two is designed to address ending hunger, achieving food security and improving nutrition and to end all forms of malnutrition (UN, 2015). Malnutrition, which is an umbrella term for both excess consumption of nutrients (overnutrition), inadequate consumption of nutrients (undernutrition) or micronutrient deficiency ("hidden hunger"), is primarily caused by a suboptimal diet (UNICEF, 2019). However, underlying factors such as economy, health care and status, food culture, gender equality, education and environmental issues all play a critical part in these causal pathways (Development Initiatives, 2018). As defined by the Food and Agricultural Organization (FAO), food security encompasses a multitude of underlying factors in four key dimensions (FAO, 2006): **Food availability**, **food access**, **utilization** and **stability**. Conversely, the concept of nutrition security is not anchored in technical terminology but has evolved from UNICEF's conceptual framework on malnutrition (Jonsson, 1992); including the dimensions of food security in addition to acknowledging the importance of key nutrition concerns such as care and feeding practices, public health and sanitation issues (CFS, 2012). Nutrition security and food security are parallel and symbiotic, and "food and nutrition security" (FNS) has been acknowledged as a representative term to combine the two concepts as a unitary goal of policy and programmatic actions (CFS, 2012).

To achieve FNS, FAO recommends a food-based approach that includes food production, dietary diversification and food fortification (FAO, 2011). The importance of terrestrial agri-food systems is widely recognized in this context, but the importance of fish and fisheries with regard to FNS tends to be underrecognized (Thilsted et al., 2014; Béné et al., 2015). Even though absolute fish consumption volumes may be low in low-and middle-income countries (LMICs), it may be an

Abbreviations: DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; FAO, The Food and Agriculture Organization of the United Nations; FNS, food and nutrition security; GDP, gross domestic product; HLPE, High Level Panel of Experts; LMICs, low-and middle-income countries; MAD, minimal acceptable diet; NGO, Non-Governmental Organization; PAH, polycyclic aromatic hydrocarbons; POP, persistent organic pollutant; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PUFA, polyunsaturated fatty acid; SDG, Sustainable Development Goals

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important source of animal protein, vitamins, minerals and essential trace elements (Tacon and Metian, 2009). The West African country of Ghana is home to an estimated 29 million people with domestic fish supply originating off the 550 km continental coastline or the many inland waterbodies covering approximately 10% of the land surface, including Lake Volta (8.482 km^2) (FAO, 2016a). Fish constitutes 50–80% of consumed animal protein in Ghana (Sumberg et al., 2016; FAO, 2018a) and the yearly per capita consumption is estimated at 28 kg (FAO, 2016a), which is significantly higher than most African countries. Still, the burdens of malnutrition are a persistent and ongoing challenge in Ghana, where there is a well-documented, high prevalence of undernutrition, stunting, anemia and vitamin A deficiency among children < 5 years of age co-occurring with increasing obesity rates in the adult population (GSS et al., 2014). The fisheries sector is essential for Ghana's economy and plays a critical role in national FNS and poverty alleviation, employing approximately 10 percent of the labor force and contributing 4.5 percent of the gross domestic product (GDP) (Republic of Ghana, 2011; FAO, 2016a). The strong linkages between fish, fisheries and FNS in Ghana are steadily gaining the attention of researchers and development agencies, however, there is a lack of focus on fish in the existing fisheries governance and food security literature and a thorough review of these topics is missing in the scientific literature. This is also the case for other emerging coastal LMICs including Bangladesh, Cambodia, the Gambia, Indonesia, Sierra Leone and Sri Lanka, where fish contributes 50% or more of total animal protein intake (FAO, 2018a). Here we provide a mixed method literature review focusing on the linkages between fish, fisheries and FNS in Ghana and their contribution to selected areas of focus within the four dimensions of food security: food availability, food access, utilization and stability (Fig. 1). The objective of this article is to review and integrate the fragmented literature on fish, fisheries and FNS in Ghana in order to assess these factors in a holistic way and to examine the potential opportunities and challenges that lie ahead.

2. Methods

The selection of literature for this review adhered to the recommendations outlined for the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement (Moher et al., 2009).

2.1. Literature search strategy

A single primary systematic literature search was performed in the following databases: Embase (OVID), Ovid MEDLINE® and Web of Science (Clarivate) from inception up to April 2019. These systematic searches were conducted in collaboration with an independent university librarian for quality assurance and to reduce the risk of selection and detection bias. The complete literature search strategies are available in the supplementary materials section (Appendix 1).

2.2. Inclusion and exclusion criteria

To select topics related to the different pillars in the food security framework, key persons were consulted to ensure the topics' relevance to fish, fisheries and FNS in Ghana before the systematic literature search was conducted (Fig. 1). Quantitative and qualitative research articles fulfilling the following criteria were identified for review: 1) written in English, 2) published after year 2000, 3) presenting data from Ghana, 4) available online, and 5) relevance to one of the selected topics on fish, fisheries and FNS presented in Fig. 1. Further, specific exclusion criteria were applied in the full text review: 1) data on non-commercial fish species, 2) data from other waterbodies than the Gulf of Guinea or Lake Volta. In the section on food safety, articles on 1) rare contaminants and/or specific non-communicable diseases (NCDs), 2) studies involving migrants or 3) sensory studies were excluded.

3. Results

3.1. Study selection

Fig. 2 shows the PRISMA flow chart outlining the steps in retrieving appropriate studies for the review. The formal systematic search yielded 848 potentially relevant articles. After duplicates were removed, 573 articles remained for screening. Upon reviewing the title and abstract, 49 articles were considered potentially relevant and full text of the articles were assessed for eligibility. Eleven out of the 49 articles were excluded due to the criteria specified in the PRISMA flowchart (Fig. 2). Thirty-eight articles met the inclusion criteria and were included in the qualitative synthesis. An overview of the number

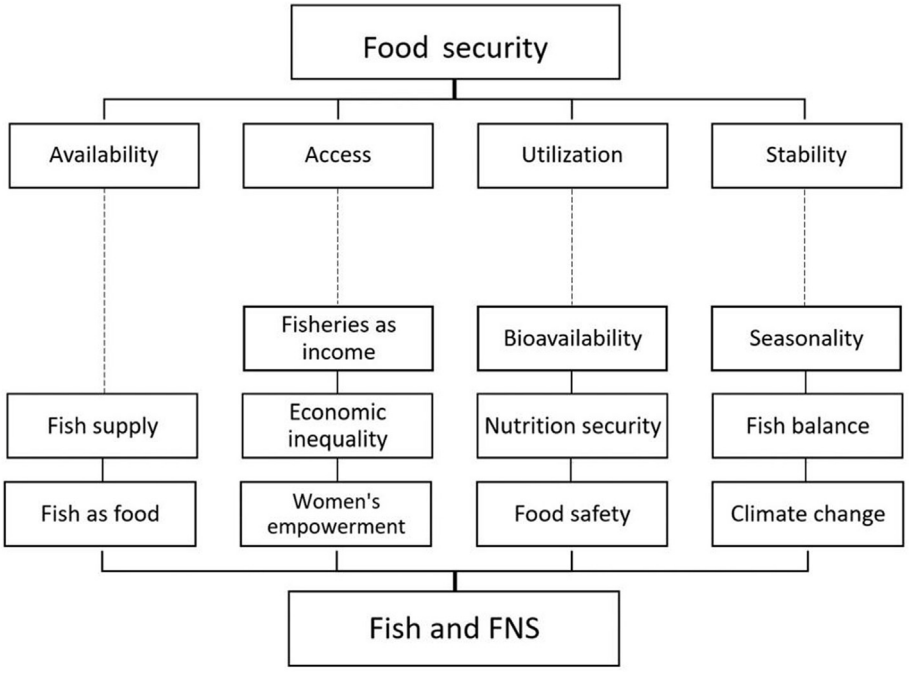

Fig. 1. Conceptual framework for the review article, the four pillars of food security (FAO, 2006) and selected focus areas related to fish and FNS in Ghana.

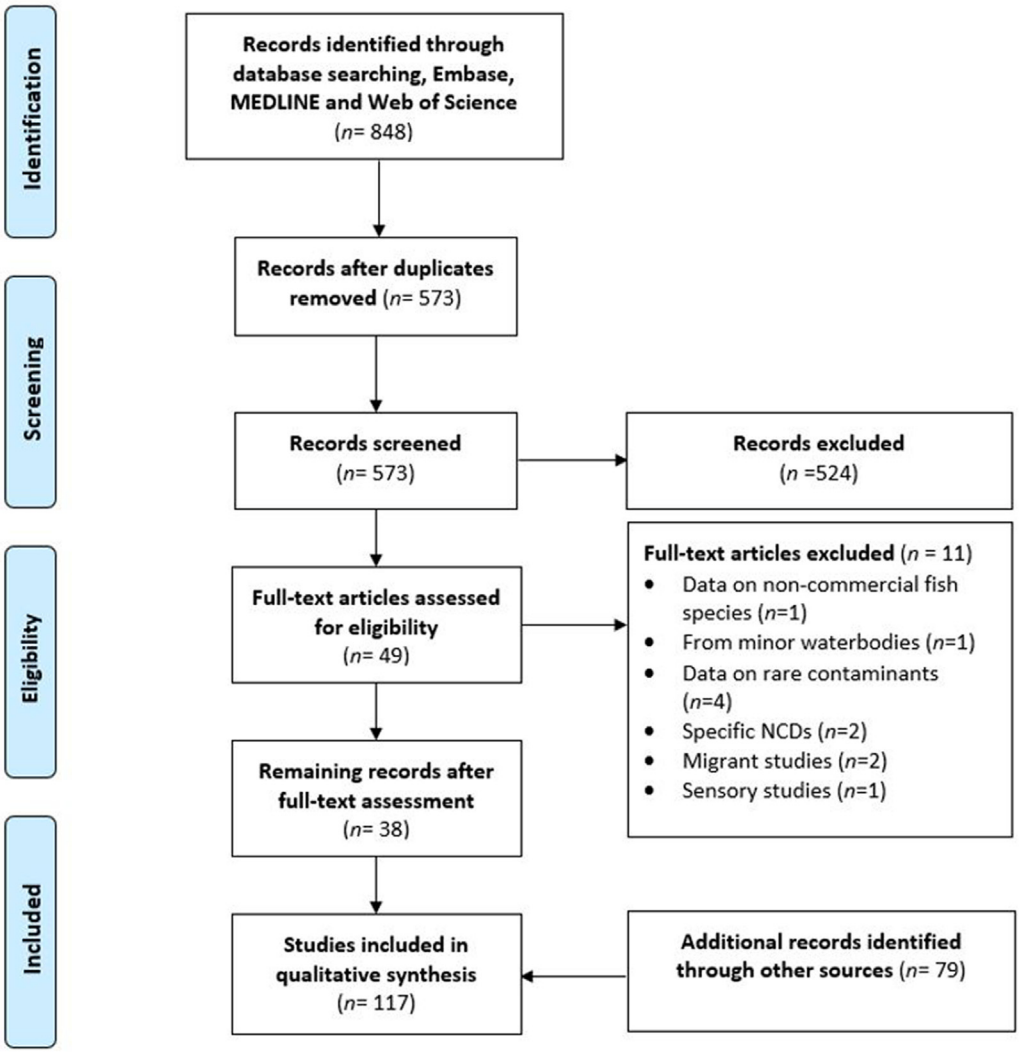

Fig. 2. PRISMA flow diagram of the study selection process (Moher et al., 2009).

of articles corresponding to each of the selected topics and pillars of food security (Fig. 1) is available in the supplementary material section (Appendix 2). The number of research articles resulting from the systematic search on each selected topic varied significantly and additional literature was needed to strengthen theoretical links in both the quantitative and qualitative research evaluations. To evaluate current legislation in the fisheries, fisheries statistics and reporting on the prevalence of stunting, wasting, underweight and other national statistics in Ghana, including official (n = 35) and NGO reports (n = 6) in the qualitative synthesis was considered essential especially given that these data are rarely provided in research articles. Furthermore, recommended research articles from associated experts (n = 38) were included to further strengthen the literature basis of this review.

3.2. Food availability

Food availability refers to the physical presence of food in sufficient quantities, supplied through domestic food production, import, stocks or aid (FAO, 2006; WFP, 2009). The referenced foods should also be of appropriate quality, and acceptable according to the local culture in a given population. We highlight two dimensions of availability in this section: 1) how the different sectors of the fisheries contribute to food availability, and 2) how fish enhances nutrient availability in the population.

3.2.1. Fish supply

The Ghanaian fisheries are diverse comprising marine, freshwater and aquaculture sectors. The marine sector is the largest and supplies approximately 80% of the recorded domestic catch (Lauria et al., 2018). The small-scale fisheries sector, using canoes of which 73% are motorized, dominates marine fisheries, and harvests approximately 70% of the coastal marine fish captures (Akyeampong et al., 2013). Sardine (*Sardinella aurita)*, Cunene horse mackerel (*Trachurus trecae*), Atlantic chub mackerel (*Scomber colias*), anchovy (*Engraulis encrasicolus*) and other small pelagic fish comprise most of the marine catch. According to FAO estimates, marine catches increased substantially with the motorization of canoes and introduction of an industrial fleet in the 1970s, peaking at nearly 500,000 mt in 1999 (FAO, 2016a). FAO statistics are currently reporting a downwards trend in marine catches in Ghana with an estimated 30% decline since the late 1990s, resulting in an annual import of up to 361,000 mt of fish and fishery products in order to satiate local demand (Table 1) (FAO, 2016a; FAO, 2019c). Data on marine fish production, however, vary considerably depending on the source consulted. For example, official FAO data estimated marine captures at 292,000 mt for 2017, while unofficial sources (SAU, 2015) reported 350,000 mt for 2014 (Table 1). There are no official estimates for the landings by small boats engaged in illegal offshore *"Saiko"* transshipments, but a recent report released by the Environmental Justice Foundation estimated that this hidden harvest equaled 101,000 mt in 2017 (Table 1) (EJF and HenMpoano, 2019) suggesting

Table 1
Fish supply estimates and utilization in Ghana (metric tons) including official and unofficial data, 2017[a].

Supply	Lower estimates	Year and source	Higher estimates	Year and source
Marine capture fisheries landings	292,000	2017 (FAO, 2019b)	350,000	2014 (SAU, 2015)
"Saiko" transshipments	0	No official data	101,000	2018 (EJF and HenMpoano, 2019)
Inland capture fisheries	90,000	2017; (FAO, 2019b)	398,000	2009 (The World Bank, 2012)
(Inland) aquaculture	57,000	2017; (FAO, 2019b)	57,000	2017 (FAO, 2019b)
Import	361,000	2017; (FAO, 2019c)	361,000	2017 (FAO, 2019c)
Total supply	800,000		1,267,000	
Utilization				
Export	72,000	2017; (FAO, 2019c)	72,000	2017 (FAO, 2019c)
Post-harvest losses	3% of landings = 11,500	FAO (2019b)	20% of landings = 170,000	FAO (2019b)
Total apparent availability[b]	716,500	Calculated from above	1,025,000	Calculated from above
Apparent per capita consumption (kg)[c]	25	Calculated from above	35	Calculated from above

[a] Data from 2017 unless not available.
[b] Apparent fish availability = (production + import – export – post-harvest losses).
[c] Apparent fish consumption per capita = (production + import – export – post-harvest losses)/population estimate (29,000,000).

significant discrepancies between official and unofficial marine fish capture estimates.

The inland fisheries are primarily centered on Lake Volta and its surrounding rivers, yielding approximately 16% of the domestic catch and includes up to 90% of the total inland fisheries production (FAO, 2016a). Reported inland fish landings are dominated by larger fish species including several species of tilapia (*Tilapia* spp.), catfish (*siluriformes*) and elephant fish (*Mormyridae*) (FAO, 2016a). Estimates of the annual yield from Lake Volta and inland waterbodies vary significantly, ranging from the official 90,000 mt presented by the FAO for 2017 (FAO, 2019b) to 398,000 mt reported by the World Bank in 2012 (The World Bank, 2012).

Aquaculture is a relatively recent addition to the Ghanaian fisheries and now operates in all ten regions of the country (FAO, 2016a; Kassam and Dorward, 2017). Nile tilapia (*Oreochromis niloticus*) represents 80% of the harvested farmed fish species, while catfish (*Clarias* spp.) make up the remaining 20%. Currently, the number of small-scale fish farms is close to 3,000 and the number of ponds and cages exceed 19,000; numbers that are expected to increase over the next years (Kassam and Dorward, 2017). Small-scale pond aquaculture has been the main production system promoted in Ghana, however, in recent years there has been a shift towards large-scale cage-aquaculture which has a higher dependency of using fish in the feed (Tacon and Metian, 2015). According to official statistics, aquaculture production has experienced rapid growth from 950 mt in 2004 to over 27,000 mt in 2012, with an average annual, overall growth rate of 73% from 2009 to 2014 (FAO, 2016a). Official sources estimate fisheries production of 57,000 mt for inland aquaculture in 2017 (Table 1) (FAO, 2019b) and although there are indications that this number may be biased low, these data currently remain unpublished.

Another increasingly important source of fish is derived from imports which have increased from ~20,000 mt in the early 1990s to ~361,000 mt in 2017 (Table 1) (FAO, 2019c). The imported fish species (mainly horse mackerel and sardinella) are relatively cheap and originate primarily from West Africa and Europe (Sumberg et al., 2016). Official data estimates that Ghana exported 72,000 mt fish in 2017 (Table 1) (FAO, 2019c), however, the full extent of trade flows in Ghana is not fully documented. Informal fish trade with neighboring countries is also prevalent which creates additional sources of uncertainty with regard to the overall accuracy of these estimates (Ayilu et al., 2016). Furthermore, improper fish handling and poor processing technologies are the main causes of post-harvest losses, which represents a significant loss (−~3% to −~20%) in total fish landings (Table 1) (FAO, 2019b).

3.2.2. Fish as food

Fish is the most frequently consumed animal protein source food in Ghana, irrespective of socioeconomic status or locality (Colecraft et al., 2006). According to official estimates the yearly per capita fish consumption in Ghana currently stands at 28 kg (FAO, 2016a), however, when unofficial data are included, this number ranges from 25 to 35 kg/cap/year (Table 1). Marine and freshwater fish species are available in many forms throughout the country, including smoked, dried and fried small pelagic species and larger fish that are mainly grilled, smoked, fried or fermented (Adeyeye and Oyewole, 2016). In combination with export and import data, fish landings and production data suggest that the main species consumed are imported mackerel and sardinella, locally landed herrings, anchovy, and tilapia and catfish from inland areas (SAU, 2015). However, factual data on fish consumption in Ghana are currently missing.

The Ghanaian diet largely consists of starchy staple foods cassava, yams, bananas and cereals (rice, maize) (Nti, 2008; FAO, 2010), with fish being central in the local cuisine serving as a complementary addition with its composition of other essential macro- and micronutrients (Kawarazuka and Béné, 2011; Weichselbaum et al., 2013). The lipid profile of fish is unique, including long-chain polyunsaturated fatty acids (PUFAs) arachidonic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Larsen et al., 2011; Weichselbaum et al., 2013). The concentration of PUFAs in fish is variable, ranging from high concentrations in marine fish species such as mackerel (3.3 g/100 g) and herring (2.4 g/100 g), to lower levels in freshwater species such as tilapia (0.47 g/100 g) (Kawarazuka and Béné, 2011). Larger fish are usually consumed for their fleshy parts, but removing the bones, viscera and organs reduces the micronutrient content compared with whole small fish (Thilsted et al., 2014). This effect was observed in a study by Bogard et al. (2017), where consumption of farmed freshwater fish at the expense of smaller wild species resulted in a decreased intake of iron and calcium in some populations. Thus, eating small fish whole is a particularly advantageous due to their rich content of minerals including iodine, selenium, iron, zinc, calcium, phosphorus and potassium, and vitamins A, D and B_{12} (HLPE, 2014; Thilsted et al., 2014; Abbey et al., 2017). Ensuring the availability of fish, particularly the nutrient-dense small fish, is therefore essential to enhance micronutrient availability and counteract micronutrient deficiencies in Ghana.

3.3. Food access

Food access refers to the ability of people to acquire adequate amounts of nutritious food by way of their own production, hunting and foraging, or purchasing of foods (FAO, 2006; WFP, 2009). We highlight three dimensions of accessibility in this section: 1) how livelihoods provided throughout the fish value chain help generate income and allow people to access nutritious foods; 2) how economic inequality affects the ability of people to access fish; 3) how gender inequality affects income generation and fish accessibility.

3.3.1. Fisheries as income

Through the livelihoods provided in the fish value chain, from boatyards and fishers to processors and market women, the fisheries sector is acornerstone of food security in Ghana (FAO, 2016a). The total value of marine fish landed in Ghana (2014, ex vessel price) was approximately 500 million USD (SAU, 2015), while fish imports in 2014 were valued at 350 million USD (FAO, 2018b). These values, in addition to the value added in the post-harvest sector, provides a significant number of livelihoods and thus allows families to access food. According to FAO, Ghana's marine sector employs 135,000 fishers, while 500,000 affiliated workers are engaged in the processing (drying, smoking, canning), distribution and marketing of fish throughout the country (FAO, 2016a). Adding the families of those gaining a livelihood in this sector, it is estimated that ~2.6 million people rely on the marine fisheries sector, and another 300,000 individuals rely on the inland fisheries sector (FAO, 2016). An increasing number of canoes as well as fishers per boat, in combination with increasing competition from trawlers (Penney et al., 2017; EJF and HenMpoano, 2019), higher input costs (Marquette et al., 2002) and declining catches (Nunoo et al., 2014a, 2014b), has resulted in apparent income reductions for small-scale fishermen and subsequently fish processors and traders. Moreover, concerns have recently been voiced that significant amounts, up to 90% of fish value landed by the industrial fleet, is concentrated in the hands of a small number of Chinese shadow owners (EJF and HenMpoano, 2019). Given the high levels of unemployment in Ghana and limited availability of alternative livelihood opportunities, a sizeable small-scale fishing fleet with high employment and diverse ownership is desirable over a scenario with a highly consolidated fleet. With the high level of capital flight associated with the industrial fleet and increasing concentration of ownership in the hands of a small group, a significant proportion of Ghanaian fish revenues subsequently does not end up benefiting the Ghanaian economy.

Due to the projected high levels of stress experienced in capture fisheries, the Ghanaian government is currently focused on furthering aquaculture development to create job opportunities and enhance fish production (MoFAD, 2019). However, studies have estimated that the costs and resources needed to adopt various forms of aquaculture are likely to be too high for the average farmer and seems to disproportionally benefit the wealthiest owners (Bénéand Obirih-Opareh, 2009; Nunoo et al., 2014a, 2014b; Kassam and Dorward, 2017). Hence, although small-scale aquaculture has the potential to increase food access and act as a source of supplementary income for some, the impact on improved FNS for poor fish farmers is currently limited (Kassam, 2014; Kassam and Dorward, 2017).

3.3.2. Economic inequality

Ghana has recently experienced significant economic growth and has reduced the poverty rate between 1992 and 2006 by ~50% while attaining middle-income country status in 2010 (UNDP, 2014; Cooke et al., 2016). However, these gains have not been evenly distributed, with increasing wealth in southern regions and high poverty rates in northern regions (UNDP, 2014). The growing economic inequality has serious implications for FNS and emphasizes the importance of having access to affordable, nutritious foods (Cooke et al., 2016). The role of fish is crucial in this regard, as it is available throughout the country at relatively low prices. Smoked sardines are particularly accessible and affordable, not only because they are relatively cheap (0.85 USD/kg) (Aheto et al., 2012), but also because they can be purchased in small quantities. According to estimates by Sumberg et al. (2016), Ghanaians spend 61% of their expenditures on animal protein source foods on fish, while fish provides 70% of the total animal protein intake, suggesting that fish is largely a relatively affordable source of nutritious food. Low-income consumers purchase less expensive fish species, however, their expenditure on fish (25.7%) exceeds the national average of 22.4%, which emphasizes their stark dependence on fish in the diet (FAO, 2016a). Conversely, more wealthy consumers have developed a preference for larger and more expensive fish such as tilapia (Asiedu et al., 2016) and are steering towards a more westernized diet with increased intake of poultry and beef at the expense of fish (Sumberg et al., 2016). Combined with other energy-dense foods, this dietary shift has increased the prevalence of obesity and related non-communicable diseases to epidemic proportions among the urban populace (Pereko et al., 2013; Ofori-Asenso et al., 2016). Thus, while securing the access to affordable fish is essential for low-income consumers, making food choices based on nutritional quality rather than ease of access could benefit wealthier consumers.

3.3.3. Women's empowerment

The Ghanaian fisheries has a distinct gender division, with female fish traders, commonly known as *konkofo,* dominating the onshore activities of the fish value chain (Gordon et al., 2011). Female fish processors, small-scale retailers and large-scale wholesalers, many of whom are wealthy and invest in canoes hiring men to fish for them, are involved in multiple sectors of the fish value chain, from landing site to consumers throughout the country (Walker, 2001; Gordon et al., 2011). Women also play a vital role in FNS, making fish available in urban and rural markets at relatively affordable prices in smoked and dried forms that can be prepared and stored in homes frequently lacking electricity, refrigerators and freezers (Overå, 2007). Although their roles in the fisheries are considered essential, Ghanaian women have limited access to funding, education and institutional support compared with their male counterparts (FAO, 2016b; Forkuor et al., 2018), which limits the role of women in decision making and their opportunities for enterprise expansion in the fisheries sector (FAO, 2016b). Most women working as fish processors and traders in the informal economy have small incomes, which represents an obstacle in terms of having sufficient funds to access fish, subsequently affecting household FNS (Overå, 2007). Despite these limitations, Kawarazuka and Béné (2010) reported that the purchasing power from selling fish (i.e. increased access) resulted in a greater proportion of income being spent on food when women were engaged in these activities. Strengthening women's role in decision making and promoting female education and empowerment in the fisheries sector is therefore an important strategy towards enhancing both food access and household FNS in Ghana.

3.4. Utilization

Utilization refers to both household and individual utilization of accessible foods, and includes several relevant themes and spheres including nutrient bioavailability, nutrition security, sanitation, feeding practices and food safety (FAO, 2006; WFP, 2009). We highlight three dimensions of food utilization in this section: 1) bioavailability of essential nutrients in fish, 2) the contribution of fish to nutrition security for children in Ghana and, 3) food safety concerns regarding fish handling and consumption.

3.4.1. Bioavailability

Fish contains numerous nutrients in highly bioavailable forms and is a valuable addition to the mainly vegetarian diets of many households affected by food insecurity (FAO, 2010; WFP, 2016). While Ghanaian staple foods contain low amounts of the essential amino acid lysine, which limits protein synthesis, fish contains particularly high levels of lysine and thereby enhances the overall protein quality from other foods when included in a meal (Kawarazuka and Béné, 2011). Iron in fish is present as readily available heme iron, in contrast to non-heme iron plant-source foods which has lower bioavailability (Béné et al., 2015; Wheal et al., 2016). Fish also counteracts the effect of inhibitors, such as phytate, found in typical Ghanaian staple foods and thus co-ingestion enhances absorption of non-heme iron and zinc from plant foods (Thilsted et al., 2014). High levels of vitamin A have been reported in small fish, but both the form and bioavailability of vitamin A varies among fish species (Roos et al., 2002). Despite containing high

levels of retinol activity equivalents, some freshwater species contain vitamin A in the form of 3,4-dehydroretinol, which may not have the ability to convert to bioavailable retinol (Kongsbak et al., 2009). Vitamin A is sensitive to sunlight and heat, but the effect of processing methods on micronutrient levels in fish is yet to be thoroughly elucidated. Sun-drying is a common processing method in Ghana, which has reduced vitamin A content in fish up to 90% (Chittchang et al., 1999). To maximize the utilization of fish in Ghana, selection of both fish species and processing method are thus important factors with regard to nutrient density and preservation, but this research is still not yet well established.

3.5. Nutrition security

Food security and nutrition security are closely interlinked but food availability and access are not always synonymous with FNS. Optimal nutrition during the first 1,000 days of life (from conception through the first two years) plays a foundational role in child development, and how well or how poorly mothers and children are nourished and cared for during this time have implications for brain and cognitive development, immune systems and growth (WHO, 2013). Although progress is being made, the most recent Ghana Demographic Health Survey reported that the prevalence of stunting, wasting, underweight, anemia (Fig. 3), vitamin A supplementation-coverage and limited access to iodized salt among children under five, are all issues of great concern (GSS et al., 2014). The critical transition from exclusive breastfeeding to solid foods has been identified as one of the main causes of child malnutrition in Ghana, where the frequency and diversity of complementary feeding (minimum acceptable diet, MAD) (Fig. 3) meet recommendations in only 13% of cases (Issaka et al., 2015; Agbadi et al., 2017). Studies have identified the attitudes of caregivers and nutrition knowledge gaps as potential barriers to optimal child feeding regimes in rural Ghana (Armar-Klemesu et al., 2018) and across different agro-ecological zones (Christian et al., 2016). Inclusion of small fish as a complimentary food during the first 1,000 days of life have been found to significantly contribute to both macro- and micronutrient intakes in infants and young children and represents a promising food-based strategy towards improving nutrition (Bogard et al., 2015). Dietary fortification of toddler food with fish powder is common practice in Ghana, however, scientific literature on the topic remains scarce. In a study by Egbi et al. (2015) the effect of adding small amounts (3%) of fish powder and vitamin C to school meals proved beneficial, resulting inthe prevalence of anemia being reduced among study participants. Fish powder is commonly made of anchovy or sardine but replacing it with cheap commodities such as underutilized fish species and byproducts is a proposed low cost strategy toward

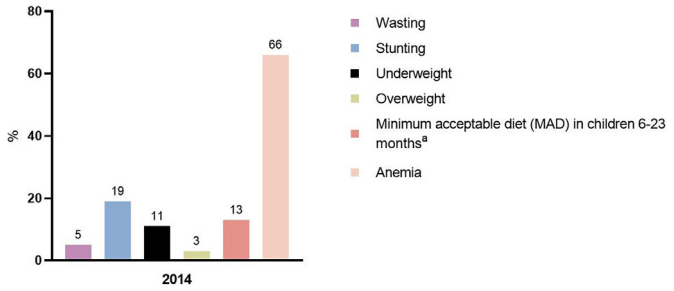

Fig. 3. Prevalence of wasting, stunting, underweight, overweight, anemia and minimum acceptable diet (MAD) of children 6–59 months in Ghana, 2014. Data source (GSS et al., 2014). [a]MAD = Breastfed children 6–23 months of age who had at least the minimum dietary diversity and the minimum meal frequency during the previous day or non-breastfed children 6–23 months of age who received at least two milk feedings and had at least the minimum dietary diversity not including milk feeds and the minimum meal frequency during the previous day (UNICEF, 2018).

alleviating micronutrient deficiencies (Nunoo et al., 2009; Glover-Amengor et al., 2012; Abbey et al., 2017). However, due to the custom of smoking and drying fish in Ghana, it remains uncertain as to what degree micronutrients are degraded by these processes and the potential consequences this represents for nutrition security. In sum, utilizing fish in the diet of young children is essential to counteract the multiple forms of malnutrition that are currently prevalent in Ghana. Furthermore, both the choice of fish species and utilization of byproducts should be considered in order to optimize the benefits of FNS in young children.

3.5.1. Food safety

While fish containa wide array of nutrients, they are also a source of contaminants. Depending on habitat, trophic position, energy flow, and proximity to anthropogenic activities, heavy metals, persistent organic pollutants (POPs), polycyclic aromatic hydrocarbons (PAHs) and microorganisms are present in varying concentrations in fish (van der Oost et al., 2003). In Ghana, fish are also affected by high post-harvest losses and freshly captured fish can undergo rapid quality deterioration and perishability as a result of the intrinsic properties such as high moisture content, near neutral pH and highly digestible protein (Ghaly et al., 2010). These conditions permit for microbial proliferation resulting in microbial contamination, and bacterial species belonging to genuses *Escherichia coli, Salmonella* spp, *Shigella*, *Streptococcus,* amongst others, have been isolated from different Ghanaian fishes (Takyi et al., 2012; Kombat et al., 2013; Kwenin et al., 2013; Antwi-Agyei and Maalekuu, 2014). Contaminated fish find their way to the markets and subsequently consumers, which raises public health concerns due to the health hazards associated with consuming contaminated fish (Scott et al., 2007). Fish from waterbodies with nearby mining activity also represents a significant potential health hazard, where mercury used for gold extraction is discharged into the hydrosphere where inorganic mercury is converted to the highly neurotoxic form, methylmercury, and subsequently bioaccumulates in fish (Hilson, 2002; Aryee et al., 2003). Variable levels of mercury have been registered in fish from areas with nearby mining-activity (Kwaansa-Ansah et al., 2011; Voegborlo et al., 2011; Gbogbo et al. 2017, 2018), and elevated blood- and urinary levels of mercury have been detected in both miners and residents of mining-communities (Rajaee et al., 2015; Henriquez-Hernandez et al., 2017). A maiden study on halogenated contaminants in tilapia from lakes and lagoons in Ghana reported low levels of selected POPs, however, the continuous discharge of untreated effluents is expected to increase their presence (Asante et al., 2013). Marine fish inhabit waters far from anthropogenic activities and point sources, but certain coastal areas in Ghana are severely polluted due to burning of e-waste and dumping of raw sewage, particularly the Agbogbloshie district in Accra (Wittsiepe et al., 2017). Analyses of pelagic fish off the Ghanaian coast show low levels of mercury (Voegborlo et al. 2004, 2011), insignificant levels of PAHs and thus poses a minimal health risk through direct consumption of fresh fish (Essumang et al., 2012). However, smoking fish in kilns operating on fuelwood causes formation of PAHs, which are known carcinogens (Nti et al., 2002). Elevated levels of PAHs have been registered in smoked sardinella from Ghana, particularly during the dry season when fat content in fish is at its highest (Essumang et al., 2012). Although the levels of various contaminants are currently low in many fish species in Ghana, implementing strategies for monitoring levels of contaminants, safe management of toxic discharge from industrial activities and continued exploration of alternative processing techniques are key actions to ensure safe utilization of fish as food.

3.6. Stability

Stability is reflected by the availability and access dimensions of food security, where a household or an individual have access to nutritious foods at all times and is resilient in adapting to economic or

environmental crisis, or cyclical events such as seasonal food insecurity (FAO, 2006; WFP, 2009). We highlight three dimensions of stability in this section: 1) seasonal variations and its effect on fish availability, 2) fish balance, and governmental strategies towards ensuring future fish availability and access, 3) climate change and its effects on fish availability and the fish industry.

3.6.1. Seasonality

While fish are readily available in Ghana during the two upwelling seasons, the minor from December–February and the major from July–September, marine fish catches are less accessible in the leaner months (FAO, 2016a). The nutrient composition of marine fish also varies seasonally, with higher water content in fish during the wet season (June–September) and higher fat content in the dry season (November–May) (Essumang et al., 2012). To compensate for reduced catches of pelagic fish in the lean season, fishermen respond by fishing further from the coast and often targeting other fish species (Lenselink, 2002; Perry and Sumaila, 2007). Seasonal fishing migration within Ghana as well as to nearby countries serves as an income generation strategy and has been practiced by Ghanaian fishermen for more than a century (Marquette et al., 2002; Mensah and Antwi, 2002). Ghanaian fisheries migrants are periodically being constrained by political actions from neighboring countries, with the intent of excluding them from their waters (Duffy-Tumasz, 2012), but the high degree of mobility continues to characterize fish harvesting patterns and is crucial for the resilience of the small-scale fisheries. In Lake Volta seasonal fluctuations in water level affect both catch rates and use of fishing gears, with fish migrating to deeper waters during recession and spawning in shallow submerged vegetation at high tide (van Zwieten et al., 2011; Mensah et al., 2019). Seasonal variations in fish availability also lead to price fluctuations, which has the greatest impact on poor inland inhabitants. During the lean season most consumers adapt by eating more imported fish while some resort to increased bushmeat hunting, which adds increased pressure on Ghana's already vulnerable wildlife (Brashares et al., 2004; Rowcliffe et al., 2005). Thus, seasonal fluctuations in fish availability have a considerable, cascading effect on economic stability and the livelihoods of fisherfolk in the marine and inland sectors. Furthermore, the seasonal variations in fish access combined with increased intake of other foods such as bushmeat during the lean season, have important implications for nutrition stability.

3.6.2. Fish balance

To bridge the gap between fish supply and demand, Ghana has increased its import of fish and the seafood trade balance has shifted from a USD 33 million surplus in 1997 to a USD 319 million deficit in 2013 (FAO, 2016a). Marine fish stocks are currently uncertain and the Ghana Fisheries Management Plan (2015–2019) aims to guide conservation of fish stocks and has implemented periodical bans on artisanal and industrial fishing (MoFAD, 2015). Moreover, fisheries regulations prevent legal access to many small species, particularly in freshwater systems (Kolding et al., 2019). The current strategy for increasing fish availability in Ghana is to stimulate aquaculture growth by prohibiting import of farmed fish and initiating The Ghana National Aquaculture Development Plan with an ambitious production target of 100,000 mt (MoFAD, 2012). While some propose that increased aquaculture production will lead to reduced poverty (Asiedu et al., 2016) and improve FNS in Ghana (Asiedu et al., 2017; Chan et al., 2019), others argue that the higher purchase price of farmed fish and the resultant changes in species and thus nutrient composition of the fish eaten will be detrimental to FNS (Kawarazuka and Béné, 2010). The nutritional value of farmed fish species can be improved by including fish-derived products such as fish oil from small pelagic fish in the feed, however, with a large group of the Ghanaian population depending on these fish for food, the sustainability of this practice is debatable (Beveridge et al., 2013; Béné et al., 2015). Although fish species such as tilapia naturally feeds on organisms lower in the aquatic food chain and are less reliant on fish-derived products in the feed than marine fish (Tacon and Metian, 2015), Fry et al. (2018) estimate that farmed tilapia only has a 15–20% protein retention compared with 35–40% for poultry. Thus, how the scale is balanced in terms of fish supply, feed requirements and nutritive quality is an issue that will have substantial implications for future FNS in Ghana.

3.6.3. Climate change

West Africa has been identified as one of the most vulnerable regions to climate change, and models predict that climate change may cause a substantial reduction in marine fish landings and lead to extensive economic losses in Ghana by 2050 (Lam et al., 2012). The effects of climate change are already evident in Ghana, and fishermen have reported increased coastal erosion, oxygen minimum zones, changes in upwelling events, stronger waves and more frequent storms as key-stressors (Freduah et al., 2017; Ankrah, 2018). The resultant interplay of climate and non-climate stressors is profound for the livelihood of coastal fishermen, who are taking greater risks in more treacherous waters to adapt and compensate for decreasing catches, increasing fuel prices and competition from industrial trawlers (Freduah et al. 2017, 2019; Ankrah, 2018). The situation is further aggravated by conflicting interests between fishermen and the offshore petroleum industry regarding the use of ocean space (Adjei and Overå, 2019). With the projected changes in performance and dynamics of aquatic ecosystems (Lam et al., 2012), it is vital that those engaged in the fisheries sector are able to have the flexibility and resilience to sustain these shocks without compromising their commitments to sustainability. However, with the current legislation periodically banning all artisanal fishing (MoFAD, 2015) and sanctioning common fishing methods targeting small fish such as light fishing and use of small mesh sizes (Kolding et al., 2019), the economic viability of fisherfolk is not taken into account. Restricting only trawl fishing periodically and allowing artisanal harvesting of small fish species could increase the resilience of fishermen substantially and lead to a more balanced harvest causing less disturbance to the ecosystem.

4. Future perspectives

4.1. Putting fish on the agenda

Fish has the potential to significantly reduce food and nutritional insecurity in Ghana and other LMICs, but its potential has repeatedly been overlooked by policymakers. The separation of fisheries from other agri-food systems was addressed by the High-Level Panel of Experts (HLPE) on FNS, underscoring the importance of incorporating fisheries as an integral element in FNS strategies, policy making and debates (HLPE, 2014). The Committee on World Food Security recognized the importance of sustainable fisheries and aquaculture for FNS and included several recommendations in its Global Strategic Framework for Food Security and Nutrition (CFS, 2014). This was partially adopted in the agenda of the FAO International Conference on Nutrition (ICN2) in 2014, where fish was recognized as having "… *a special role in nutrition and health*" (FAO, 2014). In September 2015, the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development was adopted by the United Nations (UN) (UN, 2015). In theory, fish, fisheries and FNS are interlinked with several SDGs, including SDG 1 (no poverty), 2 (zero hunger), 3 (good health), 8 (decent work and economic growth), 14 (life below water), 16 (peace, justice and strong institutions) and 17 (partnerships for the goals) (UN, 2015). However, many of the SDGs are not adapted nor conducive to small scale-fisheries which are essential to Ghana and other coastal LMICs. In 2016, the UN Decade of Action on Nutrition (2016–2025) was declared, which aims to achieve the global nutrition targets by 2025 and contribute to the realization of the Sustainable Development Goals (SDGs) by 2030 (UN, 2016). The United Nations has proclaimed a Decade of Ocean Science for Sustainable Development (2021–2030)

with a focus on reversing the cycle of decline in ocean health and supporting countries in sustainable ocean development (UNESCO, 2018). In 2021–2025, the Decade of Nutrition and the Decade of Ocean Science will coincide, providing a unique opportunity for fish and the fisheries sectors to be recognized as vital towards achieving a food and nutrition secure future.

5. Conclusion

The available literature on fish, fisheries and FNS in Ghana is fragmented, and the objective of the current article was to review and synthesize the literature in order to assess these factors in a holistic way and examine the potential opportunities and challenges that lie ahead. This review primarily contributes to filling two gaps in the literature: first, the food security and nutrition literature lacks a focus on the role of fish, and secondly that the fisheries (governance) literature lacks a focus on fish as food, and its nutritional importance. By bringing these two perspectives together through this review paper, we demonstrate that the importance of fish for food security needs to be given greater priority and inform policy at all stages of the value chain.

Fish availability is a rising challenge for FNS and the millions of Ghanaians who depend on fisheries for their livelihoods, and access to the nutrient-dense small fish species is inherently linked to the activities of small-scale fisheries rather than to the industrial or aquaculture sectors. Currently, the incursion of international industrial trawlers not only threatens the fish supply and sustainability of fish stocks but results in declining incomes of already vulnerable small-scale fishers, processors and traders, subsequently affecting their access to food. Policy makers should make sure that legislation and governance practices ensure the interests of small-scale fisherfolk, and sustainable harvests of small fish should be advocated in order to realize the potential of these species to reduce micronutrient deficiencies. This includes increasing the focus on small fish in health policy (e.g. maternal and young child feeding and school feeding programs) and evaluating the impact of declining fish and seasonal availability through local data on fish consumption patterns.

To secure fish access, investments should be made in the fish value chain by carefully supporting the import of inexpensive fish to compensate and buffer the seasonality in fish landings, and to support low-tech smoking facilities that allow for affordable yet effective preservation of fish. Moreover, an expansion of affordable electricity in the region will allow for development of cold storage and may prevent future scenarios where small and low-cost fish could be purchased by aquafeed companies to supply the growing aquaculture industry and would be highly beneficial for FNS in West Africa.

With the Decade of Nutrition and the Decade of Ocean Science coinciding between 2021 and 2025, there is a unique opportunity for policymakers to recognize the vital role of fish and fisheries towards achieving the SDGs and secure future FNS in Ghana and other LMICs.

Declaration of competing interest

All authors declare no competing financial interests nor any other conflicts of interest.

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Appendix A. Supplementary data

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