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The impacts of climate change on Food and Nutritional Security: a literature review

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Abstract *The interface between Climate Changes and Food and Nutrition Security (FNS) has been standing out in the sustainable development agenda since the early 1990's. Since then, studies show that climate changes have negative effects on the FNS, aggravated by poverty and social inequality. The purpose of this paper is to perform a review evidencing the relationships between climate changes and FNS. The research was carried out in PubMed using the descriptors "climate change and food security" on the headline, selecting only papers in Portuguese, Spanish, and English languages, and with a direct relation to the themes. The main impacts of climate changes on the FNS were related to the access, production, nutritional quality, and volatility of food prices. The studies also indicated mitigation/adaptation strategies to the effects of climate changes on the FNS, as well as a geographic panorama of the publications with fields of study in Africa and Asia, continents marked by social inequality and poverty. Climate changes affect the dimensions of FNS, especially in poorer populations in situation of social inequality. The relevance of the themes raises concern on the urgency of higher investments in public policies, studies, and research on the subject around the world.*

Key words *Climate changes, Food and Nutrition Security, Poverty, Inequality*

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Introduction

The first studies on the impacts of Climate Changes on Food and Nutrition Security (FNS) appeared in the 1990's and may be divided into: neutral phase (1994-2005): when the climate changes would not cause negative effects on FNS. It was believed that climate changes would create winners and losers, but, in the end, the food production would "get the job done"; and a negative phase (2005 to the present): increased assumption that climate changes and their effects are contributing for the world hunger[1].

Climate on the planet is clearly changing, characterized by events such as: heat waves, floods, droughts, increase of sea levels, and atmospheric pollution, which affect health either directly or indirectly, causing several impacts such as increased respiratory and transmissible diseases, countless damages, diseases, and harms against health caused by disasters, in addition to deaths, thus compromising the FNS in the medium and/or long term.

FNS is defined as the capacity to ensure that everyone has access to basic food with quality and in sufficient quantity, without compromising the other essential needs. It has four dimensions: access, availability, utilization, and stability[2,3].

In view of this context, studies affirm that climate changes have negative effects on the FNS. These are driven by multiple determiners: poverty, education level, unemployment, increase in food prices, poor access to food, faulty rights to property/land and work, besides the weather/environment[4-8], and will depend on the capacity to respond and/or adapt to the new scenario.

The number of extreme events, including extreme heat, droughts, floods, and storms, doubled since the early 1990's, with an average of 213 occurrences/year in the period between 1990 and 2016[3]. Some risks were identified: increase in precipitations variability (floods and droughts more frequent and extreme) and in river outflows; reduction in plantations productivity; global temperature rise (1.8ºC to 4ºC); soil composition[5,9,10] and alterations in the cycles of disease vectors, thus affecting the health state of the population[3,11-13]. In view of this new scenario, some cultivations appear as more sensitive than others: wheat is more sensitive to temperature changes than rice[14], for instance.

The negative effects of climate changes on the FNS have specially been studied in developing countries, with evidence of their contribution for the aggravation of the different faces of poor nutrition: malnutrition, nutritional deficiencies, and overweight/obesity. In developed countries, the focus lies on the quality and safety of food[3,15].

Climate changes may cause risks to FNS through reductions in food availability, access, utilization, and stability of the food system, which, combined with the high demand, increases the price of food. An unstable food system, with a low offer of unprocessed food and high prices, increases the search for ultra-processed and processed food, which brings to light another strand of food and nutrition insecurity: overweight/obesity[16]. Which means that climate changes interface with poor nutrition as well as food and nutrition insecurity: malnutrition/nutritional deficit and overweight/obesity, thus reinforcing the need for inter-sector public policies that comprise the determining factors influencing the food choices of the population and their consequences on poor nutrition, providing responses beyond the health sector[17].

The year 2017 registered a 25% increase in acute and chronic hunger in the world when compared to the 2 previous years, mainly due to climate-related factors (increased droughts, for instance)[3].

Knowledge about the impacts of climate changes on agriculture has significantly expanded over the last 20 years. However, there is a perceived lack of studies on the interface between climate changes and FNS, especially in developing countries, indicated by the literature as the most vulnerable to such events. In view of this context, this paper has the purpose of carrying out a scientific literature review, drawing an outline of the relationship between climate changes and FNS, aimed at contributing to reach the sustainable development goals (SDG)[18].

Methodology

The research was carried out in PubMed (http://www.ncbi.nlm.nih.gov/pubmed) database in the period between August and October 2018, using a combination of the descriptors: [*Climate change and food security*] on the headline.

Considering that this review article has the purpose of making a first approach towards the topic of climate changes and FNS in the Health Sciences, we have chosen to use only PubMed as it is the main database of journals and books in the world within the field of Public/Collective Health.

The inclusion criteria were the following: (1) only original papers; (2) Portuguese, Spanish,

and English languages; (3) direct relation with the established themes. Review articles, congress annals, monographs, thesis, dissertations, book chapters were excluded.

In order to prepare the review, the headlines were initially evaluated, followed by the abstracts reading and, further, full reading of the studies. At first, 38 original papers were identified, and after reading the abstracts, 1 was excluded. Thirty-seven papers were read in full and 3 were excluded as they did not present a direct relation with the defined themes. In total, 34 papers were deemed eligible for this review (Figure 1).

Results and discussion

The results found were organized into five (5) analytical categories: access, availability, utilization, stability, and adaptation/mitigation strategies. Next, a geographic panorama of the studies was organized.

Access

Access is one of the dimensions of FNS and covers the presence of both economic and physical resources to acquire the available food in order to meet one's needs[2]. Fifteen publications[4,5,11,12,15,19-28] discussed how climate changes might cause direct impacts on plantations and consequently reduce the production of food. This might affect the access to food, mainly due to the lack of income arising from the unemployment of farmers who lose their animals (cattle raising)[27], their lands and/or suffer from the reduced productivity of these[12,15,19,20,24-26], the increase in prices of basic foods resulting from productivity decrease and demand increase[12,15,20,26], and the difficulties in distributing and storing the production[25,23].

Fischer *et al.*[29] indicate that both food prices and temperatures will increase simultaneously and moderately by 2050, thus negatively affecting the quantity, quality, and diversity of the food consumed worldwide[3].

More broadly, Schmidhuber and Tubiello[5] discuss the concept of access related to the guarantee of political, economic, and social rights so that the populations might acquire food that is adequate both in terms of nutritional quantity and quality. Thus, gathering economic and social factors and rights around the access to food.

A case study held in Madagascar (Africa) indicates that high levels of poverty, precarious infrastructure, and lack of both financial and technical support to farmers are factors that make them potentially more vulnerable to climate risks[24]. In South Africa, rural communities that depend on agriculture also face an instantaneous risk of crop failure and cattle loss, what consequently increases hunger and malnutrition once the majority of these people gets their income from agricultural products[30].

That being said, the right to food through access is not guaranteed, especially in countries with socioenvironmental vulnerabilities (countries of low and medium income, that suffer with larger effects of climate changes), resulting in multiple types of poor nutrition (micronutrient deficiency, malnutrition, and obesity) in the population[2,3].

Malnutrition as a result of the lack of access to food is an expected effect, but obesity brings to the discussion a new standard of eating, with a larger consumption of ultra-processed foods, foods with low nutritional values, thus directly affecting the FNS[15].

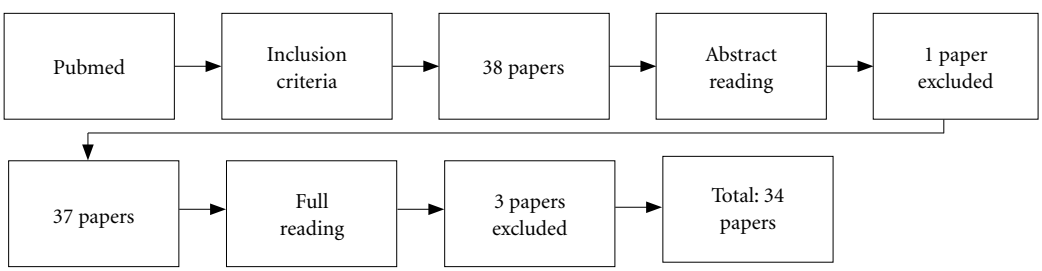

Figure 1. Scheme representing the search for papers for the study.

Source: Authors, 2020.

Availability

The availability category was the one with the least number of publications: 26 papers[1,5,11,12,15,19,20-25,28,31-43], considering that most of these covers especially the direct and indirect effects of climate changes on food production[5,12,15,19,20,22-25,31,33,38,39], which vary from one region to the other, taking into account the vulnerability of the territory and population. The direct effects are due to alterations on the agroecological conditions (increases in temperature, frequency and severity of extreme events, river levels, CO_2 concentrations in the atmosphere, soil erosions, changes to the water cycle, alterations in the cycles of vectors and pests)[34,40,43] that reduce the productivity of plantations[11,25,37] and loss of animals[11,12,19,32]. Indirect effects affect the income distribution of producers. The relationship between the effects of climate changes and the populational growth (higher demand) and less availability of food[20,35] is also discussed.

The availability dimension corresponds to the existence of sufficient quantities of food with an adequate quality, provided by means of the country's production or through imports, including food aid[2].

Populational growth and changes in food habits, with emphasis on a higher consumption of meat, dairy, and ultra-processed products, increased the demand for food. However, the increase of non-food related factors, such as the use of biofuels, urbanization, soil erosion, and climate changes have a potential influence on the FNS, especially food availability[22].

The direct and indirect effects of climate changes on agricultural productivity are also discussed: direct – climate variabilities (droughts and floods); and indirect – through pests and diseases, average increase of the sea levels, and change in water availability[44].

There is strong evidence that climate changes are driven by *El Niño* and play a fundamental role in reducing the yields of plantations, especially rice, wheat, and corn[1,3,12,15,45,46]. In addition, they might reduce both the area and quality of farmlands, mainly in Africa[5], and affect the production of fish products as well as cattle raising[12].

Discussion around the vulnerabilities is relevant when approaching the interface between climate changes and FNS. Countries such as South Africa, which present overlapping vulnerabilities (a tendency to droughts, poverty, social inequalities, lack of access to education, absence of public policies, etc.), will suffer the effects of climate variabilities on the FNS in a more frequent and intense way[20]. Studies affirm that the entire Africa and South Asia might undergo a reduction of 8% in food production by 2050[25].

A recent publication in Lancet[47] pointed out to two types of poor nutrition, malnutrition and obesity, and the climate changes as three simultaneous pandemics resulting in effects on human health. These three pandemics represent the Global Syndemic, which affects most of the people in every country and region of the world. For example, the food systems not only drive the obesity and malnutrition pandemics, but also generate between 25% and 30% of greenhouse gas emissions, deforestation, biodiversity loss, and soil degradation, factors that influence climate changes. On their turn, climate changes affect the food systems, resulting in alterations in consumption and food habits, and consequently in poor nutrition and FNS.

Considering this context, the increase of malnutrition is higher in countries of low and medium income due to the reduction in food production caused by extreme weather events. Richer countries, because of the urbanization processes, accelerated industrialization, and consequently higher emissions of greenhouse gases, show a higher prevalence of obesity when compared to countries of low and medium income. Changes in food habits should also be considered, such as an increase in the consumption of dairy products, meats, and ultra-processed foods, which, on their turn, also favor the emission of greenhouse gases.

Although the direct effects of climate changes in the productivity of crops are broadly studied, there are still important limitations when studying the impacts on food availability. First of all, these studies that map the negative effects of climate changes on plantations focus on the main cereals plus some roots and tubers. Second, the studies do not assess the effects of climate changes on cattle raising (changes on the pasture productivity, the quality of pasture, and cattle feeding). Lastly, the studies on plantations are less precise for extreme weather, which might have even more important consequences for the crops' yields[25].

Utilization

Utilization was covered by 9 papers[12,15,20,22,25,27,28,38,48], focusing on the effect of climate changes on food consumption, nutritional quality, and their social value. Nutritional

quality[12,15,22,38,48] may be affected both by reduced concentrations of micronutrients (zinc, iron, phosphor, potassium, calcium, sulfur, magnesium, copper, and manganese) in different food cultures, as well as by reduced ingestion of fruits, vegetables, nuts, seeds, and fish, foods rich in essential nutrients for the organism[7,12,38,49].

Although the impacts on the utilization of food are less studied, when compared to the other dimensions, studies suggest that climate changes have a negative effect on the nutritional quality of food[3], which influences the life conditions, nutritional status, and health of the individuals[2].

Myers *et al*.[12] suggest that climate changes cause a reduction in the food production/harvest, including the fishing sector, which makes millions of people more vulnerable to nutritional deficits, mainly the poorer, directly affecting their health.

As occurs with the previous dimensions, utilization contributes for statuses of poor nutrition (malnutrition, micronutrients deficiency, and obesity) and, consequently, for alterations in growth, cognitive development, immune system, and a higher risk of non-transmissible diseases (arterial hypertension, diabetes mellitus, cancer), especially in vulnerable groups such as newborns, children under 5 years, breastfeeding women, and elders[2]. Children in situation of poverty tend to be shorter in stature and present severe nutritional consequences as a result of climate changes on the access, production, and utilization of food[27].

Studies carried out in Bangladesh and Indonesia have shown that climate changes affected the production and caused an increase in the price of rice, a situation associated with the increased prevalence of low weight on children, directly affecting their nutritional status[2,3].

Stability

Stability corresponds to the guarantee of availability, access, and adequate use of food by individuals and, therefore, encompasses the other 3 dimensions. This analysis opted for selecting the papers that focused on the volatility of food prices.

This was the category with the least number of publications: 6 papers[4,5,12,25,28,50], which discussed the relationship between climate changes and the reduction of agricultural production as well as the quantity of food available in the food systems, which alters the food prices (volatility)[5,12,25], especially in rural areas[50].

In general, the urbanization processes, depletion of natural resources, soil occupation, deforestation, climate changes, and natural disasters are factors that affect the access, availability, and utilization of food, and, therefore, the stability of food systems[2].

Climate changes affect the stability of food systems as the weather is an important determiner in the patterns of production, offer, and demand for food, resulting in short-term and long-term price variabilities, mainly in poorer and more vulnerable populations[2,25]. With the occurrence of natural disasters, such as droughts and floods, the food production is harmed and/or there is also a reduction of farmlands, creating relevant impacts on the food systems. About 25% of the negative economic impacts of disasters reflect on the agricultural sector, which becomes a threat to FNS.

The variability of food prices has a direct impact on the more vulnerable populations, considering that the expenses with food represent a higher proportion of their income and they tend to have a smaller capacity/possibility to change their consumption patterns, forcing them to consume food with lower nutritional quality. On the other hand, the drop in food prices causes small producers to suffer with significant fluctuations on their income and have lower access to technologies, infrastructure, and resources to deal with the volatility of prices, generating significant costs to the food systems[2].

The elasticity of food prices associated with the lack of stability of food systems arising from climate changes results in a reduced consumption of all food groups and, consequently, in situations of food and nutrition insecurity, especially in more vulnerable populations.

This way, it is possible to affirm that climate changes also influence the stability of the food system, considering that this dimension is transverse to the other three (access, availability, utilization). This situation generates a higher consumption of food with low nutritional quality, such as processed and ultra-processed products, directly affecting the nutritional status of individuals (higher prevalence of overweight/obesity). Besides, alterations in stability cause lower access and production of food (quantity), causing nutritional deficiencies and malnutrition[16,47]. Both situations alter the FNS, resulting in the different types of poor nutrition.

Recent data demonstrate that 672 million adult individuals are obese (13.3% of the total population in this age group) and suffer from the

consequences of excess weight. At the same time, 821 million people around the world are famish, whereas 2 billion live in a situation of severe/moderate food insecurity[47,51].

It is worth emphasizing that climate changes may increase the number of people under risk of starvation by 20% until 2050[52], which will cause a non-compliance with the 2nd SDG: "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture"[18].

Figure 2 brings the main impacts of climate changes on the FNS.

Mitigation/adaptation strategies

The mitigation/adaptation strategies category had the second higher number of publications, comprising 24 papers[4,5,15,20-25,28,31,34-39,41,43,49,50,53-55].

Mitigation/adaptation strategies aim at making the food systems more resilient to climate changes in the future, namely: the implementation of public policies[39], agricultural development plans, market protection laws, opening of local markets and agricultural subsidies[5,41], as well as maintenance and recovery of affected soils[5,20,35,39]; adaptation of planting to the periods of precipitation; increased use of irrigation[20]; increase in crop rotation and variety[37]; use of inorganic fertilizers and low-carbon agriculture; fortification and biofortification; pest control; reforestation; technological innovations (genetics, biotechnology, and agronomy), and the use of biofuels[5,15,22,24,25,28,31,36,43,49,50,53,55].

The discussion on the union between the adaptation needs related to maintaining agricultural productivity and the ecosystem integrity, aimed at reducing poverty, protecting the agricultural production, and the ecosystem services, is also present in the studies as an adaptation and mitigation strategy (agroforestry)[54].

The papers also mention the need to implement effective alert and alarm systems and monitoring tools to assist with the decision-making process in order to protect the agricultural production[28]. Added to that, they point out to the need to prepare integrated plans for the prevention, protection, response, and rehabilitation of the exposed areas with social participation[36,39,50]. However, it requires the civil society to be aware and capable in what concerns the risks and actions for preparation, response, and communication of risks by means of educational and sustainable practices[21,23,24,38].

Lipper *et al.*[56] point out to the importance of coordinated actions involving multiple actors (farmers, civil society, researchers, private sector, and managers) to build the resilience against climate changes and propose the implementation of the climate-smart agriculture (CSA). CSA is a weather-resilient/resistant agriculture anchored on sustainable agricultural practices aimed at increasing productivity and income, resilience of the means of subsistence and the ecosystems, and reducing/removing greenhouse gases from the atmosphere[57], thus transversely contributing towards the SDG. According to the FAO, CSA is the key for FNS against the challenges of climate changes[58].

The transformation of the agricultural sector is urgent and fundamental for responding to the climate changes. According to the FAO[59], such purpose requires increasing the investments on research about the effects of climate changes on agriculture; the monitoring of climate data/information and alert/alarm systems that allow anticipating actions and reducing damages (mapping, statistic models, etc.); besides agricultural credit, dissemination of knowledge on the subject, involvement of the private sector for the implementation of sustainable agricultural techniques, access to agricultural insurance, and the organization of cooperatives[58,59].

It is important to emphasize that "*climate action*" is one of the 17 SDG of the government agendas by 2030[18].

Considering the analytical categories discussed above, a chart was prepared comprising a summary of the main results found in this study (Chart 1).

Study locations

Aimed at contextualizing the theme within the international scenario, the places of publication of the 34 papers deemed eligible for the study were also analyzed (Figure 3).

Figure 3 shows that the studies found were predominantly carried out in countries from Africa and Asia, the two (2) most populous continents in the world, considering that some papers deemed eligible for the study (14 in total) did not have information about localization.

Africa

The African continent is the second most populous continent in the world, with over 60% of its population living in rural areas. It is poor, little industrialized, and has low rates of economic development. Its riches represent 1% of the world's

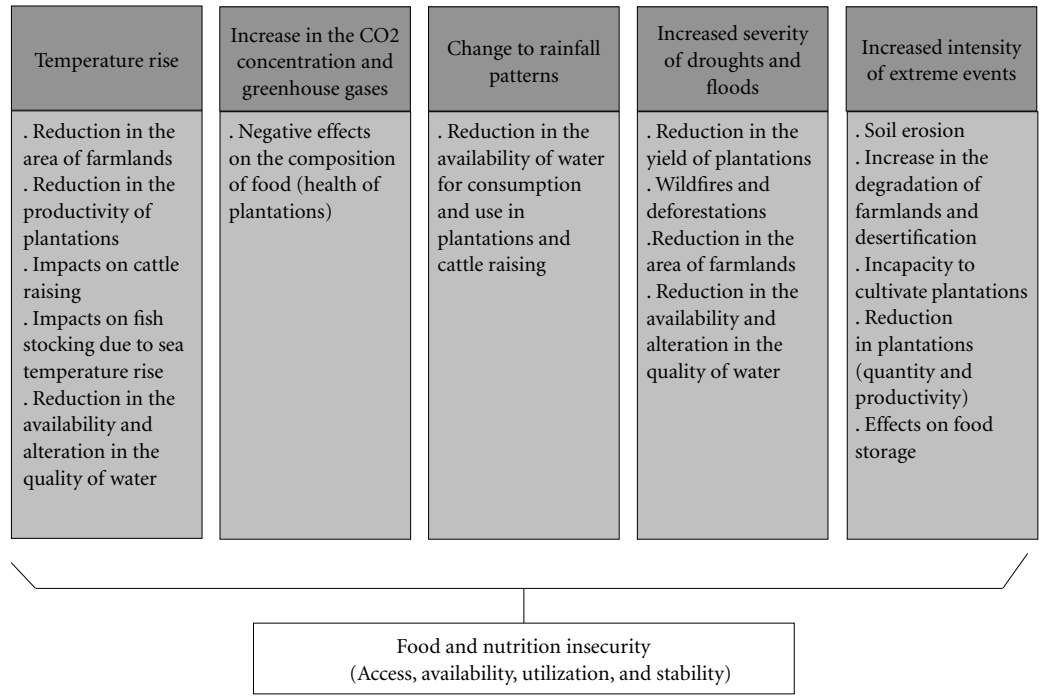

Figure 2. Main impacts of climate changes on the FNS.

Source: Adapted from Raiten and Aimone[16] and Masipa[20].

Gross National Product (GNP) and the GNP per capita is around US$ 915.00. The main issues are: hunger, epidemics (especially HIV), and ethnical conflicts. Social indicators are not good as well, with a population of around 40% illiterates and a child mortality rate that reaches 100-200 thousand deaths for every 1000 births (the highest in the world). Added to that, the continent is home to 1/3 of the world population in conditions of extreme poverty, and 7 out of the 10 countries with the highest inequality rates in the world are located in the African continent[60].

As regards FNS, the Hunger Map published by the World Food Programme (WFP) in 2018[61] presents the climate variability as one of the key points of world hunger and brings data on the prevalence of malnourished among the total population (%) in the period between 2015 and 2017. The African countries that appear in the publications deemed eligible to this study (most of them located in East Africa) predominantly have prevalence classified by the study as moderately high (15-24.9%), high (25-34.9%), and very high (35% or more), except for West Africa and South Africa, which have a moderately low prevalence (5-14.9%)[61]. That is, around 20% of the African population starves due to several causes, among which the effects of climate changes on the continent's agricultural production.

It can be concluded that the African continent has a wide range of vulnerabilities: social, economic, and nutritional, among others not emphasized by this study. It is known that risk varies from one place to the other and the impacts can also be disproportional from one place to the other. This is mainly due to the fact that the places have different capacities to prepare, respond, and recover in the face of adverse situations, besides diverse exposure patterns. That is to say that a high vulnerability is potentialized by a low capacity of confrontation/response. Considering this scenario, it is also important to mention the high number of natural disasters that affected the African continent over the last years. Data from 2017 indicate Africa as the 3rd continent in number of natural disasters recorded around the world, and the second in number of fatal victims of natural disasters in that year: 1 out of 5 fatal victims of natural disasters in the world are from the African continent[62].

Chart 1. Summary of the results found in the studies.

Categories	Related papers	Total papers	Results found
Access	4,5,11,12,15, 19-28	15	- Lack of income arising from the unemployment of farmers who lose their animals (cattle raising), their lands and/or suffer from the reduced productivity of these - Increase in prices of basic foods resulting from productivity decrease and demand increase - Difficulties in distributing and storing the production, resulting in lower access to food
Availability	1,5,11,12,15,19, 20-25,28,31-43	26	- Climate changes directly affecting the availability of food, especially in what concerns the production of food - Due to alterations on the agroecological conditions (increases in temperature, frequency and severity of extreme events, river levels, CO2 concentrations in the atmosphere, soil erosions, changes to the water cycle, alterations in the cycles of vectors, etc.) that reduce the productivity of plantations, such as corn, wheat, sorghum, and rice, and loss of animals (fish, cattle, pigs, and poultry) - Studies on populations' perception also discussed the relationship between the effects of climate changes and the production of food, as well as the population growth, higher competition for resources, and higher demand of food, besides a lower availability of food due to climate variabilities
Utilization	12,15,20,22,25, 27,28,38,48	9	- Climate changes may affect the consumption of food, the nutritional quality of foods, and their social value - Nutritional quality may be affected by a reduced concentration of several micronutrients (minerals) - Lower ingestion of fruits, vegetables, nuts, seeds, and fish, which may cause deficiencies of zinc, iron, vitamin A, vitamin B12, vitamin D, protein, and omega 3
Stability	4,5,12,25, 28,50	6	- Relationship between climate changes affecting the reduction of agricultural production as well as the quantity of food available in the market, which consequently increases the food prices in the market, especially in rural areas that tend to be more sensitive to weather variations
Mitigation and adaptation strategies	4,5,15,20-25, 28,31,34-39, 41,43,49, 50, 53-55	24	- Implementation of public policies, agricultural development plans, market protection laws, opening of local markets and agricultural subsidies, as well as maintenance and recovery of soils affected by climate changes - Reduce the plantation areas of certain crops; plant varieties of crops with a shorter growth period; delay the beginning of planting according to the precipitation; use of conservation agriculture, removal of wastes, and use of crop rotations; invest in additional machinery to shorten the planting time; rainwater collection, creating grooves near planted areas; increase the use of irrigation, enlarge the crops/plantations fields through the use of non-genetically modified species, and increase the variety of crops, besides the use of pastures, considering that these have the capacity to sequester additional carbons from the atmosphere and store them in the soil - Technological innovations through genetics; biotechnology; agronomy; use of biofuels; reduction in the use of fertilizers and contaminants; use of inorganic fertilizers; utilization of low-carbon agriculture; fortification and biofortification; sequestration of organic carbon; pest control; crop rotation; crop intensification; reforestation; and irrigation - Union between human and natural adaptation needs related to maintaining the agricultural productivity and ecosystem integrity (agroforestry) - Alert and alarm systems and monitoring tools, as well as the preparation of integrated plans for the prevention, protection, response, and rehabilitation of the exposed areas through social participation - Knowledge, awareness, and communication as ways to adapt to climate changes through educational and sustainable practices

Source: Authors, 2020.

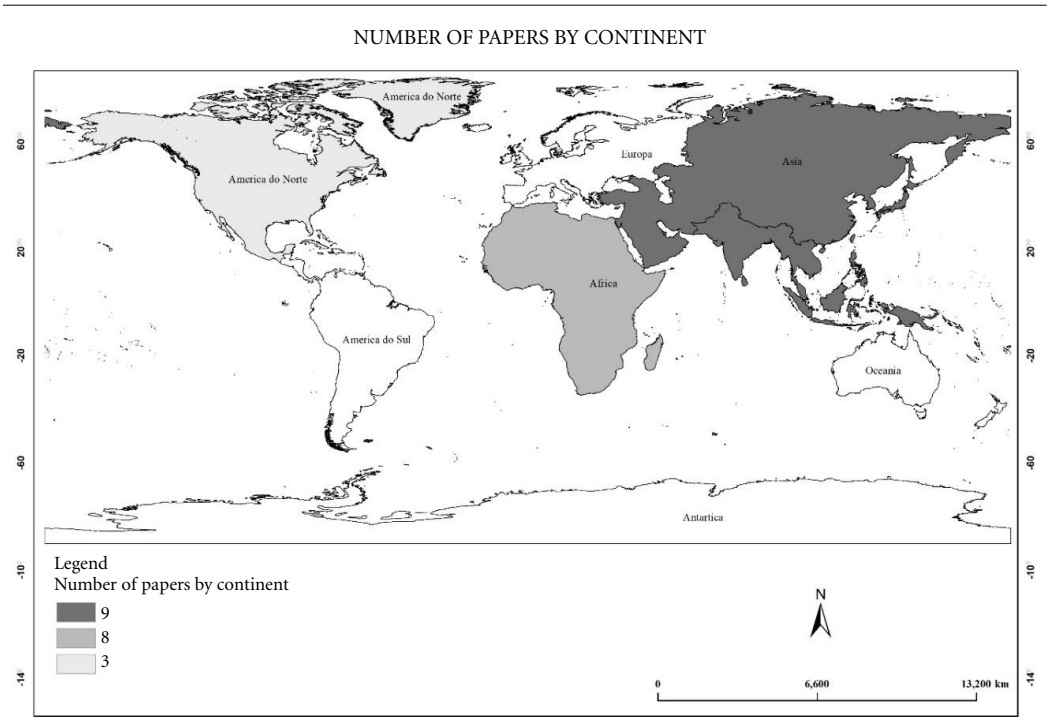

Figure 3. Distribution of publications deemed eligible for the study by continent.

Source: Authors, 2020.

Asia

Asia is the largest continent in the planet and also the most populous, with around 60% of the entire world population. Most of the Asian countries are in a situation of extreme poverty, in contrast with small clans that own large riches, what makes social inequality a huge problem in the continent.

Among the social indicators, it is important to emphasize that 1 out of 5 Asians is illiterate and that the child mortality rate in the continent reaches 115 in Afghanistan (one of the highest in the world ranking). Added to that, the continent faces problems such as: maternal mortality, sexual violence, armed conflicts, public health emergencies.

The Asian countries that appear in the publications deemed eligible for this study appear in the Hunger Map[61], with prevalence of malnourished among the total population between moderately high (15-24.9%) and high (25-34.9%), except for India that presented a prevalence classified as moderately low (5-14.9%). This shows us that FNS is an important issue in the continent[61].

It can be concluded that, despite large world powers being located in Asia, the continent has an overlapping of vulnerabilities: social, economic, and nutritional, among others not emphasized by this study. This situation, associated with the increased frequency and intensity of natural disasters, one of the effects of climate changes, turns into a concern. In the year 2017, Asia was the continent with the highest number of natural disasters recorded in the world (40% of the total), and with the highest number of deaths (58%). Three of the 5 countries in the world ranking of fatal victims of natural disasters are Asian[62].

FNS x poverty x social inequality

The relationship between climate changes, poverty, and inequality is complex, multifaceted, and specific por each context analyzed. The first studies arose in 2017, when it was perceived that climate changes could increase poverty and deepen the preexisting inequalities through their adverse effects on agriculture and health. However, there is currently a consensus that this relationship is characterized by a vicious cycle that retro-feeds itself: the existing poverty causes, for

instance, the unfavored or poorer populations to live in areas more prone or more exposed to different risks, including climate risks (geographic and environmental vulnerability), just as it causes these same individuals/groups in disadvantage to disproportionately suffer from the effects of the risks of climate changes or be more susceptible to them, considering that they have less resources to face them and recover from them. Once affected, the poorer populations become even more vulnerable, aggravating even more the pre-existing poverty and social inequality in the location/population and that will make them more exposed or more prone to new risk scenarios[63].

Added to that, there is also political vulnerability: less favored groups have less voice and representativity, being usually excluded from the decision arenas and, consequently, from public policies[63].

The effects on health are also important in this discussion, as people living in poverty conditions are more susceptible to diseases that the effects of climate changes help to propagate, including those related to vectors and contaminated water, besides having less access to health services[63].

Studies show that the poorer regions are more severely affected by climate threats than the rich ones. As well as people in social and demographic disadvantages, including those that face discrimination based on gender, age, race, social class, caste, are particularly more affected by the negative effects of these. Besides that, factors such as the type of occupation of the individual (a choice strongly influenced by their socioeconomic condition) might intensify the effects of climate changes. Example: a population that makes their living predominantly from agriculture and exercises field activities totally depending on the weather will suffer more from the effects of climate changes[63].

Considering this context, a point that draws attention is the inexistence of studies in Brazil about the effects of climate changes on FNS, once the country is considered 1 of the 10 hotspots for climate changes and where food insecurity, as well as poverty, is deemed a public health problem, especially by the unequal and inadequate conditions of access and distribution of food for the population[54,64,65].

The current global food system drives the bad types of nutrition (malnutrition, nutritional deficiencies, overweight, and obesity) through larger emissions of greenhouse gases, deforestation, and soil degradation, biodiversity loss, massive use of pesticides, all these contributing for changes on the weather and the environment[47]. On their turn, climate changes cause alterations on the access, availability, utilization, and stability of the food systems, thus affecting the nutritional status of the populations and intensifying the several types of poor nutrition[47]. This situation becomes even more serious and worrisome among those more vulnerable to FNS that have less capacity to adapt, not only to the variations in food production and prices, but also the effects of climate changes[51].

It is worth emphasizing as a limitation of this study that the choice for one single database, in this case PubMed, might have resulted in losses for this research in terms of a reduced number of papers covered and revised. In view of that, it is necessary to broaden the studies and research about the relationship between climate changes, bad types of nutrition, and FNS.

Conclusion

The results of this study indicate that climate changes affect both directly as well as indirectly the four dimensions of FNS, especially in poorer populations[4,50], and bring to discussion the mitigation/adaptation strategies to this new scenario.

Thirty four papers were deemed eligible for the study, which cover the interface between climate changes and FNS, in the period between 2004 and 2018, which generates an average of 2.2 papers per year and draws the attention to the gap that exists about the subject in the literature. However, the relevance of the theme for the FNS agenda raises concern on the urgency of public policies for social protection and incentives for research, especially in the poorest countries of the world, which will be the most affected ones. Such research should view the problem from a holistic perspective, focused on the construction of a food system that is more resilient/resistant to weather, and not only for issues related to agricultural production, in view that a sufficient and sustainable food production will not ensure that the population is free from hunger, and from the types of poor nutrition, such as malnutrition and obesity, despite it solves part of the problem[51].

The absence of studies in Brazil draws the attention, as it is a country that suffered for decades with hunger and malnutrition, and which experienced progresses related to FNS in the period between 2004 and 2013 with the implementation of public policies of income transfer ("*Bolsa Família*

(Family Grant)", for instance) and public policies for FNS promotion, which resulted in the country leaving the Hunger Map in 2014[66-68]. Currently, Brazil experiences the dismantling of public policies by the federal government, besides strong budgetary restrictions for these agendas, regressions that could cause it to re-enter the Hunger Map[67].

It is concluded that the impacts of climate changes on FNS are real and consist of an obstacle to meet the 2030 agenda throughout the entire planet. In view of that, restructuring the food system is urgent, as well as the world agricultural profile, and a change in the food and consumption profile of the population, in order to face the negative effects of climate changes.

At last, it is necessary to prepare and implement public policies capable of articulating different government agendas, regardless of the political arena at the time, aimed at ensuring the human right to and adequate and healthy eating.

Collaborations

TMA Alpino and ML Mazoto participated in the study's conception and planning, data collection and analysis, writing the text, and revision and approval of the final version. DC Barros and CM Freitas participated in the study's conception, data analysis, writing the text, and revision and approval of the final version.

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