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A REVIEW OF GHANA'S FOOD SYSTEM AND ITS IMPLICATIONS ON SUSTAINABILITY AND THE DEVELOPMENT OF NATIONAL FOOD-BASED DIETARY GUIDELINES

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ABSTRACT

Food-Based Dietary Guidelines (FBDG) provide culturally-appropriate and actionable recommendations based on which populations can make healthy food choices. Food systems sustainability, from production to consumption, and disposal of food and food-related items, should be a critical consideration for developing such guidelines. This rapid review assesses Ghana's food systems to determine the level of sustainability to inform the FBDG recommendations. Peer-reviewed articles, documents and reports of relevance to Ghana were included in this rapid review. A hundred and eight papers, answering different questions on food system sustainability were reviewed. Bread, cereals, fish and indigenous vegetables are the most frequently consumed food groups. Sugar-Sweetened Beverages are the most consumed imported foods. In rural areas, 53% of dietary protein comes from plant sources. Fish is the main the source of animal protein for most Ghanaian households. There is intensive exploitation of marine and fresh water resources. Most livestock are raised by smallholder farmers using free-range system. Poultry is frequently kept on deep litter system and only a few are large-scale. Crop production for household consumption and small-scale animal rearing are predominant, especially in Northern Ghana. By weight, fruits and vegetables are the least cultivated and consumed crops at the household level. Wood is the commonest source of fuel for cooking, especially in rural areas. Single use plastic is the most used and preferred material for food packaging. Indiscriminate and poor management of waste and pesticide misuse is commonly reported. The findings suggest the need for promoting production diversification, use of clean fuel and reusable food packaging as part of FBDGs to enhance sustainability of Ghana's food systems.

Key words: sustainability, food system, Ghana, Food-based Dietary Guidelines, production, diversification

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INTRODUCTION

As the world's population continues to rise steadily [1], there is increased global awareness and efforts to produce adequate quantities and variety of nutritious, affordable foods, while preserving the biosphere. This awareness has resulted in a renewed focus on concepts such as food system sustainability. Food system sustainability is the process of providing food and nutrition security to the entire population while preserving the economic, social and environmental qualities of the bio-system so that future food and nutrition needs can be met [2, 3].

Currently, one-third of global food produce is lost or wasted [4]. This is equivalent to losing the net amount of food produced in sub-Saharan Africa. Meanwhile, future predictions suggest that food production should increase to meet global population demands [4, 5]. The rapid development of the middle class, globalization, and urbanization, continue to shift global consumption patterns away from fresh plant-based foods and plant proteins, towards increasing consumption of animal protein (meat, fish), and ultra-processed foods. The main challenge is that these emerging consumption patterns are environmentally unsustainable [6-9]; they increase greenhouse gases emission and take up more scarce resources (freshwater, arable land, energy from fossil fuels) across the entire food systems. For instance, meat produces about 250 times the greenhouse gases produced by legumes [9].

Food loss/waste is a major challenge to the global fight against hunger, carbon dioxide emissions and loss of human, physical, and natural resources needed to maintain our well-being. This situation is further affected by the declining role of backyard/subsistence farming, and intensification methods requiring the application of inorganic fertilizer to meet food productivity needs [10, 11]. Industrialisation has fuelled agricultural commercialisation which favours mono-cropping, which puts biodiversity at risk [12]. In light of the above, adapting resilient, sustainable practices which conserve the food system while ensuring continuity and resistance of the agricultural system to damage is required [14].

Agricultural productivity in sub-Saharan Africa is low with an annual growth rate of 1.8%, compared to a population growth rate of 2.9%. Thus, many African countries import large quantities of food [15]. Additionally, Africa is rapidly losing its forest cover and productive agricultural lands to deforestation for wood fuel and constructing buildings to meet the accommodation needs of an increasing urban population [16].

The Ghana agricultural sector employs close to 50% of the labour force and contributes to about 19% of Gross Domestic Product (GDP) [17]. Food loss contributes significantly to the low productivity of the Ghanaian food system. Annually, about 20-30% of cereals and legumes, 20-50% of fruits and vegetables, roots and tubers produced in the country do not reach the final consumer and this has plunged the country into the importation of food [18]. Ghana imported 70% and 15%, respectively, of rice and maize requirements in 2014 [19]. Thus, the Ministry of Food and Agriculture has outlined several components of the Medium-Term Agriculture Sector Investment Plan to improve agriculture sustainability and food security. These included

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modernizing agriculture by improving productivity, mechanization, irrigation and water management among other components [20].

Strategic investment in food systems and agricultural-related activities from production, marketing and consumption will ensure sustainability. Adequate evidence is needed to better understand issues on production, management, consumption and waste disposal practices. Such information can support national food guidance, such as food-based dietary guidelines. This rapid review assessed the sustainability of Ghana's food systems focusing on production, consumption and waste disposal.

METHODS

Search strategy

Peer-reviewed articles, documents, and reports of relevance to Ghana, irrespective of their publication date, were included in this rapid review. Google, Google Scholar, Science Direct, PubMed and JSTOR databases were searched from 20th July to 4th August, 2020. Details of the search terms used and the search period for each database is presented in table 1. Experts and stakeholders working in different governmental and non-governmental institutions provided additional relevant documents for this review.

Inclusion and exclusion criteria

The rapid review included papers conducted in Ghana or and of relevance to Ghana. All papers and documents that collected data on any dimension of food system sustainability such as food waste and or loss, production methods, packaging, energy use, consumption practices, waste disposal, and nutrition education were included in the study.

Evidence synthesis

A total of 161, 959 documents were retrieved from online databases; an additional ten documents were obtained from experts in various institutions, resulting in 161, 969. A total of 161, 800 were rejected based on titles. The abstracts of 169 papers with relevant titles were screened. The full versions of 123 documents that passed abstract screening were read. Sixty-one papers were rejected at these two stages. A total of 108 studies were included in this review. Figure 1 shows the Prisma flow diagram for study selection. Majority of the documents were based on cross-sectional (68.5%) studies. Greater Accra region was the site for almost one-fifth of the documents (16.7%). Study designs of documents and their regional distribution are presented in figure 2 and 3. The papers included in this rapid review were diverse. For those who reported on food production, most assessed the number of crops produced and the total land covered by cash and crop farming. Studies that assessed household-level consumption usually used multiple 24-four-hour recalls, dietary diversity score and food frequency questionnaire.

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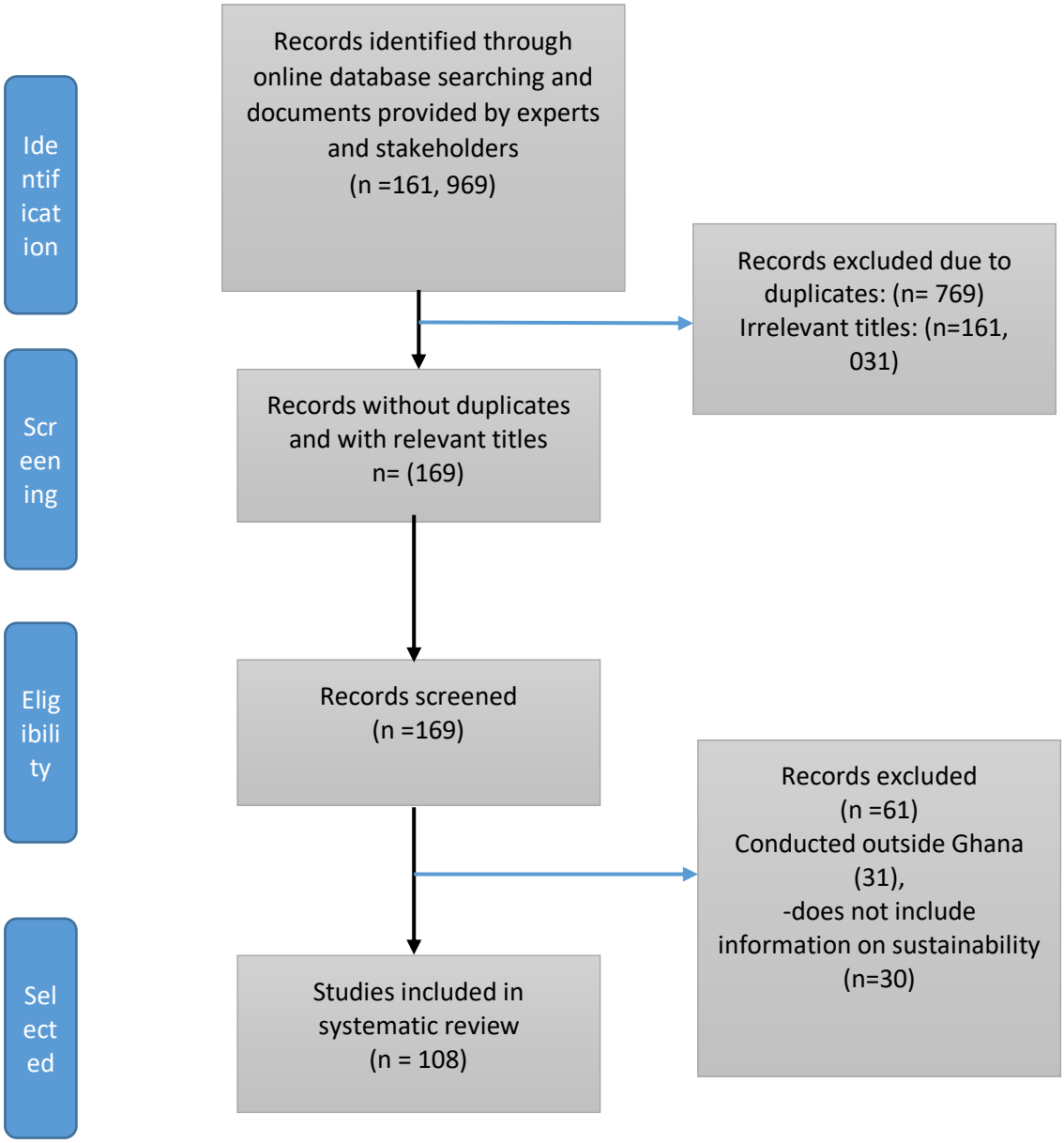

Figure 1: Data extraction table

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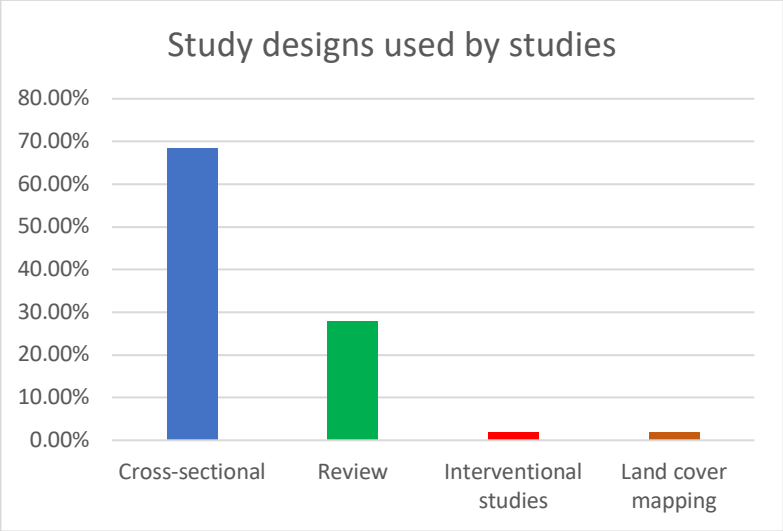

Figure 2: Study design of studies included in the review

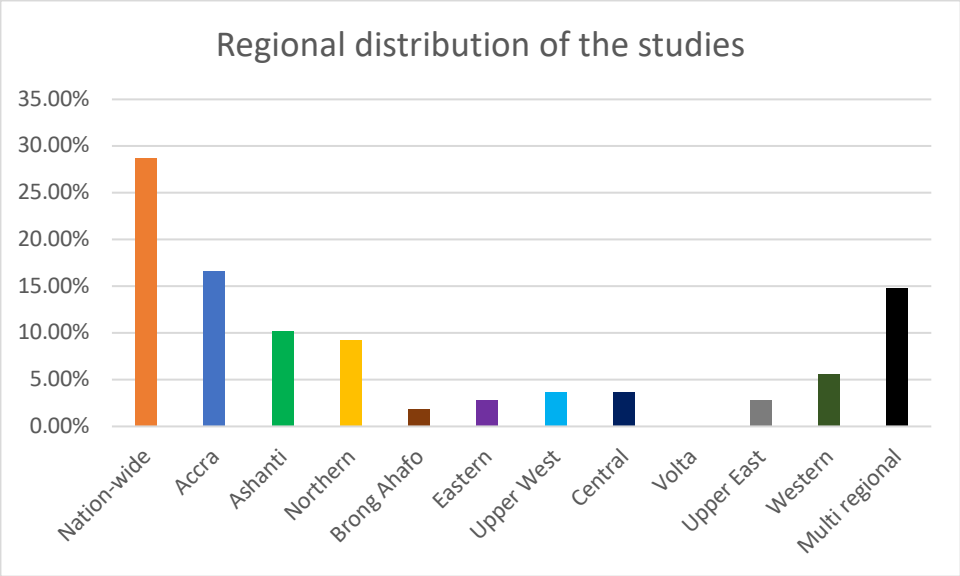

Figure 3: Regional distribution of studies

Evidence extraction

Data extracted from the included studies were author, year of publication, region or district in which studies were conducted, sample size, mean, median or age range of study participants, methods and findings on agriculture sustainability.

Quality Assessment

The Effective Public Health Practice Project (EPHPP) quality assessment tool was used to rate papers on their quality level. Studies were rated as strong, moderate or weak based on a priori criteria. The criteria comprised of representativeness of sample size, percentage of sample size, appropriateness of study design, description of cofounders, blinding for interventional studies, validity and reliability of data collection tools and procedures, drop-outs and appropriateness of analytical methods. Each criterion is rated

as strong, moderate or weak. Each paper's overall rating was either strong, moderate or weak based on each criterion's rating. Papers were rated as strong if they had no weak rating in all the criteria, moderate if they had one weak rating and weak if they had two or more weak ratings.

Limitation of the review

The majority of the documents included in the review were cross-sectional. Although a large number of the included documents indicate research on food system sustainability in Ghana, the studies were predominantly localized in some regions of Ghana while in some regions, there was only one study conducted. Additionally, only one paper was found on nutrition education of school children in Ghana.

Findings

The framework presented in figure 4 shows a summary of the findings of the review.

Food Consumption

Fifteen studies reported on food consumption [21-31]. Carbohydrate foods are the main source of energy and consist mainly of cereals, roots, tubers and plantain [25]. Cassava is the most consumed staple crop [32]. Of the cereal group, the most frequently consumed are maize and rice. Among urban dwellers, most of whom depend on food purchases to meet dietary needs, there has been a reduction in tubers and other indigenous staple foods and an increase in refined foods such as imported rice. For instance, rice consumption, most of which is imported, is greater than three times per week among 60% of households in Accra [23]. Cereals, roots, tubers and plantain are usually consumed with vegetable-based soups and sauces, but the quantities of the former are usually far lesser than the latter.

In the Northern part of the country such as in the Upper West region, guinea corn, millet and legumes are important staple crops [33] while rural dwellers in the Eastern region of the country frequently consumed plantain, yam and cocoyam. Nation-wide analysis of available dietary data from urban areas indicates that, among the general Ghanaian population, the least consumed food group is milk and dairy [31]. Its consumption ranges between 0-0.7 servings per week. Fruit consumption is also low and is occasionally consumed as a result of their seasonality and or because they are not part of traditional eating behaviour [30, 33, 34].

Among urban Ghanaians, the most frequently consumed snacks were sugar-sweetened beverages, pastries, sweets, roasted corn, roasted plantain and groundnut [31]. The young and wealthy group of the urban population frequently consumed milo, sugar-sweetened beverages, rice, red meat, eggs, margarine and exotic vegetables. On the other hand, deprived and the elderly frequently consumed fruits, plantain, smoked fish, palm oil, beans, 'banku' (corn and cassava dough meal) and indigenous vegetables [31]. Among urban dwellers in the Ashanti Region, the dietary pattern consisted of dairy products, red meat, processed meat, eggs, pasta, legumes, rice, snacks and condiments while that of rural dwellers consisted of refined cereals, fruits, nuts, seeds, roots, tubers, plantain and fermented maize [25]. Within 1991/1992-2011/2012, the consumption of eggs increased from 0.56 kg per capita to 1.2 kg per capita while meat

consumption increased from 1.27 kg per capita to 7.98 kg per capita. Poultry meat consumption has also increased over the years, and its share of total food expenditure rose from 3% in 1991/1992 to 8% in 2012/2013. The observed increase is more profound among urban and peri-urban households.

Agricultural land use; animal and crop farming

Thirty-five papers reported on agricultural land use, crop production, livestock rearing and fishing [24, 33-66]. Smallholder farmers dominate the agricultural sector in Ghana, and altogether, they produce 80% of the total agricultural output [62]. In a nationwide study, Ecker & Fang [48] observed an increase in the size of cultivated land and the number of food crops. Land size increased significantly from 6.68 ± 7.56 acres in 2006 to 7.19 ± 7.04 acres in 2013 whereas the number of food crops cultivated increased from 2.11 ± 0.98 to 2.13 ± 0.9 but this increase was not significant. Asante & Amuakwa-Mensah [62] in congruence also reported an expansion of land under cultivation but no increase in the number of crops. Cropland in the Northern region decreased from 57% to 51% within eight years and the remaining face a significant risk of being converted to residential land; the average landholding in the Northern and Brong Ahafo was 2.9 hectares [39, 43]. Poor households in Western and Eastern regions could not access land for agricultural production due to land acquisition changes and the sale of potential farmlands by kinsmen for economic gain rather than releasing it to family members for farming [59]. In rural areas of the Northern and Ashanti regions where a similar situation occurs, it has reduced the number of cash and non-cash crops produced, mono-cropping, and intensification of grain production. These practices have negative impacts on nutrition security and food systems sustainability in the country [52].

Farming remains a predominant rural activity, particularly among rural households in the Northern regions [26]. The commonly cultivated crops were maize, cowpea, groundnut, millet, plantain, green leafy vegetables, garden eggs, okro, pepper, tomatoes oranges, pineapples, bananas, [24, 57]. Of these, maize was the most grown, but tubers, roots and plantain were the most consumed home-grown foods followed by maize and other cereals [38, 39, 41, 52, 57]. About 650,000 hectares of land in the country is dedicated to maize production [53]. The average household land holdings are larger in the south compared to the northern regions. Average household land holdings were 3.6 ha in the Brong Ahafo region, 3.3 ha in the Northern region, 3.0 ha in the Upper West region and 1.8 ha in the Upper East region. In rural areas of the Ashanti Region, the average household land holding was 5.7 ha (42). Households in the Northern part of the country use 30 kg of maize, 20 kg of rice and 12 kg of soyabeans produced over 2.7 ha of land as seeds, while a majority of food consumption needs are met by own cultivated crops [39, 46]. The least cultivated crops were fruits and vegetables, and they were also the least consumed own grown foods [26]. Cash crops cultivated were predominantly cocoa, oil-palm, rice, soya beans, maize and tomatoes [37, 39, 40, 44]. Across the country, cocoa is the most cultivated cash crop [63]. Cash cropping was associated with food insecurity as households were unable to meet their food needs with income generated from the sale of cash crops [40, 60]. Poultry, most of which consisted of chicken were reared on a small scale wherein family labour is used, and locally available raw materials are used for feeds. The number of poultry birds kept per farm or

household range between 10 and 5000 [36, 41, 50]. Among farmers engaged in poultry farming in the Greater Accra municipality, 80% kept more than 500 birds [50], [41]. However, nationwide trend analysis reveals a significant reduction in poultry quantities produced in the country [58]. Between the period of 1970 to 1980, Ghana produced enough poultry mainly chicken and eggs to meet its local consumption needs, however, there was a consistent decline in domestic poultry production due to infiltration of frozen chicken imports which tend to be cheaper [58]. About 39 million chickens were reared by Ghanaian households in 2012/2013 [26]. Five other papers reported on ruminants and non-ruminants aside poultry [33, 34, 26, 41, 49]. Generally, animals including cattle, sheep and goats are reared mostly in the Northern part of the country, on a small scale, purposively for sale or as security during times of urgent need for cash; on the average households consumed less than 10% of their own produced livestock [26, 33]. National data from the 2012 survey indicates that goats were the most raised ruminants, and about 1 million goats are raised altogether by Ghanaian households [26]. Within ten years spanning 2001 to 2010, the production of goat, sheep and cattle increased by 52%, 36% and 11%.

Three studies reported on fish farming [26, 64, 66]. The studies documented that a total of 331, 500 metric tons of fish are produced in Ghana. Fishing is a major source of livelihood for urban households in coastal areas [26, 66]. Aquaculture production increased by about 15% per year between 2009 and 2014, but it constitutes 11.6% of overall fish production in the country. Marine fisheries production constitutes 61% of fish produced in the country, but there has been a decline from 420,000 metric tons in 1997 to 203,000 metric tons in 2014 [66]. Freshwater fish make up 27% of the total fish produced in the country. The small-scale fishing industry produces 70% of marine fish supply. There has, however, been a decline in fish production in recent years [66, 67].

The current level of mixed-crop and livestock farms

Three studies reported on mixed-crop and livestock farms [33, 26, 41]. More than half (51.5%) of households in Ghana are engaged in farming. A greater proportion of households (4.9 million) are engaged in crop farming than livestock raising (4.5 million) [26]. Livestock rearing is dominant among households in the rural North and is usually an adjunct to crop farming. Faeces from livestock production could be used in the crop farm for fertilizing soil while farm products such as unwholesome maize could be used for feeding livestock. In the Greater Accra region, about 10% of households are engaged in mixed farming [41]. In the northern part of the country, the land is purposely provided for crop farming but not for livestock raising. Livestock farmers, therefore, rely on the free-range system for animal feeding [33].

Production of ruminants and non-ruminants

Three studies reported on the production of ruminants and non-ruminants [26, 33, 34]. Non-ruminants comprising mainly chicken are the most raised livestock. As of 2012, two million households in the country raised chickens, a million raise goats and a small number of households raise other types of livestock. A total of 39 million chickens are raised in the country, and 4 million guinea fowls are reared. A total of 7 million goats, 6 million sheep, 2 million cattle are reared altogether by Ghanaian households [26].

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Extensive and intensive livestock and poultry farming

Eight studies reported on extensive and intensive livestock and poultry farming [23, 26, 33, 34, 36, 58, 68, 69]. Majority of livestock and poultry farmers are small scale holders—the majority of farmers who keep livestock such as cattle practice free-range system and open grazing [33]. In the northern part of the country, household members' usually adult children are responsible for herding, tethering, feeding and caring for sick animals [33]. For those who raise poultry, most practice deep-litre system [68]. About 1508 broiler chicken- producing poultry farms and 2889 egg-producing farms exist in the country. The distribution of the 1508 farms are as follows; Greater Accra, 21.1%, Eastern, 18.4%, Central 14.7%, Ashanti region, 14.2%, Brong Ahafo 13.7%, Western 9.9%, Volta 5.4%, Northern 0.9%, Upper West 0.9%, Upper East 0.7%. Majority of the poultry farms 98.7% operate on a commercial scale and are found in the southern part [68]. Of this number, only about thirty are large scale farms, and the rest are small scale [69].

Animal and Plant source Food Consumption

Twenty-one papers reported on food consumption [21, 24, 28, 29, 30, 31, 33, 37, 40, 49, 64, 66, 70-78]. Protein makes up 8% of total energy intake and is composed mainly of fish; which accounts for 60% of total animal protein consumed. Per capita, fish consumption was 28kg in 2014 [78]. Dried fish consisting of mostly herrings was the most frequently consumed fish type [21, 29, 74]. The most commonly consumed meat is beef (50%) and chicken (31.3%). Pulses and nuts, including soya beans and groundnuts, are an important source of protein for households in the Northern part of the country. Among children under five years in the Northern region of the country, 96.4% consumed grains, roots and tubers, 45-60% consumed legumes, 15% consume diary, while less than 1.5% consume eggs [64]. The children's diet completely lacked fruits, while the consumption of fresh vegetables was high in the post-harvest period. Non-timber forest products such as mushrooms, snails, honey and fruits were frequently consumed by households in the Western region, especially by poor households (5-6 times per week) [37].

In rural areas of Ghana, plant source contributed 53% of total protein intake while animal sources contributed 47% [74]. In the Western Region, the consumption of plant source protein was greater than animal source, especially among poor households. Bushmeat consumption is common among rural households in the Western and Ashanti regions [21, 71]. Bushmeat consumption is more prominent during lean seasons and contributes significantly to protein consumption of rural farmer households in the Western region [74]. In the same region, 21,410 kg of bushmeat was consumed monthly, which is equivalent to 0.001kg/person/day [71].

Fuel for Cooking

Three studies reported on fuel used for cooking [26, 81, 82]. A high proportion of Ghanaian households (41.3%) use wood as a main source of cooking. Charcoal is used by about 30%, while 22.3% use gas. The use of firewood is more prevalent among rural households, where more than 70% of households rely on wood for cooking [26]. This is especially so for rural households (87.4%) in the Northern region. Among rural

dwellers in the Ashanti, Eastern, Western, Northern, Upper West and Volta region, 80% use wood as the main source of cooking [81]. In rural areas of the Upper East region, 100% of residents use wood as a main source of cooking; among urban households, fuel usage is 10% for wood, 60% for charcoal and 29.9% for gas [82]. Nationwide, households in urban areas use predominantly charcoal (43.6%) or gas (35.8%) for cooking [26].

Food Packaging

Two studies reported on food packaging in Ghana [83, 84]. Among urban residents in the Eastern region of Ghana, about 90% use plastic bags for food packaging, while close to 50% preferred plastics for food packaging. Of those same residents, 7% used glass, 3.5% used paper and less than 2% used leaves. Meanwhile, about a quarter of respondents preferred leaves packaging because they opined that leaves are more environmentally friendly [83]. In urban areas of the Ashanti region, leaves are used in packaging wide varieties of local foods such as kenkey [84].

Nutrition Education

Only one study reported on nutrition education, and this was an interventional study [85]. A six-week nutrition education intervention was carried out among primary school children in the Eastern and Greater Accra regions. The education encompassed topics on food groups, serving and portion sizes, food safety and personal hygiene. The nutrition education significantly improved nutrition knowledge in both lower and upper primary pupils who belonged to the intervention group.

Waste and waste management

Thirty-one studies reported on waste and waste management [51, 66 86-99, 100-110]. The average amount of waste generated daily by households in urban areas ranged from 0.25 kg to 2 kg [87, 93, 100]. Across the country, about 14, 000 tonnes of plastic waste are generated annually from sachet water consumption [109]. Approximately half of the households in Ghana dispose of waste at public disposal sites, about 20% burn or bury the waste while 19% dump waste in water bodies and gutters. Open dumping is more common in the three Northern regions as opposed to Accra, where a majority of households have communal dustbins that are collected periodically from the household [89, 103, 110]. In the Greater Accra and Kumasi metropolises, low-income households usually separate plastic waste consisting mainly of water sachet from other waste generated because of monetary incentive for collecting empty water sachets [91, 96, 108]. With the exception of waste separated for monetary reward, majority of Accra households do not practice waste separation, and medical waste is also disposed of together with household waste [107, 111]. In the Ashanti and Greater Accra regions, indiscriminate waste disposal was more common in rural areas compared to urban areas [98]. Households in the Greater Accra and Central regions store household waste in polythene bags or uncovered containers prior to disposal. In the Accra, Kumasi, Takoradi and Tamale metropolises, households were willing to pay for improved garbage collection and waste management services [94, 112]. Waste management services could significantly reduce the amount of waste generated, but a majority of the households in Accra who use waste management services are not satisfied with their services [86, 100, 110, 111]. Five studies reported on food loss [51, 66, 92, 105, 110].

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Among households in the Greater Accra region, about 93% disposed of food debris as waste [110]. An assessment of post-harvest fish losses in the Western region of Ghana reveals that within six years, 92 metric tons of fish were lost. The leading causes of fishing loss were inadequate storage facilities and lack of ice for preservation [51, 66]. For rice produced in an urban area in the Ashanti region, about 8% was lost at the harvesting stage while about 9% was lost to drying and storage [92].

Agricultural practices and their impact

Seventeen studies reported on agricultural activities and their impact on the environment [62, 73, 113-115, 117-127]. Agriculture is the second largest contributor to greenhouse gases in Ghana and contributes 15% to total greenhouse gas emissions, of which clearing land through bush burning contribute 45% [127]. Livestock rearing, chemical application, rice farming and burning contributes most to greenhouse emissions [118, 123]. The gas emissions consist of carbon dioxide, methane and nitrogen dioxide [118, 123].

Five studies specifically reported on hunting [71, 73, 115, 116, 117]. Hunting was a common practice among rural households and is sometimes used as a pest control strategy rather than as a source of bushmeat for food [21]. In the Ashanti region, 28% of households actively engage in hunting and 25% hunt throughout the year [21]. In the Western region, the total volume of bushmeat hunted and sold per month was 15, 859 kg, a situation that has led to the extinction of some mammal species within some parts of the area [71, 74].

Six studies reported on pesticide use [119, 120, 121, 124, 125, 128]. There is a high level of indiscriminate pesticide use among Ghanaian farmers. In the Eastern and Greater Accra regions, pesticide use is about 13 times higher than the level recommended and posed a significant risk to aquatic systems [119, 124]. Farmers in the two regions were not knowledgeable on pesticide use and applications and mixed different types of pesticides into one spray for application [119]. The use of unregistered pesticides was rampant in the Ashanti region [113]. Pesticides are mostly applied to cocoa, vegetables and fruits [120].

Two studies reported on bad fishing practices [114, 123]. During unfavourable climatic conditions where there is a significant reduction in big fish catch, fisher folks (72.7%) in the Brong-Ahafo region catch smaller fish and fingerlings to compensate for the low catch. In the Greater Accra region, the practice of light fishing is common among fishermen and contributes to the depletion of fingerlings and high levels of fish spoilage [114].

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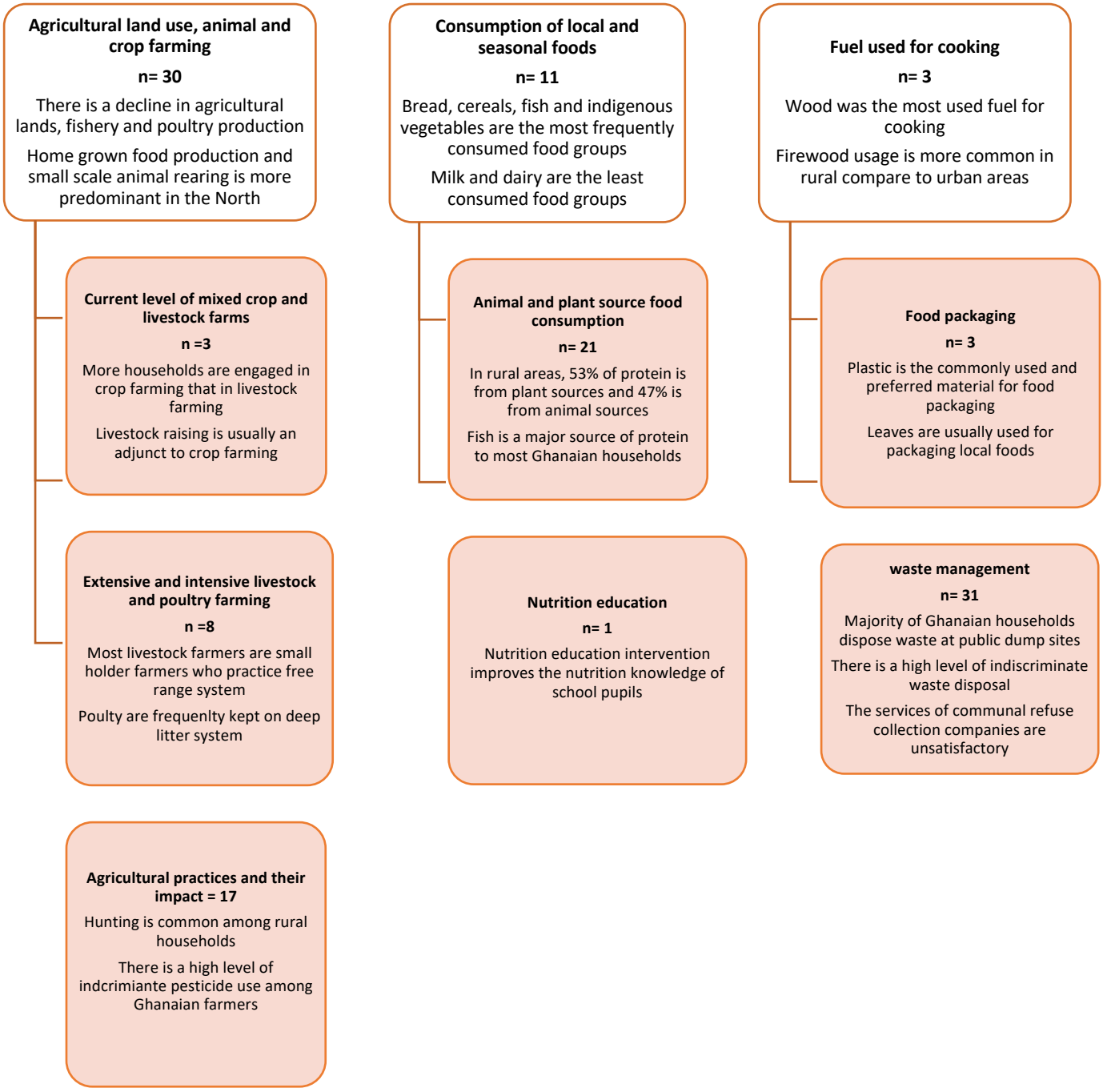

Figure 4: The conceptual framework used for the summary of findings

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DISCUSSION

This review provides essential information on the different aspects of Ghana's food system, including food production, consumption and waste disposal practices and its implications on sustainability and the development of national food-based dietary guidelines. It also reveals the opportunities that exist for strengthening sustainable practices and for dis-incentivizing unsustainable ones.

The consumption data available indicate that staple foods such as roots, tubers, grains and indigenous vegetables still form a major part of the Ghanaian diet despite the country undergoing nutrition transition as evidenced by frequent consumption of sugar-sweetened beverages especially among the urban wealthiest and youngest population. This trend is typical for African countries undergoing the nutrition transition; the initial adoption to dietary changes occurs among the aforementioned groups before it penetrates other population members and becomes ubiquitous [129]. Studies on the broad-based consumption practices remain limited in Ghana, and the possibility of underestimating current consumption levels for ultra-processed foods and snacks remains high. Livestock raised at the household level are usually sold, and protein consumption is inclined towards plant proteins, especially among rural dwellers and poor households. This consumption pattern is environmentally sustainable, but there is the need to promote complementary proteins and consumption of vitamin C foods with plant-sourced proteins to prevent anaemia and other essential amino acid deficiencies which are prevalent among the Ghanaian population [8]. These can be attained through strengthened agricultural production systems; however, pooled results from this rapid review suggest a decline in agricultural production fuelled by land acquisition changes that plunge the country into food importation of which majority are processed prior to importation.

Countrywide observations also suggest a focus on a limited number of crops, irrespective of land size and therefore, limited options exist for dietary diversification [48, 60, 62]. Bush burning, which contributes significantly to agriculture-related greenhouse emissions remains the main mode for preparing land for planting. Household-level production contributes significantly to dietary intake especially among rural households, and in urban households home grown foods complement foods purchased. There is much focus on staples like maize at the household level, while fruits and vegetables remain the least produced and consumed [26]. Fruits and vegetables are the most expensive food group, and home production for consumption is an avenue for achieving inexpensive, healthy diets. Nutrition education provides an opportunity for influencing dietary behaviour, but its level of incorporation into the curriculum is under-researched, and its impact is unknown. Indiscriminate use of pesticides especially in fruit and vegetable cultivation and fishing raises food safety concerns among the Ghanaian public especially regarding the safety of consumption of fruits and vegetables which further compounds the problem of inadequate intake [130].

Ghana is far from achieving the sustainable development goals, especially goal seven (7) which targets transitioning to clean and affordable domestic fuel use for the entire global population. More than a quarter of Ghanaian households use wood as a main

source of cooking, and in rural areas, the proportion is much higher. Household interventions should focus on making clean fuel affordable because cost remains the strongest barrier to clean fuel adoption [131]. Cooking fuel is often not mentioned in FBDG, but households that rely on wood fuel often face intermittent fuel shortages and are sometimes unable to cook at home resulting in the reliance on unhealthy street foods.

The area of food packaging remains under-researched, but the predominant preference and use of plastics as food packaging is problematic, and this unsustainable trend has a devastating impact and implications for food production and consumption. Current waste disposal services and practices are inadequate to effectively dispose of the tonnes of plastic waste produced by the consumption of sachet water alone. Waste disposal in the country remains conventional, further deepening the need for promoting reusable and recyclable food packaging.

Food-based dietary guidelines should be comprehensive, taking into account the sustainability implications on the environment and global environmental targets and not only focus on promoting healthy foods [132-134]. However, they should also be practical by considering the socio-economic and environmental contexts within which food consumption occurs [135-137]. Evidence from this review indicates that Ghana is far from attaining dietary targets set by international organizations like the World Health Organizations (WHO) and Eat Lancet recommendations regarding the usage of FBDG to achieve healthy food consumption and sustainable environments. Majority of food-based dietary guidelines do not meet global targets, but FBDG are based on consumption evidence, and countries including Ghana will have to transition gradually from its current stage to optimal recommendations set by international agencies [135, 136].

CONCLUSION

The WHO recommends country-specific targets that are practical in each country's context. In Ghana's case, promoting complementary proteins, backyard farming for fruits and vegetables, nutrition education, clean fuel use, and reusable food packaging constitute an initial sustainable step in the development of FBDG for the country.

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Table 1: Search strategy and search terms used

Database	Date	Search terms/combinations
Google and google scholar	20-24th July, 2020	1. Agriculture 'OR' farming 'AND' land use 'AND' trends 'AND' Ghana 2. Food consumption 'OR' diet 'AND' animal 'AND' Ghana 3. Food consumption 'OR' diet 'AND' crop 'OR' plant 'AND' Ghana 4. Crop farming 'OR' agriculture 'AND' method 'AND' Ghana 5. Livestock 'OR' animal farming 'AND' method 'AND' Ghana 6. Sustainable agriculture 'AND' Ghana 7. Sustainable diet 'OR' food 'AND' Ghana 8. Household 'AND' food waste 'OR' food loss 'AND' Ghana 9. Disposal 'AND' household waste 'AND' Ghana 10. Nutrition education 'OR' food 'OR' diet 'AND' School 'AND' Ghana 'AND' children 11. Fuel 'OR' energy 'AND' household 'AND' food 'AND' preparation 'OR' cooking 'AND' Ghana 12. Food package 'OR' plastic 'AND' Ghana 'AND' sustainable 'OR' Planet, and Waste 'AND' manage 'AND' Ghana 'AND' Food
PubMed	25-26th July, 2020	
Science Direct	27th -31st July, 2020	
JSTOR	3rd – 4th August, 2020	

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Table 2: Data Extraction table

Study title	Author	Sample size	Study site	Mean age if reported	Study design	Main study methods	Major findings	QA
1. Agricultural transformation and food and nutrition security in Ghana: Does farm production diversity (still) matter for household dietary diversity	Oliver Ecker, (2018)	3994 in 2006 7223 in 2013	Nationwide	Not reported	Cross-sectional	Questionnaire	Cultivated land size increased from 6.68 ±7.56 in 2006 to 7.19 ±7.04 in 2013.	Strong
2. The poultry industry in the Wa municipality of the Upper West region of Ghana; Prospects and Challenges	Agyemang, 2014	10 poultry farmers	Wa municipality Upper West	Not reported	Cross-sectional	Use of secondary and primary data Key informant interviews Focus group discussion	There is a high preference for imported chicken because it is affordable.	Weak
3. Exploratory and multidisciplinary survey of the cowpea network in Tolon-Kumbungu district of Ghana: A food sovereignty perspective	Quaye *et al*., 2009	86	Tolon-Kumbungu, Northern Region	Not reported	Cross-sectional, questionnaire	Focus group discussion	47% of farmers reported cowpea as soil nitrogen booster, and this was ranked first as the chief role of cowpea in the farming system.	Moderate
4. Socio-economic Characteristics of Subsistent Small Ruminant Farmers in Three Regions of Northern Ghana	Faizal Adams, Kwasi Ohene-Yankyera, 2014	249	Northern region Upper West region Upper East Region	47.29±16.00	Cross-sectional	Mixed methods	The average area of farmland was 6.69±7.75 acres. (North 6.32±4.47, Upper East 3.55±3.33, Upper West 11.2 ± 12.87)	Moderate

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5.	Adaptation Strategies of Poultry Farmers to Rising Temperature in the Greater Accra Region of Ghana	Gbedemah *et al*., 2018	38	Accra	Not reported	Cross-sectional	Questionnaire	Almost 80% of the farms have a capacity of more than five hundred birds.	Weak
6.	Is Deagrarianisation Real? A Study of Livelihood Activities in Rural Northern Ghana	Joseph AwetoriYaro, 2006	600 households	Northern Region	Not reported	Cross-sectional	Qualitative and quantitative data, focus group discussion	Main crops cultivated include rice, soybeans, groundnuts, and gardening. Animals reared include poultry, sheep and goat.	Moderate
7.	Population and agriculture in the dry and derived savannah zones of Ghana	Samuel NiiArdeyCodjoe and Richard E. Bilsborrow, 2011	504 households	Upper East and Ashanti Region Kassena-Nankana district Ejura-Sekyedumase district	52.2 years	Cross-sectional	Questionnaire	Derived savannah households had considerably larger farm holdings, with a mean farm size of 0.6 ha vrs 2.1 ha.	Moderate
8.	Agricultural commercialisation models, agrarian dynamics and local development in Ghana	Yaro *et al.*, 2017	3 farming areas	Western region, Eastern region	Not reported	Cross-sectional	Interviews	There has been a change in customary land acquisition as family heads prefer to sell land to strangers for profits than to other family members.	Moderate
9.	Synergies and trade-offs between cash crop production	Anderman *et al*., 2014	250 households	Ashanti region	Not reported	Cross-sectional	Qualitative assessment,	Significant negative relationship was	Moderate

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and food security: a case study in rural Ghana						household survey	found between a household's cash crop production and dietary diversity.	
10. Land-Cover Dynamics in an Urban Area of Ghana	Braimoh and Vlek, 2004	Not reported	Northern Region, Tamale	Not reported	Land cover mapping	Land cover modelling	In 1984, cropland occupied over 57% (about 1400 ha) but decreased to about 51% in 1992.	Moderate
11. Land rights, sustainable natural resource use and agricultural productivity in Ghana	Dzanku, 2008	11 districts in Ghana	Nationwide	Not reported	Not reported	Not specified	Land rights tend to have no significant effect on the propensity to invest in irrigation and soil improvements.	Strong
12. The association between the diversity of crop production and nutritional indicators of rural households in Northern Ghana	Argyropoulou, 2016	Northern region Karaga District (rural)	328 households	0-23 months	Cross-sectional	Dietary diversity score, crop diversity indicators	96.4% of children consumed grains, roots and tubers as their main foods.	Moderate
13. Assessing the land use and land cover changes due to urban growth in Accra, Ghana	Yeboah *et al.,* 2017	Accra	Not reported	Not reported	Land use land cover maps	Land satellite images, secondary data on aerial photographs	Agricultural lands which include both cultivated and irrigated lands, decreased from 94.7 km2 in 1985 to 69.2 km2 in 2010.	Moderate
14. Fisheries and Food Security	USAID, 2018	Nationwide review	Not reported	Not reported	Not reported	Review	Fish supplies 60% of the animal protein in the national diet with annual per capita fish consumption in 2014 growing to 28kg.	Moderate

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15. Innovation for Sustainable Agricultural Growth in Ghana	PARA, 2017	Nationwide review	-	-	Review	-	8% of total dietary energy supply comes from protein while 66% comes from cereals, roots and tubers.	Strong
16. Ghana's Poultry Sector: Limited Data, Conflicting Narratives, Competing Visions	Sumberg *et al.,* 2013	Nationwide trend analysis	-	-	Trend Analysis	Trend analysis of poultry production, consumption and trade	Between the period of 1970s and 1980s, Ghana was self-sufficient in chicken meat and eggs. But now there is high infiltration of frozen imported chicken.	Moderate
17. Ghana Living Standards survey round 6	Ghana Statistical Service, 2014	Nationwide	18000 households	Not reported	National survey	National survey, household questionnaire	It is estimated that a little over half (51.5%) of households in Ghana own or operate a farm and this is higher in rural areas.	Strong
18. Improvement in Crop Production in Ghana: Is it due to Area Expansion or Increased Productivity?	Akudugu *et al.,* 2013	Nationwide	-	-	Analysis of secondary data	Time series data	The results showed that improvements in the production of most staple crops in Ghana in recent years are largely due to area expansion rather than improvements in productivity.	Moderate
19. Impact of adoption in Ghana of an improved fish processing technology on	Nti *et al*., 2002	51 women	Greater Accra region	46 years	Cross-sectional	24-hour dietary recall,	Protein intake, for example, was more than 200% of the RDA. This is obvious	Moderate

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	household income, health and nutrition						because of access to and high fish intake by the respondents adopting the improved fish preservation technology.	
20.	Food and nutrient gaps in rural Northern Ghana: Does production of smallholder farming households support adoption of food-based dietary guidelines?	Jager *et al.*, 2018	329 households	Northern region, Karage sub-district	11.6±8.2 months	Cross-sectional	Interviews, dietary diversity score, (Ecker and Fang, 2016)	Own food production allowed 60% of households to cover their maize and groundnut needs, less than 40% for rice and sorghum, and less than 5% for cowpea and okro.	Moderate
21.	Seasonal migration and land-use change in Ghana	BRAIMOH, 2004	42 farming households	Northern Region, (rural)	Not reported	Cross-sectional	Questionnaire, Land stat TM	There was an increase of over 14 per cent in cultivated land in the second period (1992–1999).	Weak
22.	Promoting sustainable agriculture in Africa through ecosystem-based farm (Nchanji, 2017) management practices: evidence from Ghana	Agula *et al.*, 2018	300 households	Upper East Region, Kassena-Nankana West District and Kassena-Nankana East District	42±11 years	Cross-sectional	Qualitative and quantitative methods; focus group discussion, questionnaire, key informant interviews	One of the major problems in terms of distance is that most farmers usually find it difficult to transport organic manure. As such, only few farmers can apply organic manure on farms that are far.	Moderate
23.	Sustainable Urban Agriculture in Ghana: What Governance System Works?	Nchanji, 2017	40	Northern Region, Tamale	Not reported	Ethnographic study	Informal conversations, focus groups	Some farmers cultivate on government lands,	Moderate

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						discussions, interviews	communal lands (by accessing plots of land through chiefs, family heads or clans).	
24. Urbanisation and its impact on agricultural lands in growing cities in developing countries: a case study of tamale in Ghana	NAAB *et al*., 2013	Not specified	Northern region, Tamale	Not reported	Cross-sectional	Questionnaire, secondary data, observations	Rapid urbanization has caused a drastic change in the land holding arrangements in Tamale. Demand for land has increased leading to increase in value prices of such lands.	Moderate
25. Assessment of postharvest fish losses: The case study of Albert Bosomtwi-Sam fishing harbour, Western Region, Ghana	Gyan *et al*., 2020	330	Western, Sekondi	31-69 years	Cross-sectional	Questionnaire, interviews, informal fish loss assessment, direct observation,	Postharvest fish loss from 2010 to 2016 was estimated to be 92 tonnes.	Moderate
26. Meat Consumption Trends in Some Selected Households in Accra Ghana	Nkegbe *et al*., 2013	188 households	Greater Accra Region, Accra	Not reported	Cross-sectional	Questionnaire,	Only 8.5% of the 188 households used meat in their menu daily, 53.2% used meat in their menu once a week, 2.9% used meat only during weekends. 9% rarely used meat in their menu.	Moderate
27. Fish consumption and implications for household	Quagrainie *et al*., N.D	4011	Nationwide	Not reported	Cross-sectional	Food consumption score,	The average improvement in food	Strong

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nutrition and food security in Tanzania and Ghana						secondary data	security is between 13.9 and 15.5 points.	
28. Meat production and consumption in the Wa Municipality of Ghana	Mahaboubil-Haq and Adzitey, 2016	110	Upper West, Wa	21-50 years	Cross-sectional	Semi-structured questionnaire	The results showed that beef was the most preferred type of meat, followed by chicken, chevon (goat meat), mutton, pork and guinea fowl.	Weak
29. Adoption and Impacts of Improved Maize Production Technology: A Case Study of the Ghana Grains Development Project	Morris *et al*., 1999	420 farmers	Nationwide	Not reported	Cross-sectional	Socio-demographic factors,	Maize is the most widely consumed staple food in Ghana.	Moderate
30. Changes in Ghanaian Farming Systems Stagnation or a Quiet Transformation?	Houssou *et al*., 2016	Not reported	Ejura–Sekyedumase Ashanti region Savalegu–Nanton Northern region (Rural)	Not reported	Cross-sectional	Key informant interviews, focus group discussion, land stat images, mapping out of farm systems	In Hiawoanwu, farmers indicated that anyone who needs farmlands must now buy them. Likewise, in Tindang, no more land is available, and farmers are forced to move far into neighbouring land abundant communities to acquire new lands.	Moderate
31. Economic Development and Nutrition Transition in Ghana: Taking Stock of Food Consumption Patterns and Trends	Ecker and Fang, 2016	Not specified	Nationwide	Not reported	Review	Dietary trend analysis	Large shares of the foods consumed in Ghanaian households are own produced on households' farms.	Moderate

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32. Improving Nutrition and Health through Non-timber Forest Products in Ghana	Ahenkan and Boon, 2011	200 households	Western region, Bibiani-Bekwai and Sefwi Wiaso	Not reported	Cross-sectional	Questionnaire, interviews, previous farming practice, observations	Crops grown were cocoa, maize, oil palm, cassava, cocoyam. 44.4% of respondents engaged in beekeeping.	Moderate
33. Household food security, food consumption patterns, and the quality of children's diet in a rural northern Ghana community	Armar-Klemesu *et al*., 1995	20 households	Upper East	Not reported	Cross-sectional	Weighed food record,	Guinea corn, millet, and groundnuts were the main staples and energy sources of the area. Shea butter and, to some extent, groundnuts were the main and sources of oil.	Weak
34. Animal and Meat Production in Ghana-An Overview	Adzitey, 2013	Not specified	nationwide	Not specifie d	Review	Analysis of animal and meat production within a ten-year period	Animals produced in Ghana are solely for local consumption.	Moderate
35. Agricultural Production Survey for the Northern Regions of Ghana: 2013-2014 Results	Amanor-Boadu *et al*., 2015	527 households	Upper West, Upper East, Northern region, Brong Ahafo region	Not reported	Cross-sectional	Diary approach, provision of periodic information, questionnaire	The average size of household land holding was about 2.9 ha, and ranged from under a tenth of a hectare to 63.1 ha.	Moderate
36. Dietary diversity and nutritional adequacy of under-fives in a fishing community in the central region of Ghana	Bandoh and Kenu, 2017	250	Central region	27 months	Cross-sectional	Dietary intake assessment, food frequency questionnaire,	The main food group consumed daily was foods from flesh foods group (meat, and fish consumption	Moderate

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						dietary diversity score	79.8%). Daily fish consumption was 78% (195 of 250) and accounting for the high consumption of flesh foods daily.	
37. Accra: urban agriculture as an asset strategy, supplementing income and diets	Armar-Klemesu and Maxwell, N.D	559	Greater Accra	Not reported	Cross-sectional	Household survey	A total of 88 reported a family member being engaged in some form of agriculture; 11 reported fishing as a livelihood.	Moderate
38. Vegetable production, consumption and its contribution to diets along the urban-rural continuum in Northern Ghana	Chagomoka *et al*., 2015	240 households	Tamale	Not reported	Cross-sectional	Dietary diversity score, 24-hour recall	Vegetables cultivated included okro, pepper, tomatoes, roselle, jute mallow, egusi, amaranth, onion, garden eggs. They were mainly cultivated for subsistence, as most households sold less than 50% of the crops and consumed the rest.	Moderate
39. Household dietary practices and family nutritional status in rural Ghana	Nti, 2008	400	Eastern Region, ManyaKrobo	28.3 years	Cross-sectional	Food frequency questionnaire, 24-hour recall	The main starchy staples consumed are cassava, plantain, yam and cocoyam, with cassava being the most frequently consumed. Fish was found to be the main	Moderate

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							source of animal protein.	
40. Fuel-wood usage assessment among rural households in Ghana	Wiafe and Kwakwa, 2010	207	Ashanti, Eastern, Western, Northern, Volta, Upper West	38.1±18.1	Cross-sectional	Semi-structured questionnaire	67.6% used charcoal for cooking while 80% used firewood for cooking.	Moderate
41. Rural-urban differences in cooking practices and exposures in Northern Ghana	Wiedinmyer *et al.,* 2017	Not reported	Upper East Region	Not reported	Interventional study	Household survey	100% of the rural sample used wood as a main source of cooking. For urban households, the percentages were 10% for wood, 60% for charcoal and 29% used LPG.	Moderate
42. Environmental effects and waste management practices of local food packaging materials in the Birim Central Municipal, Ghana.	Awusi and Kyei, 2017	300 respondents	Eastern Region, Akyem Oda	15-47 years	Cross-sectional	Questionnaire, site observation	264 (88%) of respondents used plastics mostly bags, 20(6.7%) used glass, 11(3.7%) used paper, and 5 (1.7%) used leaves to package local foods.	Moderate
43. Perceptions of the use of indigenous leaves as packaging materials in the ready-to-eat cornmeals	Mensah *et al.,* 2012	230	Ashanti region (Urban areas)	15 years above	Cross-sectional	Questionnaires, observation, interviews	Eleven available leaves-packaged corn meals were identified in the market.	Moderate
44. Primary school-based nutrition education intervention on nutrition knowledge, attitude and	Antwi, 2020	351	Greater Accra, Eastern region	6-12 years	Interventional study	Assessment of nutrition KAP. Nutrition	The six-week nutrition education intervention significantly	Moderate

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practices among school-age children in Ghana						intervention; The intervention encompassed six nutrition topics.	improved children's nutrition knowledge in both the lower and upper primary levels in the intervention group.	
45. Understanding drivers of urban bushmeat demand in a Ghanaian market	McNamara *et al*., 2019	Not reported	Ashanti Region Atwemonom , Kumasi	Not reported	Longitudinal study	Market survey	Herrings were the most commonly consumed of all marine and freshwater species. The consumption of bushmeat is elastic to their price.	Moderate
46. Environmental risk assessment of pesticides currently applied in Ghana	Onwona-Kwakye *et al*., 2020	Not reported	Eastern and Greater Accra regions	Not reported	Not reported	Pesticide Risks in the Tropics to Man, Environment and Trade; risk assessment performed using primet	Many pesticides might pose an acute risk to aquatic ecosystems adjacent to the treated fields.	Weak
47. Climate change adaptation strategies and fish catchability: The case of inland artisanal fishers along the Volta Basin in Ghana	Mabe and Asase, 2020	397	Brong Ahafo region	41.6±11.9	Cross-sectional	Questionnaire	Out of 397 respondents, 72.7 % catch smaller fish to compensate for the unavailability of bigger fishes due to climate change.	Moderate
48. The importance of bushmeat in the livelihoods of cocoa farmers living in a wildlife	Björn, 2011	63 households (791 individuals)	Western Region	Not reported	Cross-sectional	Questionnaire, farm and	The harvest of bushmeat in the Sui FR was limited to 15	Moderate

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depleted farm-forest landscape, SW Ghana						hunter trap surveys	mammal species, indicating that 55% or 56%1 of mammalian forest species present in nearby protected areas were locally extinct in the study area.	
49. Unravelling the Pangolin Bushmeat Commodity Chain and the Extent of Trade in Ghana	Boakye *et al*., 2016	Not reported	Western Ashanti Brong Ahafo Eastern Central	Not reported	Cross-sectional	Direct observation Questionnaire	A total of 341 pangolins were recorded to have been traded by hunters, chop bar operators and wholesalers between September 2013 and January 2014.	Moderate
50. Pesticide Use Practices and Perceptions of Vegetable Farmers in the Cocoa Belts of the Ashanti and Western Regions of Ghana	Afari-Sefa *et al*., 2015	Not reported	Ashanti region And Western region	10-69 years	In-depth interviews, focus group discussions	437	77.4% of farmers use the same pesticides. It appears that even those who claim to have received some form of official training seemed to be still misusing and abusing pesticides in their vegetable fields.	Moderate
51. An exploration of the role of bushmeat in Ghana's rural communities, MSc thesis	Alexander, 2015	177	Ashanti region	Not reported	Cross-sectional	Questionnaires, interviews	During the household interviews a total of 37 in Kwaman and 11 households in Jachie	Moderate

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							reported 'actively hunting' on their farms.	
52. Analysis of the determinants of fish consumption by households in Ghana	Akuffo *et al*., 2020	2185	Nationwide	Not reported	Cross sectional secondary data	Secondary data from the GLSS 6	For traditional families, fish is complementary to chicken but a substitute for red meat. Non-traditional families also think of poultry as a supplement to fish, yet red meat and pork are the substitutes.	Strong
53. Lacking in abundance: undernutrition in a Peri-urban fishing community in Coastal Ghana	Bandoh *et al*., 2018	250	Central region	6-59 months 28.7±9.5 for care givers	Cross-sectional	Questionnaire,	Of the two hundred and fifty respondents, 79.2% consumed fish more than three times in the past week, whiles 85.6% consumed staples more than three times in the past week.	Moderate
54. Climate Change and Variability in Ghana: Stocktaking	Asante *et al*., 2015	-	Nationwide	-	-	Review	In the year 2000, the total direct greenhouse gas emission in Ghana was estimated at 12.2 MtCO2e (based on carbon dioxide, methane, nitrous oxide and perfluorocarbons	Strong

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55. Food and nutrition security	Laven *et al*., 2018	-	Nationwide	-	Cross sectional	Dietary diversity score	Eggs and condiments are available throughout the year and are consumed in small quantities. Dairy, fish, and meat are generally available but unaffordable.	Moderate
56. Determination of organochlorine pesticide residue in sediment and water from the Densu river basin, Ghana	Kuranchie-Mensah *et al*., 2011	Not reported	Eastern region and Greater Accra	Not reported	Cross-sectional	Collection of water samples	The mean levels of gamma-HCH were relatively similar at all sites with Nsawam detecting the highest concentration of 0.608 lg kg1.	Moderate
57. Fishery value chain analysis-Ghana	Antwi-Asare and Abbey, 2011	-	Nationwide	-	Review		Fish output increased appreciably in the late 1960s, thus the marine fish caught between the year 1967-1972 increased from around 105,100 to 301,762 tonnes.	Moderate
58. Greenhouse Gas Emissions in Ghana	USAID	-	Nationwide	-	Review		Ghana's GHG profile is dominated by emissions from the land-use change and forestry sector.	Strong
59. Climate change, agriculture, and food crop production in Ghana	Pinto *et al*., 2012	-	Nationwide	-	-	-	Agriculture is estimated to be the second largest contributor to	Moderate

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							Ghana's greenhouse gas emissions.	
60. Is there a causal effect between agricultural production and carbon dioxide emissions in Ghana?	Owusu *et al*., 2017	-	Nationwide	-	Analysis of secondary data	-	There was evidence of a long-run equilibrium relationship running from copra production, corn production, green coffee production, milled rice production, millet production, palm kernel production and sorghum production to carbon dioxide emissions.	Moderate
61. The decline of a regional fishing nation: The case of Ghana and West Africa	Atta-Mills, 2004	-	Nationwide	-	-	Review	Much of the fish that is currently imported is frozen (more than 100,000 tonnes annually) and not of high value (approximately US$ 19.4 million or US$ 1,330 per tonne) (FAO, 1998).	Moderate

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62. Structure and Operation of a Bushmeat Commodity Chain in Southwestern Ghana	Cowlishaw *et al*., 2004	70	Western region	Not reported	Cross-sectional	Interviews, direct observation,	The estimated monthly volume of bushmeat sales by market traders and chop bars in Takoradi was 15,859 kg.	Moderate
63. Health Risk Associated with Pesticide Contamination of Fish from the Densu River Basin in Ghana	Fianko *et al*., 2010	Not reported	Eastern and Greater Accra	Not reported	Cross sectional	Analysis of contaminants from fish	Farmers were not knowledgeable in pesticide application and applied pesticides without reading instructions.	Moderate
64. Rural protein insufficiency in a wild life depleted West African farm-forest landscape	Schulte-Herbrüggen *et al*., 2017	-	Western region	-	Cross-sectional	Protein consumption estimation	Protein derived from food crops and animals contributed 53% and 47% to total protein consumption, respectively.	Moderate
65. Nutrition knowledge and food consumption practices and barriers in rural Ghana: The case of foods for preventing vitamin A and iron deficiencies	Omari, 2017	300	Brong Ahafo and Ashanti region	Not reported	Cross-sectional	Focus group discussions	In all the communities, game (bush meat), frozen poultry, and fish were usually consumed.	Moderate
66. Organochlorine Pesticides in Water, Sediment, Crops, and	Ntow, 2000	Not reported	Ashanti	Not reported	Cross sectional	Analysis of organochlorinates in water	Endosulfan sulfate was the most frequently	Moderate

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	Human Fluids in a Farming Community in Ghana						and human fluids	occurring (78%) Organochloride in water with a mean concentration of 30.8 ng/L.	
67.	Pesticides Use and Policies in Ghana An Economic and Institutional Analysis of Current Practice and Factors Influencing Pesticide Use	Gerken *et al*., 2001	-	Nationwide	-	-	Review	The study results show that the situation with pesticide in Ghana is similar to those in many other African countries.	Moderate
68.	Dietary behaviours in the context of nutrition transition: a systematic review and meta-analyses in two African countries	Rousham *et al*., 2019	-	Nationwide	-	Systematic Review	-	In Ghana, one study reported dairy product consumption of 50·1 g/d (95 % CI 47·4, 52·9, equivalent to 350 g/week.	Moderate
69.	Light Fishing Operations in Small-scale Fishing in Ghana – A case study of the Chorkor and Teshie–Nungua fishing communities in the Greater Accra Region of Ghana	Agyekum, 2016	40	Greater Accra	Not reported	Cross-sectional	Observation, interviews, questionnaires ,	Light fishing is the main reason for the destruction of the country's fishing stocks because of the frequent harvesting of juvenile fish.	Moderate
70.	Dietary patterns and type 2 diabetes among Ghanaian migrants in Europe and their	Galbete *et al*., 2018	-	Ashanti region	-	-	-	In urban Ghana, carbohydrates supplied most of	Moderate

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	compatriots in Ghana: the *RODAM* study						the daily energy; and in rural Ghana, energy intake from carbohydrates is much higher.	
71.	Assessment of Greenhouse Gas Emissions from Different Land-Use Systems: A Case Study of CO2 in the Southern Zone of Ghana	MacCarthy *et al*., 2018	-	Greater Accra	-	Cross-sectional	Assessment of co2 using gas entrapment methods, measurement of soil temperature and soil moisture	The highest CO_2 emission was observed from the cattle kraal, followed by the paddy rice and the forest ecosystem.	Moderate
72.	Adoption of organic agriculture: Evidence from cocoa farming in Ghana	-	Eastern region	48.7	-	Cross sectional	-	30% of organic farmers experienced CSSVD, less 20% of conventional farmers experienced the disease.	Moderate
73.	Climate-smart agricultural practices in Ghana	Naaminong *et al*., 2016	-	Upper West and Ashanti	-	Cross sectional	Profiling of technology practices	Participants identified 61 and 21 CSA technologies and practices in the Guinea Savannah and the Forest zones respectively and recommended scaling up of these	Moderate

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							technologies in other zones.	
74. Can Local Products Compete against Imports in West Africa? Supply- and Demand-side Perspectives on Chicken, Rice, and Tilapia in Accra, Ghana	Andam *et al*., 2019	-	Accra	-	Cross sectional	Consumer survey, questionnaire	Three-quarters of respondents eat rice more than once a week, and 20 percent eat rice every day.	Moderate
75. A Chicken and Maize Situation; The Poultry Feed Sector in Ghana	Andam *et al*., 2017	-	- Nationwide	-	Review	-	Maize is Ghana's most important cereal crop and is grown by the vast majority of rural households. It is widely consumed throughout the country and is the second most important staple food in Ghana.	Moderate
76. Status of Disease Management and Veterinary Service Delivery for Increase Poultry Production in Ghana*	Akunzele *et al*., N.D	-	Nationwide	-	Review	-	There is under-utilized capacity along the chain (day-old-chick production, veterinary services, feed production, marketing).	Moderate
77. Eggs before Chickens? Assessing Africa's Livestock Revolution with an Example from Ghana	Andam *et al*., 2017	-	Nationwide	-	Review	-	318 commercial poultry farms were identified in Dormaa Ahenkro. These farms focus on egg	Moderate

							production, with seasonal production of broilers for chicken meat.	
78. Structure of Ghana's Chicken Industry in 2015	Amanor-Boadu *et al*., 2016	4,000 poultry farms	Nationwide	-	Cross-sectional	Interview	Day-old chicks and deep-litter flooring are the preferred stocking and housing methods in Ghana's chicken industry. About 87 percent of the about 1,500 commercial broiler chicken farms were small.	Moderate
79. Poultry Inputs, Production Costs, and Marketing Channels in Ghana: Findings from a Targeted Field Assessment	GSSP and IFPRI, 2015	-	Nationwide	-	Field assessment, Analysis of secondary data	Assessment of egg production	Chicken consumption increased from 1.27 kg in 1991/1992 to 7.98 kg in 2011/2012, while egg consumption has almost doubled from 0.56 kg to 1.2 kg over the same period.	Moderate
80. Analysis poultry sector Ghana 2019 < An update on the opportunities and Challenges	RVO, 2019	-	Nationwide	-	Review	-	There are 29 large scale commercial poultry farms currently in Ghana and mostly found in the Ashanti region (13), Brong Ahafo (12) and Greater Accra region (4). These form about 20	Moderate

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							per cent of the total poultry sector, producing mainly eggs.	
81. An assessment of house-hold solid waste management in a large Ghanaian district	Stephen T. Odonkor, Kwasi Frimpong, Napoleon Kurantin (2020)	600 respondents	Large Ghanaian district	Not reported	Cross-sectional design	A self – administered questionnaire was used but paraphrased into local language for respondents who for literacy reasons could not answer in English.	Majority (57.3%) of the respondents indicated that communal waste collection bins were far from households. Majority (56.5%) of the households walked a distance of 11-15 min before reaching the refuse site.	Moderate
82. Households' source separation behaviour and solid waste disposal options in Ghana's Millennium city	Alhassan, H., kwakwa, P.A and Owusu-Sekyere, E. (2020)	525	Accra	Not reported	Cross-sectional	A structured questionnaire was used to collect data. A three-staged sampling design was used to select 525 households heads and/ orand	The results revealed that majority (58.1%) of the respondent separate waste informally at source. Waste separation among low-income households is motivated by monetary incentive (63%).	Moderate
83. Behaviour of households in Accra-Ghana to source separation and recycling in achieving sustainable solid waste management	Doris Baah and Kharlamova (2017)	60 respondents	Accra	-	Descripti ve research	A mixture of survey, literature and reports review were used as	The household is the first level for waste separation at source in Accra. Willingness to separate waste at	Moderate

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						well as information from stakeholders in the waste management sector.	source is to base on financial gains from the sale of the materials.	
84. Domestic waste disposal practice and perceptions of private sector waste management in urban Accra	Yoada, R., M., Chirawurah, D. and Adongo, P. B (2014)	364 households heads	Nkwantana a electoral area, Accra	31 – 40 yrs	Cross-sectional design	A mixed-method approach using a survey questionnaire and in-depth interviews	Majority (93.1%) of the households disposed of food debris as waste and 77.8% disposed of plastic materials as waste.	Moderate
85. Correlates of domestic waste management and related health outcomes in Sunyani, Ghana: a protocol towards enhancing policy	Addo *et al*., 2017	700 households	Sunyani, Brong Ahafo	Not reported	Descriptive cross-sectional study design	A structured questionnaire was used in the data collection waste recycling, cost of disposing waste and distance to dumpsite were assessed	Each surveyed household generated 0.002 t of waste per day, of which 29% are both organic and inorganic.	Moderate
86. Stakeholders' views on waste and its management in Tamale Metropolis, Ghana	Adongo *et al*., 2015	11 stakeholders from both private and public sectors	Tamale Metropolis, Northern	Not reported	Cross-sectional	Primary data was collected using a questionnaire	Metropolis. The major problem reported by the stakeholders is the improper disposal of waste.	Weak
87. Household solid waste generation and disposal in some selected communities in	Asare *et al*., 2015	100 households	Kwamo, Ejisu and FumesuaAshanti	Not reported		A mix method approach was used for the data collection,	The results indicated that there were high levels of putrescible	Weak

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Ejisu-Juaben Municipality, Ghana						it includes field investigation, survey, face-to-face interviews and the use of semi-structured questionnaire	waste in all the selected towns.	
88. An econometric model of factors influencing households willingness to pay for improved Solid Waste Management Service within the Sekondi-Takoradi Metropolis in the Western Region of Ghana	Padi *et al*., 2015	300 respondents	Sekondi-Takoradi Metropolis (Effiakuma Western	Not reported	Cross-sectional	A survey questionnaire was used	The study revealed that the factors which influenced households willingness to pay for an improved SWM service were environmental awareness, occupation, income, perception and house ownership.	Moderate
89. Do socioeconomic factors influence households' solid waste disposal systems? Evidence from Ghana	Adzawla *et al*., 2018	16767 households	nationwide	46 years	Analysis of secondary data	The study used data from the Ghana Living Standard Survey round six collected in 2012/2013	About 48% of the respondents dispose of garbage at public dumps, 19.9% bury or burn their trash and 19.1% dump at open places such as gutters, water bodies and streets.	Moderate
90. Fee-based solid waste collection in economically developing countries: The case of Accra metropolis	Oduro-Appiah *et al*., 2013	5382 households	Ablekuna South (Accra)	Not reported	Cross-sectional	Information was obtained through survey and	Results from the questionnaire showed that households that were willing to	Moderate

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						questionnaire from residents across the socio-economic divide to determine willingness and ability to pay for solid waste collection services	participate and had the ability to pay for solid waste collection services.	
91. Missing links in solid waste management in the Greater Accra Metropolitan Area in Ghana	Oteng-Ababio, 2010	-	Greater Accra Metropolitan area (AMA, TMA and GDA)	Not reported	Mixed methods	This study uses primary and secondary data from literature. Solid waste management practices were observed to determine how each stakeholder cooperate in the process	In both low-income and high-income areas, wastes were lumped together before it is sent to the dumpsite.	Moderate
92. Dumping on the poor: the ecological distribution of Accra's solid-waste burden	Baabereyir, A., Jewitt, S. and O'Hara, S (2012)	450 households, Senior staff of the waste management departments	Accra	-	Mixed-method approach	A multi method approach involving interviews, a household questionnaire,	There is a high level of indiscriminate waste disposal which is higher in low-income areas.	Moderate

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						direct field observation and documentary analysis		
93. Characteristics and management of household solid waste in urban areas in Ghana: the case of WA	Monney *et al*., 2013	15 households	Upper West	The modal age is 36 – 60 years	Cross sectional	A structured questionnaire was administered to residents, the waste management department and the only private waste management company in waste.	The rate of waste generation in Wa is 0.68±0.24kg/cap/day with an average bulk density of 44.9±28 kg/m^3. The household waste generated involves organic waste (48%) and inert materials (33%).	Weak
94. Characteristics of diverted solid waste in Kumasi: A Ghanaian city	Wahabu *et al*., 2014	Seven informal waste pickers	Kumasi Metropolis Ashanti	Not reported	Cross sectional	The study involves a quantitative measurement of diverted waste by informal waste pickers at communal collection points	The study shows a daily diversion rate of 19.4±9.2kg per informal waste picker per day with no statistically significant difference.	Weak
95. Comparative Analysis of Households Solid Waste Management in rural and urban Ghana	Boateng *et al*., 2016	400 households	Rural and urban districts in the Ashanti and Greater	Not reported	Cross-sectional study	Face-to-face interviewer-administered structured questionnaires	The results revealed that location significantly affects solid waste management in	Moderate

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			Accra regions of Ghana			were used to collect field data	Ghana. Urban communities had lower mean scores than rural communities for poor solid waste situation in homes.	
96. Urban households' willingness to pay for improved solid waste disposal services in Kumasi Metropolis, Ghana	Awunyoo-Vitor *et al*., 2013	600 respondents	Kumasi Metropolitan Ashanti	Not reported	Cross-sectional	Data was collected through individual interviews using a well-structured questionnaire	The logistic model shows that income, age, number of children, quantity of waste generated and education have significant effects on the willingness to pay.	Moderate
97. Environmental and health impacts of household solid waste handling and disposal practices in third world cities: the case of the Accra Metropolitan Area, Ghana	Boadi and Kuitunen (2005)	960 female heads of households	Accra	Not reported	Cross-sectional	Detailed structured questionnaire was used to collect information on household solid waste storage and disposal practices	Majority of the respondents store solid waste in plastic bags and open containers inside their homes whilst only 22.6% store it outside the house.	Moderate
98. Awareness and practice of solid waste management in the Winneba municipality of Ghana	Twumasi, A. K (2017)	120 respondents	Winneba Central	Not reported	A descriptive cross-sectional survey was used to	A well-designed and validated questionnaire was used for data collection	Attitudes towards social commitment to participate in solid waste management was low.	Moderate

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					identify various methods of waste management employed	as well as interviews		
99. Household willingness-to-pay for improved solid waste management services in four major metropolitan cities in Ghana	Boateng *et al*., 2019	1560 households	Accra, Takoradi, Kumasi and Tamale Accra, Western, Ashanti	-	Cross-sectional multi-center study	A structured questionnaire was used	The overall Willingness To Pay (WTP) was 53.7% with variations across the different cities. WTP was associated with socio-economic factors.	Moderate
100. Households' demand for better solid waste disposal services: Case study of four communities in the New Juaben Municipality, Ghana	Alhassan and Mohammed (2013)	200 respondents	Four communities in the New Juaben Municipality, Ashanti	45 years	Cross-sectional	The contingent evaluation method used to assess respondents' Willingness-To-Pay (WTP) for improved solid waste disposal	From the pre-test results, four denominations were chosen as the amount participants are willing to pay. Participants were willing to pay a small token for improved waste disposal.	Moderate
101. Rethinking waste as a resource: insights from a low-income community in Accra, Ghana	Oteng-Ababio (2014)	25 key informants	Accra	Not reported	Mixed methods	Key informant's interviews, participants observations and a comprehensive review of documents to	The results showed that a greater part of the waste can be recycled and that a well-coordinated program will ensure an immense reduction of waste volume.	Moderate

						generate empirical data		
102. Examination of household solid waste management in Nadowli township in Ghana: A waste management hierarchy approach	Bukari *et al*., 2017	100 respondents	Upper West region Nadowli	-	Cross-sectional study design with quantitative and qualitative approaches	The study used questionnaire, observation and interview guides	Waste disposal is the least preferred but most practiced method. Avoidance, reduction, reuse and recycling were less practiced.	Moderate
103. Towards a zero waste: assessing solid waste management in the LedzokukuKrowor Municipal Assembly in the Greater-Accra region, Ghana	Acquah, 2015	82 respondents, and 14 informants	LedzokukuKroworMunicipal Assembly, Accra	Not reported	Cross-sectional	Qualitative methods were used with questionnaire, semi-structured interviews and observations to gain a deeper understanding of solid waste management	The study showed that apart from the main actors there are other actors in solid waste management who play various roles that are not seen. For example, people who operate with tricycles.	Moderate
104. Solid waste management in coastal Ghana	Akuoko, 2018	44 households	Tertrem, Elmina, Central	Not reported	Cross-sectional	Use of household interviews and waste quantification and characterization.	Findings from the preliminary research showed that the highest waste present was organics (48.07%), followed by inert (22.25%) and then plastics (14.92%).	Moderate

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105.	Solid medical waste: a cross sectional study of household disposal practices and reported harm in Southern Ghana	Udofia *et al*., 2017	600 households	Ga South Municipal Assembly, Accra	Modal age 45+	Cross-sectional design	A survey questionnaire was used	80% and 89% of respondents disposed unwanted medicines and sharps in household refuse bins respectively. A corresponding 23% and 35% of respondents discarded these items without a container. respectively.	Moderate
106.	The impacts of reducing food loss in Ghana: a scenario study using the global economic simulation model MAGNET	Rutten and Verma (2014)		nationwide	Not reported		We specifically implemented a set of food loss reduction scenarios	When Ghana reduces food loss by 50% by the year 2025, at all stages of supply chains, consumers will benefit from price reduction.	Moderate
107.	Estimation of packaged water consumption and associated plastic waste production from household budget surveys	Wardrop *et al*., 2017	18, 000 households	Nationwide (1200 enumeration areas were selected from 10 regions)	Not reported	Secondary data analysis	Data from 2012-13 Ghana Living Standards Survey Round 6 was used.	In Ghana, 11.3% (95% C: 10.3 – 12.4) ML per day of sachet water were consumed. This generated over 28, 000 tonnes per year of plastic waste.	Strong
108.	The role of hunting in village livelihoods in the Ashanti region, Ghana: environmental and ecological economics.	Crookes *et al*., 2007	468 hunter and non-hunters	Ashanti region	42.4±11.4 years	Cross-sectional	Interview	Hunting is an important contributor to total income in the villages, particularly for poorer households. Hunting increases during lean seasons.	Moderate

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