

Food Security, Agriculture and Climate Change Mitigation Strategies: A Scientific Production Panorama

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Abstract

Understanding the complexity among food security, climate change and agriculture is a challenging topic. Projected growth rate of world population suggests a chaotic scenario in terms of food and water scarcity. This study reviews the major contributions by the scientific community in regards to effects on agriculture and food security as a result of climate change. The main conclusions are that the implementation of effective policies and mitigation measures for the effects of climate change are required to guide actions for a sustainable agriculture. The need for an intensive agriculture along with adaptation measures for human nourishment is necessary.

Keywords: Food Security; Mitigation; Climate Change; Agriculture.

Introduction

There are several projections that indicate future exponential world population growth. It is estimated that by the year 2025, the population will reach 8 billion, causing an increase in demand for food, energy and other resources, which limits development (CNA, 2014). Thus, the future of agricultural production appears to be quite unstable, resulting in a crucial need for mitigating climate change as well as to achieve food security for present and future generations.

According to the Rome Declaration on World Food Security and World Food Summit Plan of Action (FAO, 2015^a), “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”. Poverty is a major cause of food insecurity and despite the continuous reduction of hunger that the Food and Agriculture Organization of the United Nations (FAO) has estimated, there is still the reality that one of ten people worldwide do not have enough food to live healthily and actively, and this vast majority of people suffering from malnutrition live in developing countries (FAO, 2015^b).

In addition to the challenges in the process of reducing hunger, climate issues are another important factor to consider because of their direct impact on food production. Since developing countries (Bhatt & Mall, 2015) are usually major producers of food (Seaman et al, 2014, Misra, 2014), climate instability causes greater suffering and vulnerability in these nations. Thus, within the context of the development of nations, understanding food security through strategies of mitigating climate change is essential to achieve positive results.

Academia plays an important role in studies focused on understanding this reality; therefore, this research was developed from the following question: What is the contribution of scientific productions (2000-2015) in understanding food security in the context of climate change mitigation strategies?

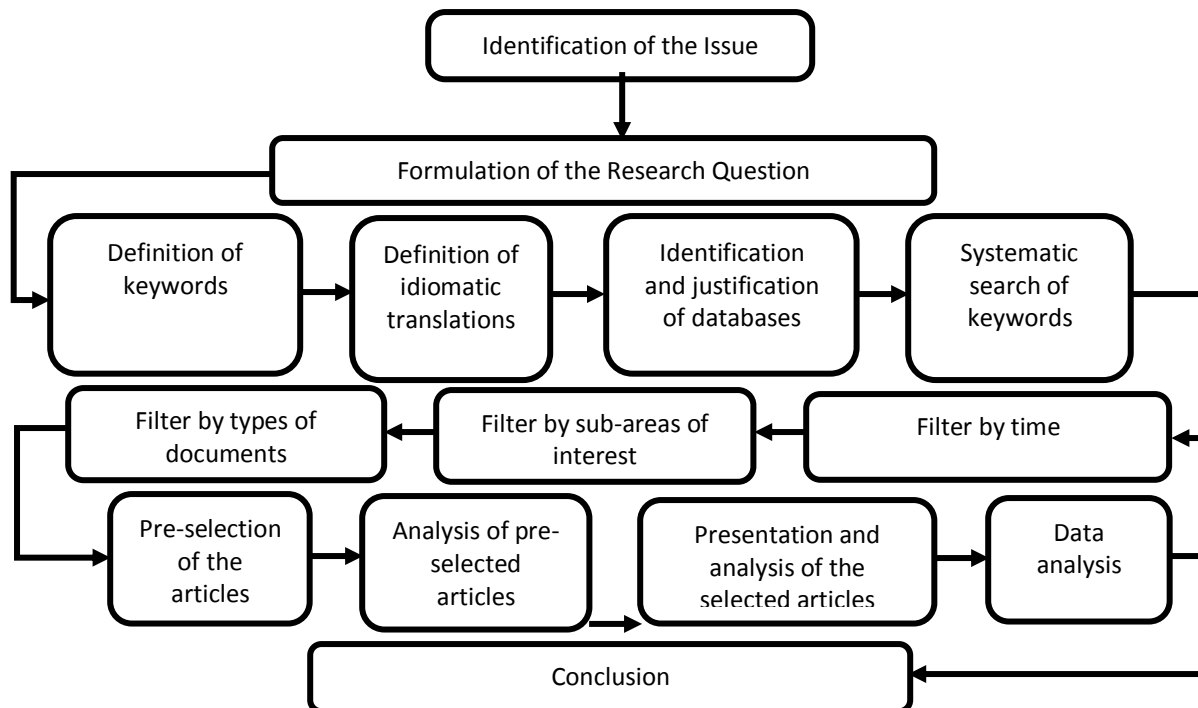
To answer this question, the article aims to analyze food security scientific productions in the context of climate change mitigation strategies, using as a methodological parameter of the systematic review of literature, with a qualitative meta-synthesis (bibliometric method).

Method

The qualitative approach applied in this study seeks to achieve a complete understanding of the parameters that govern food security in the context of climate change mitigation strategies. The research can be classified as exploratory and descriptive since it seeks to explain and describe the consequences of climate change on food security policies. In addition, this work can be conceptualized as a bibliographic survey of the theoretical and empirical nature that is realized through a systematic literature review in which data were obtained from primary sources.

According to Castro (2006), a systematic literature review was planned in order to respond to the tabled question. This literature review consists of fourteen steps, defined as a search strategy to the proposed theme. The steps were used to identify, select and systematically evaluate the previously published studies, as shown in Figure 1.

Figure 1: Step by step of the Systematic Literature Review. Source: Elaborated by the authors, 2015.



The first step relates to the theme identification. In the second step, the research question is defined. Finally, in the third step, four keywords were selected: food security; mitigation; climate change and agriculture, and from these, the fourth step was carried out, consisting of the idiomatic translation of each word.

The fifth step deals with the identification and justification of the databases, which are: Scopus, Web of Science (WoS); and Science Direct, which have been chosen for their relevance to academia. Scopus is the largest abstract and citation database of peer-reviewed literature with nearly 21,000 peer-reviewed journals, 5,000 international publishers, 370 book series and an extensive conference coverage, with about 5,5 million papers (Elsevier, 2015). The WoS is part of Thomson Reuters, and currently supports 15 different databases, with an approximate number of 2, 6 million publications (Thomson Reuters, 2015). And the last database, Science Direct, has 1/4 of the world's scientific and technical content and has nearly 2,500 periodicals, over 30,000 books and an approximate number of 13, 4 million publications (Science Direct, 2015).

The sixth step of this method, refers to the survey based on the previously chosen keywords and their appropriate combinations, which were held with their respective idiomatic translation, nevertheless, searches with isolated keywords were first performed as shown in the Table 1 below.

Table 1 – Results of the research with the isolated keywords. Source: Elaborated by the authors, 2015.

| KEYWORDS | SCOPUS | WEB OF SCIENCES | SCIENCE DIRECT |
|----------------|-----------|-----------------|----------------|
| Food Security | 947,529 | 1,433,809 | 1,418,059 |
| Mitigation | 691,109 | 669,075 | 906,109 |
| Climate Change | 178,547 | 175,828 | 167,571 |
| Agriculture | 284,240 | 650,321 | 497,965 |
| Total | 2,101,425 | 2,929,033 | 2,989,704 |

It can be seen that the research results of each keyword produce a significant number of publications and records related to the keywords "Food Security" and "Mitigation" in the three databases.

In this systematic literature review process, new activities continued carried out in order to verify in detail publications that address keywords and their idiomatic combinations. The results are shown in Tables 2 to 4.

Table 2 – Results of the research on the combination of two keywords. Source: Elaborated by the authors, 2015.

| KEYWORDS | SCOPUS | WEB OF SCIENCE | SCIENCE DIRECT |
|--------------------------------|--------|----------------|----------------|
| Food Security + Mitigation | 19,240 | 20,219 | 189,995 |
| Food Security + Climate Change | 9,014 | 10,842 | 49,300 |
| Food Security + Agriculture | 45,119 | 73,809 | 236,008 |

| | | | |
|------------------------------|---------|---------|---------|
| Mitigation + Climate Change | 20,196 | 21,633 | 47,382 |
| Mitigation + Agriculture | 10,082 | 17,701 | 77,118 |
| Climate Change + Agriculture | 16,745 | 19,879 | 55,840 |
| Total | 120,396 | 164,083 | 655,643 |

Table 2 makes reference to the beginning of the process that combined the chosen keywords of this study, in order to achieve a larger filter of the studied subject. It is clear that in all databases the combination with the highest number of publications is related to Food Security and Agriculture, especially in the Science Direct database. The combination of the keywords Mitigation and Climate Change is also highlighted, which presented a balanced number of publications in the three used databases.

Although Table 2 shows satisfactory results in terms of number of publications, the systematic literature review process was followed by a more keywords combination in order to obtain a more fine-grained filter of the scientific publications. The three keywords combination is shown in table 3.

Table 3 – Results of the research on the combination of three keywords. Source: Elaborated by the authors, 2015.

| KEYWORDS | SCOPUS | WEB SCIENCE OF | SCIENCE DIRECT |
|--|--------|----------------|----------------|
| Food Security + Mitigation + Climate Change | 1,710 | 1,613 | 19,605 |
| Food Security + Mitigation + Agriculture | 1,802 | 2,198 | 41,141 |
| Food Security + Climate Change + Agriculture | 3,139 | 2,887 | 27,532 |
| Mitigation + Climate Change + Agriculture | 3,455 | 3,529 | 22,406 |
| Total | 10,106 | 8,214 | 110,684 |

The construct related to Food Security, Agriculture and Mitigation was highlighted, due to the sum of its results, thus emphasizing the importance and interdependence of these three sectors. Finally, Table 4 sets out the combination of the four keywords set forth in this study, since it responds more accurately to the survey question of this article.

Table 4 – Results of the research on the combination of four keywords. Source: Elaborated by the authors, 2015.

| KEYWORDS | SCOPUS | WEB SCIENCE OF | SCIENCE DIRECT |
|---|--------|----------------|----------------|
| Food Security + Mitigation + Climate Change + Agriculture | 783 | 874 | 12,684 |

The seventh step of this method consists of a filter, established by means of a cut-off time of last 15 years of publications (2000-2015). It is emphasized that searches were obtained only for the first half of 2015, more specifically, through the month of June, when this research was initiated. This period of time was chosen by the authors in order to gather studies and information that would represent the latest available data. It is noteworthy that all the available publications, previous to this period of time, are not irrelevant to this study, and might be considered in future studies.

Table 5 illustrates the total number of publications available in the databases to which they correspond, comprising the combination of the four keywords. It also displays the total number of publications that remained after the temporal filter was applied.

Table 5- Selection per year (2000-2015). Source: Elaborated by the authors, 2015.

| SCOPUS | | WEB OF SCIENCE | | SCIENCE DIRECT | |
|--------|-------------------------------------|----------------|-------------------------------------|----------------|-------------------------------------|
| Total | Total/Years of Interest (2000-2015) | Total | Total/Years of Interest (2000-2015) | Total | Total/Years of Interest (2000-2015) |
| 783 | 761 | 874 | 860 | 12,684 | 11,108 |

In the eighth step, a filter was used according to the subareas of interest found in each database. Thus, the most relevant to this study were selected by the authors so as to conduct the search scope in sufficient detail.

The subareas used in Scopus were: Agricultural and Biological Sciences; Environmental Science, Social Sciences; Earth and Planetary Sciences; Engineering; Economics, Econometrics and Finance; Energy; Business, Management and Accounting; Multidisciplinary; Decision Sciences and Undefined.

Web of Science database chosen subareas were: Agriculture; Environmental Sciences Ecology; Science Technology Other Topics; Nutrition Dietetics; Developmental Biology; Biodiversity Conservation; Food Science Technology; Meteorology Atmospheric Sciences; Business Economics; Engineering; Water Resources; Geology; Forestry; Plant Sciences; Parasitology; Geography; Public Administration; Government Law; Evolutionary Biology; Energy Fuels; Social Sciences Other Topics; Fisheries; Oceanography; International Relations; Demography; Urban Studies; Biophysics; Social Issues; Public Environmental Occupational Health and Area Studies

The subareas of research employed in Science Direct database were: Soil; Food; Water; Energy; Plant; Forest; Land; Climate Change; Environmental; Climate; Co2 Emission; Earth; Ghg Emission; Renewable Energy; Carbon; Ghg; Ecosystem Service; Global; Ecosystem; Fish; Biomass and Agricultural.

Table 6 shows the results obtained at this step of the systematic literature review.

Table 6 – Selection per subareas of interest. Source: Elaborated by the authors, 2015.

| SCOPUS | | WEB OF SCIENCE | | SCIENCE DIRECT | |
|--------|-----------------------------|----------------|-----------------------------|----------------|-----------------------------|
| Total | Total with area of interest | Total | Total with area of interest | Total | Total with area of interest |
| 761 | 598 | 860 | 698 | 11,108 | 4,628 |

In the ninth step, another filter was added to the databases, aiming to select publications from their document types. In Scopus, those applied were: Article; Conference Paper; Book Chapter; Article in Press; Book and Conference Review. In Web of Science database, the selected documents were: Article; Meeting and Book. In the Science Direct, the chosen documents were: Journal and Book. As can be observed, table 7 presents the number of remaining publications, after the application of this filter.

Table 7- Selection per Documents of Interest. Source: Elaborated by the authors, 2015.

| SCOPUS | | WEB OF SCIENCE | | SCIENCE DIRECT | |
|--------|-----------------------------|----------------|-----------------------------|----------------|-----------------------------|
| Total | Total with area of interest | Total | Total with area of interest | Total | Total with area of interest |
| 598 | 500 | 698 | 624 | 4,628 | 4,628 |

In the tenth step of the systematic literature review, after applying all the filters, 56 publications were obtained, acquired by pre-select only the ten most relevant and the ten most cited articles in each database. Subsequently, the eleventh step consisted of analyzing the pre-selected articles. Thus, the results found in the previous step were explored and verified by titles, keywords and abstracts, culminating in the final selection of 25 items.

Presentation and analysis of the selected studies

The twelfth step of this research is the selection of studies, represented in Table 8, that include the 25 most relevant publications intended to answer the following research question: What is the contribution of scientific productions (2000-2015) for the understanding of food security in the context of climate change mitigation strategies?

Table 8 – Articles selected for analysis with the combination of keywords: Food Security; Mitigation; Climate Change and Agriculture. Source: Elaborated by authors.

| TITLE OF ARTICLE | AUTHORS | YEAR | JOURNAL | CITATIONS |
|--|---|------|---|-----------|
| Adapting agriculture to climate change | S. Mark Howden, Jean-François Soussana, Francesco N. Tubiello, Netra Chhetri, Michael Dunlop, and Holger Meinke | 2007 | Proceedings Of The National Academy Of Sciences of the United States of America | 680 |

| | | | | |
|---|--|------|--|-----|
| Adaptation and mitigation strategies in agriculture: An analysis of potential synergies | Cynthia Rosenzweig & Francesco Nicola Tubiello | 2007 | Mitigation and Adaptation Strategies for Global Change | 135 |
| Climate benefits of changing diet | Elke Stehfest · Lex Bouwman · Detlef P. van Vuuren · Michel G. J. den Elzen · Bas Eickhout · Pavel Kabat | 2009 | Climatic Change | 295 |
| Climate Change and Agriculture: The Policy Challenge for the 21st Century? | Hsin Huang, Wilfrid Legg and Andrea Cattaneo | 2010 | Euro Choices | 3 |
| Climate change and food security | Philip A. Gregory, John Ingram and Michael Brklacich | 2005 | Philosophical Transactions of the Royal Society B: Biological Sciences | 350 |
| Climate change and sustainable food production | Pete Smith and Peter J. Gregory | 2012 | Proceedings of the Nutrition Society | 33 |
| Climate change: Can wheat beat the heat? | Rodomiro Ortiz, Kenneth D. Sayre, Bram Govaerts, Raj Gupta, G.V. Subbarao, Tomohiro Ban, David Hodson, John M. Dixon, J. Iván Ortiz-Monasterio, Matthew Reynolds | 2008 | Agriculture, Ecosystems and Environment | 242 |
| Climate change through a gendered lens: Examining livestock holder food security | Sarah L. McKune, Erica C. Borresen, Alyson G. Young, Thérèse D Auria Ryley, Sandra L. Russo, Astou Diao Camara, Meghan Coleman, Elizabeth P. Ryan, | 2015 | Global Food Security | 0 |
| Climate science in support of sustainable agriculture and food security | Ramasamy Selvaraju, René Gommès, Michele Bernardi | 2011 | Climate Research | 8 |

| | | | | |
|---|---|------|---|-----|
| Climate-Smart Landscapes: Opportunities and Challenges for Integrating Adaptation and Mitigation in Tropical Agriculture | Celia A. Harvey, Mario Chacón, Camila I. Donatti, Eva Garen, Lee Hannah, Angela Andrade, Lucio Bede, Douglas Brown, Alicia Calle, Julian Chara, Christopher Clement, Elizabeth Gray, Minh Ha Hoang, Peter Minang, Ana María Rodríguez, Christina Seeberg-Elverfeldt, Bambi Semroc, Seth Shames, Sean Smukler, Eduardo Somarriba, Emmanuel Torquebiau, Jacob van Etten, & Eva Wollenberg | 2013 | Conservation Letters | 27 |
| Crop responses to climatic variation | John R. Porter and Mikhail A. Semenov | 2005 | Philosophical Transactions Of The Royal Society B: biological Sciences | 419 |
| Enhancing the Social Amplification of Risk Framework (SARF) by exploring trust, the availability heuristic, and agricultural advisors' belief in climate change | Amber S. Mase Hyunyi Cho, Linda S. Prokopy | 2015 | Journal of Environmental Psychology | 0 |
| Global food demand and the sustainable intensification of agriculture | David Tilman, Christian Balzer, Jason Hill, and Belinda L. Befort | 2011 | Proceedings Of The National Academy Of Sciences Of The United States Of America | 707 |
| Greenhouse gas mitigation by agricultural intensification | Jennifer A. Burney, Steven J. Davis and David B. Lobell | 2010 | Proceedings Of The National Academy Of Sciences Of The United States Of America | 395 |
| Historical warnings of future food insecurity with unprecedented seasonal heat | David. S. Battisti and Rosamond L. Naylor | 2009 | Science | 753 |
| Identifying potential synergies and trade-offs for meeting food security and climate change objectives in sub-Saharan Africa | Cheryl A. Palm, Sean M. Smukler, Clare C. Sullivan, Patrick K. Mutuo, Gerson I. Nyadzi, and Markus G. Walsh | 2010 | Proceedings Of The National Academy Of Sciences Of The United States Of America | 53 |

| | | | | |
|---|---|------|---|------|
| Mitigating climate change through food and land use | Sara J. Scherr, Sajal Sthapit | 2009 | Worldwatch Paper | 55 |
| Perceptions and responses to climate policy risks among California farmers | Meredith T. Niles, Mark Lubell, Van R. Haden | 2013 | Global Environmental Change | 9 |
| Prioritizing Climate Change Adaptation Needs for Food Security in 2030 | David B. Lobell, Marshall B. Burke, Claudia Tebaldi, Michael D. Mastrandrea, Walter P. Falcon, Rosamond L. Naylor | 2008 | Science | 1209 |
| Review of greenhouse gas emissions from crop production systems and fertilizer management effects | C.S. Snyder, T.W. Bruulsema, T.L. Jensen, P.E. Fixen | 2009 | Agriculture Ecosystems and Environment | 388 |
| Sequestering carbon in soils of agro-ecosystems | Rattan Lal | 2011 | Food Policy | 126 |
| Shaping agricultural innovation systems responsive to food insecurity and climate change | Sally Brooks and Michael Loevinsohn | 2011 | Natural Resources Forum | 32 |
| Soil management in relation to sustainable agriculture and ecosystem services | D.S. Powlson, P.J. Gregory, W.R. Whalley, J.N. Quinton, D.W. Hopkins, A.P. Whitmore, P.R. Hirsch, K.W.T. Goulding | 2011 | Food Policy | 122 |
| The dynamics of rural vulnerability to global change: The case of Southern Africa | Leichenko, R.M., O'Brien, K.L. | 2002 | Mitigation and Adaptation Strategies for Global Change | 272 |
| Toward a whole-landscape approach for sustainable land use in the tropics | Ruth S. DeFries Cynthia E. Rosenzweig | 2010 | Proceedings Of The National Academy Of Sciences Of The United States Of America | 125 |

From the information shown in Table 1, it is evident that the period from 2009 until 2011 presented a greater portion of the selected publications, with four articles annually. Regarding the article with the highest number of citations, "Prioritizing Climate Change Adaptation Needs for Food Security in 2030" stood out, having been published in the journal Science in 2008, and cited 1,209 times.

According to the above, this step sets a focus on the analysis of the selected articles, related to Food Security and Mitigations as well as Climate Change, in alignment with the predecessor steps.

“Adapting agriculture to climate change” S. Mark Howden, Jean-François Soussana, Francesco N. Tubiello, Netra Chhetri, Michael Dunlop and Holger Meinke

Climate change is leading humanity to adapt its agricultural activities. To be able to feed a population on a global basis, a greater understanding is necessary of issues related to science, production and politics, among others.

We argue that achieving increased adaptation action will necessitate integration of climate change-related issues with other risk factors, such as climate variability and market risk, and with other policy domains, such as sustainable development (Howden et al., 2007, p. 19691).

Multidisciplinary problems require multidisciplinary solutions. Strategies should be taken so that adjustments are made. Policies need to be relevant, governments and industries should invest more intensively in new policies and science will need to study in depth the issues of climate change and its mitigation.

The urgent need for a drastic change and adaptation of agriculture standards is conspicuous when set against a backdrop of future climate change scenarios. In order to achieve positive results, science will have to adapt to this reality, working along with decision makers.

3.2 “Adaptation and mitigation strategies in agriculture: an analysis of potential synergies” Cynthia Rosenzweig and Francesco Nicola Tubiello

Climate change will affect crop productivity and geographical distribution. The main factors which influence this scenario are related to increases in the atmospheric concentrations of carbon dioxide, further increasing global temperatures and the frequency of extreme weather on a global scale, possibly leading to more drought and flooding.

The article summarizes recent studies on how climate change will affect agriculture in the future and focuses on the potential for adaptation, mitigation and their interactions. According to the authors, Rosenzweig and Tubiello (2007, p. 858),

Despite uncertainties about the rate and magnitude of climate change, recent assessment studies have consistently shown that agricultural production systems in the mid and high latitudes are likely to benefit in the near term (approximately to mid-century), while production systems in the low-latitudes may decline over the coming few decades. Since most of the developing countries are located in lower-latitude regions, increased divergence in climate vulnerability between these groups of nations is expected.

The choice of effective adaptation and mitigation strategies will represent a key challenge for farmers in the coming decades. Optimal strategies are those that through proper land management maintain or increase the resilience and stability of production systems. Adaptation strategies often take precedence over mitigation, considering the ongoing climate changes. Farmers will have to adapt in order to maintain the production systems, and therefore, their own income and livelihoods.

In summary, the biggest climate change challenge and its impacts on agriculture, is the inclusion of appropriate adaptation and mitigation solutions through the integration of insights from the physical, biophysical and social sciences.

“Climate benefits of changing diet” Elke Stehfest, Lex Bouwman, Detlef P. van Vuuren, Michel G. J. den Elzen, Bas Eickhout, Pavel Kabat

Climate change mitigation policies tend to focus on the energy sector, while the livestock sector surprisingly receives little attention, despite the fact that it is responsible for 18% of greenhouse gases emissions and 80% of the total anthropogenic land use.

The analyzed article explored the potential impact of dietary changes on achieving ambitious climate stabilization levels. The authors found that a global food transition to less meat, or even a complete switch to plant-based protein food, is necessary to have a dramatic effect on land use.

According to Stehfest et al (2009, p.84) "[...] dietary changes may not only be attractive from a climate perspective, the impacts they might have on human health and life expectancy are of great interest also from a public health perspective"

The consumption of animal products, including meat from ruminants, is increasing rapidly, especially in developing countries. The impact on livestock farmers can be a major obstacle in the implementation of low-meat diets. However, permanently changing eating patterns benefits human health, climate and the feasibility of stabilizing atmospheric emissions, reasons important enough to put this matter on the political agenda.

“Climate Change and Agriculture: The Policy Challenge for the 21st Century?” Hsin Huang, Wilfrid Legg and Andrea Cattaneo

The studied article aims at understanding, as well as finding solutions to the challenges of creating policies to address climate change and agriculture. An analytical process of data and projections was carried out, most of the prognosis showed population growth, which will increase the demand for essential resources, such as water and food. Therefore, is necessary to create policies that satisfy basic human needs while also ensuring the mitigation of climate change and environmental issues.

Future policy reforms might better target specific environmental outcomes, such as encouraging production techniques that minimise GHG emissions (Huang; Legg; Cattaneo, 2010, p. 13).

The increasing volume of the scientific production regarding climate matters, population growth, in among others, demonstrate a troubling scenario when it comes to the future development of societies.

Policies need to be created so that human needs are met in the coming years, as well as climate and environmental problems needed to be restrained and mitigated so that sustainability is achieved.

It is concluded that, sustainable development can be achieved with the creation and implementation of new policies, turning agriculture and the quest for climate problems mitigation even more interconnected and sustainable.

“Climate change and food security” Philip A. Gregory, John Ingram and Michael Brklacich

The purpose of this study is to introduce the concept of the food system and its relation to food security and climate changes; to exploit the vulnerability of food systems to climate changes; to examine some alternatives for the adaptation of food systems in response to climate changes and highlight some results in the modification of food systems.

Gregory, Ingram and Brklacich (2005), the authors, state that:

(...) food security depends on robust food systems that encompass issues of availability, access and utilization (not merely production alone), and consequently that the nature of key research issues changes as questions

more related to food security are formulated, led the international global change research community to establish the joint project global environmental change and food systems.

The article demonstrates that climate change is just one of the many changes affecting food systems and that it varies according to the regions, and according to the different social groups in each region. The adaptation of food systems by interventions in availability, access and use is responsible for overcoming climate change on different levels, though its results worldwide have been not completely analyzed.

While increasing agricultural productivity is a key step in reducing rural poverty, the favorable macroeconomic and trade policies, good infrastructure and access to credit, land and markets are also necessary for rapid growth rates. Climate change will aggregate a new dimension to the challenge of ensuring food security for all, especially for the poor.

“Climate change and sustainable food production” Pete Smith and Peter J. Gregory

This article presents the possible impacts of climate change on agriculture, also analyzing some mitigation measures that focus on the reduction of greenhouse gas emissions (GHG) in agricultural production. In this context, it is evident that to feed a world with 9 to 10 billion people by 2050 is a great challenge, even taking into account the reduction of GHG emissions.

The scale of the problems of food security, reducing climate impact and providing resilience to future climate change, means that we are not in a position to choose between production- and consumption-based food production systems; we clearly need both (Smith; Gregory, 2012, p. 27).

The authors can realize the complexity of this issue, which involves not only food production but many other activities, such as food processing, distribution, consumption, etc. Ensuring that food safety becomes even more complicated as the population grows, along with the advancement of the need to mitigate climate problems and ensure the reduction of GHG emissions.

So that humanity faces a major challenge of this century (difficulties in the management of food production and climate problems), some measures are required to guarantee an improvement in agricultural efficiency, as well as a change of diet, reduction of waste or reduction in the demand for food products.

“Climate change: Can wheat beat the heat?” Rodomiro Ortiz, Kenneth D. Sayre, Bram Govaerts, Raj Gupta, G.V. Subbarao, Tomohiro Ban, David Hodson, John M. Dixon, J. Iva'n Ortiz-Monasterio, Matthew Reynolds

This paper presented a review and updating of some approaches related to the effects of climate changes on wheat production in some of the most important areas of cultivation, especially in germplasm adaptation process, management and mitigation systems. In addition, to deal with the effects of climate change, a research and development agenda needs to follow a holistic approach that brings together genetic enhancement, crop management, training and knowledge sharing.

The authors affirm that:

About 21% of the world's food depends on the wheat (*Triticum aestivum*) crop, which grows on 200 million hectares of farmland worldwide. Although wheat is traded internationally and developing countries are major importers (43% of food imports), the reality is that 81% of wheat consumed in the developing world is produced and utilized within the same country, if not the same community (Ortiz, et. al., 2008, p.46).

Several research approaches are being tested to understand and face the effects of climate changes on large areas of wheat planting in the world. Research in this area is generally long-term because it depends on observation and simulation of planting areas due to the effects of global warming. New cultivars must be

developed for adaptation of crops to the new environments and climatic conditions, especially in developing countries.

“Climate change through a gendered lens: Examining livestock holder food security” Sarah L. McKune , Erica C. Borresen , Alyson G. Young , Thérèse D Auria Ryley , Sandra L. Russo , Astou Diao Camara , Meghan Coleman , Elizabeth P. Ryan , 2015

This article shows the nexus of gender (male and female) between the livestock and food security. A conceptual framework based on gender is proposed to understand the impact of climate change on food security among ranchers, with a highlight for the potential ways of vulnerability and intervention points to be considered in global health strategies to improve household food security.

This review examines how gender influences food security vulnerability related to climate among ranchers. According to the authors, “(...) Incorporating gender into the development of policies and legislation is an ongoing process and, consequently, must be continually initiated as new issues arise, including the impacts of climate change on food security of livestock holders” (McKune, et. al., 2015, p.6).

Using a gender framework to understand the variability related to climate on food security among livestock farmers, the authors realized that the role that gender plays in shaping the mechanisms and pathways by which climate change can affect food availability, accessibility and consumption.

The article presents some recommendations for gender relations, livestock and climate change: using gender analysis tools to assess climate impacts; including urban and semi-urban ranchers in the discussion of climate changes; providing an explicit link between livestock production, gender, climate change and food security; engaging women in activities of extension of livestock-based agriculture; identifying approaches to increase the legal property and assets of livestock by women; developing protocols for climate researchers to understand the dynamics of gender in their work.

3.9 “Climate science in support of sustainable agriculture and food security” Ramasamy Selvaraju, René Gommès, Michele Bernardi

The world population is expected to reach 9.1 billion in 2050; feeding this population will require increasing global food production by 70% by 2050 in comparison with 2005/2007 production levels. The science of climate has a lot to offer in overcoming these challenges, especially with regard to characterization of agro-climatic resources and the development of policies of climate responses for water and agriculture. This article aims to present the main impacts of food production in the context of the increasingly frequent weather events today.

Strong partnerships and collaboration among international institutions, national hydrometeorology services, agricultural extension agencies, national research institutions, community-based organizations and social networks are pre-requisite for the advancement of guidance on the climate for the agricultural sector.

The intensity of tropical cyclones and the frequency of heavy rainfall tend to increase along the 21st century in many regions, with consequences for the risk of flooding. At the same time, the proportion of dry lands tends to increase in addition to a tendency for droughts during the summer, particularly in the sub-tropics, and medium and low latitude regions.

According to Selvaraju, Gommès and Bernardi (2011, p. 97): “Climate change and increasing climate variability will affect food security in all of its 4 dimensions: availability, accessibility, utilization and stability.”

Climate science is doing its part in assisting systematic characterization of geo-climatic resources, which is one of the criteria for the development of policy responses to climate and agricultural adaptation. Climate is a key resource for agriculture and directs nearly every ecosystem level processes at the level of plants.

In short, climate science for the management of climate risk and food and agricultural resources is more important than ever, because the food system is expanding more at a marginal level in vulnerable areas and of climate risk.

“Climate-Smart Landscapes: Opportunities And Challenges For Integrating Adaptation And Mitigation In Tropical Agriculture” Celia A. Harvey, Mario Chacón, Camila I. Donatti, Eva Garen, Lee Hannah, Angela Andrade, Lucio Bede, Douglas Brown, Alicia Calle, Julian Chará, Christopher Clement, Elizabeth Gray, Minh Ha Hoang, Peter Minang, Ana María Rodríguez, Christina Seeberg-Elverfeldt, Bambi Semroc, Seth Shames, Sean Smukler, Eduardo Somarriba, Emmanuel Torquebiau, Jacob Van Etten, & Eva Wollenberg

This article aims to highlight the opportunities for synergies between adaptation and mitigation activities in tropical agricultural scenarios, in addition to exploring how this process can be planned and managed so these synergies can be reached. It also identifies some of the main barriers to achieving these synergies, providing preliminary information on how they can be overcome.

This approach is concentrated in tropical agricultural systems because they have a higher mitigation potential than temperate climate systems, they are highly vulnerable to climate changes, and are crucial for the global efforts to improve food security and reduce poverty. According to the authors:

Intentional integration of adaptation and mitigation activities in agricultural landscapes offers significant benefits that go beyond the scope of climate change to food security, biodiversity conservation, and poverty alleviation. However, achieving these objectives will require transformative changes in current policies, institutional arrangements, and funding mechanisms to foster broad-scale adoption of climate-smart approaches in agricultural landscapes (Harvey et. al., 2013, p.77).

There is not yet a general formula for capturing synergies between adaptation and mitigation, its joint assessment in landscape planning, research, technical support, government policies and funding mechanisms that significantly help for the accomplishment of this goal. Thus, a renewed and strengthened commitment toward sustainable agriculture, as well as an increased focus on integrated management of scenarios, would help promote tropical agricultural systems and scenarios that would improve the potential for adaptation and mitigation, besides contributing to food security, reduction of poverty and biodiversity conservation.

“Crop responses to climatic variation” John R. Porter and Mikhail A. Semenov

This work aims to analyze the impacts of climate change in the quantity and quality of the cultivation of different species for food production. The increase in temperature variation and precipitation should be prevalent in aspects related to climate change in the future, which will affect agricultural production and, therefore, the availability of food in the world.

The global temperature is rising and there is a debate on whether this event is a result of human activity, such as burning fossil fuels and burning in forest clearing, or an expression of a ten-year variability for a millennial scale in temperature. What is noticeable is that in geographically located contexts the temperatures and extreme events are becoming more frequent and this affects food production as a whole.

According to Porter and Semenov (2005, p. 2026):

Obtaining such data at a temporal scale relevant for crop production needs to be a high priority, in order to inform the debate on the extent and importance of climatic variability. In addition, information is required as to how climate and weather variability may change under a general climate warming.

The article concludes that in regional and global scale the extent and frequency of changes in climate are increasing and this will affect agricultural production. Within the context of adaptation to climate changes, the article considers the possibility of using genetic manipulation to make the crops more resistant to climatic variations, although these measures are much criticized. Another line is the possibility of using new species of plants, as well as new cultivation and management techniques.

“Enhancing the Social Amplification of Risk Framework (SARF) by exploring trust, the availability heuristic, and agricultural advisors' belief in climate change” Amber S. Mase, Hyunyi Cho, Linda S. Prokopy

Using a survey with agricultural experts from around the Midwest of the United States, this article explores two additional questions to the Social Amplification of Risk Framework (SARF). The relationship between demographic factors, belief in climate change, perceived risk and attitudes of experts in relation to adaptation to climate change are examined. Three-quarters of the experts believe climate change is occurring, but disagree on the human contribution.

According to the authors: “the Social Amplification/Attenuation of Risk Framework (SARF) is an established theoretical tool for understanding how risks are perceived, interpreted, and amplified or attenuated as they are communicated throughout a society” (Mase et. al., 2015, p.167).

An online survey with 7,770 agricultural experts located in Indiana, Iowa, Michigan and Nebraska was conducted in the spring of 2012. The distribution of responses (n = 1,745) with the belief in climate change reveals that 74% of the counsellors believe that change climate is occurring, but disagree as to the role of human activities as the only responsible for climate change. A good proportion of board members (around 25%) consider climate change a natural phenomenon, while around 50% see human activity as equally or even more responsible for climate change when compared with the natural variation.

“Global food demand and the sustainable intensification of agriculture” David Tilman, Christian Balzer, Jason Hill, and Belinda L. Befort

With the environmental impact generated by the expansion of agriculture, and the high demand for food projected for the coming years, it is possible to observe a major problem between the "produce and mitigate" in an efficient way.

The preservation of global biodiversity and the minimization of the GHG impacts of agriculture may well hinge on this trajectory. A trajectory that adapts and transfers technologies to underyielding nations, enhances their soil fertility, employs more efficient nutrient use worldwide, and minimizes land clearing provides a promising path to more environmentally sustainable agricultural intensification and more equitable global food supplies (Tilman et al., 2011, p. 20264).

With population growth and increased demand for food, both the developed and the developing countries will have to adapt their agriculture from investments in technology. This adjustment must be made aiming to preserve the biodiversity, minimizing impacts and the production of greenhouse gases in agriculture.

“Greenhouse gas mitigation by agricultural intensification” Jennifer A. Burney, Steven J. Davis, and David B. Lobell (2010)

The article analyzed presents a study of the evolution of agricultural activity and the level of greenhouse gas emission, both by area extension and by intensive agriculture, by considering two scenarios.

The first scenario, AW1, assumes that the population, the global economy and the socio political situation develop exactly like in the real world (RW), but with agricultural technology and the cultivation practices from 1961. This scenario raises the question of what it would cost in terms of GHG emissions to replicate the global current standard of living in the absence of investment in yield improvements in agricultural production. The

second scenario, AW2, presents a reality where agricultural production increased only enough to keep the living standards of the year 1961 by 2005. While the AW1 scenario replicates the evolution of living standards but meets the production needs with extensive agriculture, the AW2 scenario simply keeps the living standards at the levels of 1961, again by extensification rather than intensification.

Following Burney et. al. (2010, p.12055),

Our results demonstrate the importance of land use change emissions over direct emissions of methane and nitrous oxide from agricultural systems, and suggest that the climatic impacts of historical agricultural intensification were preferable to those of a system with lower inputs that instead expanded cropland to meet global demand for food.

The world population is expected to reach 8.9 billion in 2050, with the demand for food growing on the order of 70%. The improvement of crop yields should be prominent among strategies to reduce global emissions of greenhouse gases. In order to accelerate the adoption of agronomic advances that improve crop yields (intensive agriculture), mechanisms to encourage investments in productivity gains in the global carbon market should be explored.

“Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat” David. S. Battisti and Rosamond L. Naylor

The article has studied the global impacts on food production, agriculture and livestock, in the context of climate change, by observing 23 climate models. With a probability (> 90%) of growth of high-temperature seasons in the tropics and subtropics, the end of the 21st century will have periods with temperatures that will exceed those registered from 1900 to 2006.

This study also presents historical examples to illustrate the magnitude of damage in food production caused by the hot seasons and shows that these short-term events can become future trends without sufficient investment in adaptation.

The paper calculated the differences between historical and projected temperatures from 23 global climate models. The results showed that until the end of the 21st century temperatures will exceed the figures recorded so far, especially in tropical and subtropical regions. In those regions, there are over 3 billion people, and many are living on less than \$2 a day and depend primarily on agriculture for their maintenance.

With the growth of temperatures beyond the historical limits, some questions arise: will people in these regions have access to food considering the future demand and thus ensuring food security?

Battisti and Naylor (2009, p. 242) affirm that:

Severe heat in the summer of 2003 affected food production as well as human lives in Europe. Record high daytime and nighttime temperatures over most of the summer growing season reduced leaf and grain-filling development of key crops such as maize, fruit trees, and vineyards; accelerated crop ripening and maturity by 10 to 20 days; caused livestock to be stressed; and resulted in reduced soil moisture and increased water consumption in agriculture.

Three important conclusions can be presented. First, tropical countries will experience lower extreme temperatures than countries with temperate climates, which will be the first to experience unprecedented heat stress. Second, the average summer temperature in the tropics and subtropics by the end of the 21st century will exceed the hottest summer recorded so far. Finally, it will be extremely difficult to balance the food deficit in one part of the world with the surplus elsewhere, unless investments are made in adaptation for the development of varieties of crops that are tolerant to heat and lack of water coupled with the need for irrigation systems for several agricultural systems. Genetics, genomics, and the capacity of cultivation,

management and engineering for this adaptation can be developed globally, but it will be expensive and will require prioritization of policies.

“Identifying potential synergies and trade-offs for meeting food security and climate change objectives in sub-Saharan Africa” Cheryl A. Palm, Sean M. Smukler , Clare C. Sullivan , Patrick K. Mutuo , Gerson I. Nyadzi , and Markus G. Walsh

This article explored the interaction between food production and climate change mitigation in two situations in African low-Sahara (sub-Saharan Africa - SSA) where deforestation and land degradation overlap with hunger and poverty.

When investigating four scenarios for food production increase in two sites in the SSA, Sauri, Kenya and Mbola in Tanzania, which are part of the Millennium Villages Project (Millennium Villages Project - MVP), where there are extreme degradation and poverty rates, the article analyzed and compared, by means of a numerical model, the expansion practices of the cropping area through deforestation; fertilization by use of mineral fertilizers as N source; green manure application to growing vegetables for fixing N in the soil and agroforestry intensification by planting of leguminous trees for fixing N in soil.

The author states that:

Curbing deforestation and land degradation in SSA requires substantial increases in crop productivity on already cleared lands. Increasing productivity depends on reversing soil nutrient depletion on small-holder farms where decades of nutrient removal through crop harvest and erosion have not been balanced by replenishment (Palm, C.A., Palm, Sean M.S.,Clare C.S., Patrick K.M., Gerson I.N., and Markus G.W., 2010, p. 19661).

The article concludes that to be possible to balance food security and climate change mitigation in large areas in the tropics, policies need to allow access, the positive cost-benefit, and the encouragement for the adoption of alternative sources of N, including mineral fertilizers and vegetal coverage with legume crop. Avoiding deforestation in forests in the studied areas requires a combination of political instruments including financial incentives, such as support through direct payment and fertilizers, and the regulation of forestry resources and extension activities. The reduction of emissions from deforestation and forest degradation in developing countries (REDD - Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) through incentive policies can increase the potential for synergy between climate mitigation and food safety.

“Mitigating Climate Change Through Food and Land Use” Sara J. Scherr, Sajal Sthapit

This report aimed at presenting some paths to be followed to reduce the emission of greenhouse gases by means of food production techniques and land use.

The planet Earth has $\frac{1}{4}$ of its surface composed of soil and plants that accumulate three times more carbon than the atmosphere. Over 30% of all emissions of greenhouse gases come from sectors that make use of the land. Thus, no global climate change mitigation strategy can be complete or successful without reducing emissions in agriculture, forestry industry and other land uses. Furthermore, only carbon sequestration based on the use of land or “terrestrial” carbon offers the possibility of large-scale removal of greenhouse gases in the atmosphere through photosynthesis of plants.

According with Scherr and Sthapit (2009, p.5) “the top five strategies to reduce and sequester carbon on earth are: I) enrich the soil with carbon; II) cultivation of perennial plants such as palms and trees; III) friendly agricultural production, with proper management, grazing techniques, methane capture, among other; IV) protect the natural habitat; V) restore degraded watersheds and pastures”.

The report concludes by recommending six principles to achieve the mitigation potential based on land use: include in the range of reduction of terrestrial emission options of storage and C sequestration in climate and investment policies; incorporate investments in agriculture and land use in the cap-and-trade systems; link the terrestrial climate mitigation with adaptation strategies, rural development and conservation; encourage programs for control and management of the land based on large areas; encourage voluntary markets of compensation of gas emitted from agriculture and land use; and mobilize a global movement network for food production that respect the climate, the forests and other land uses.

“Perceptions and responses to climate policy risks among California farmers” Meredith T. Niles, Mark Lubell, Van R. Haden

The article analyzed highlights that an understanding of responses to the climate risk policies and other social, economic policies is a vital component to understand the changes in beliefs, risks and behaviors and should be fully considered in future works.

This study also suggests that existing surveys underestimate a key feature of adaptation: how farmers perceive and respond to climate risk policies. According to the authors the concept of climate risk:

(...) is defined as a regulation or policy that may present economic, environmental or social risks to an individual or enterprise. In the context of agriculture, climate policy risk is the potential threat posed by climate change regulations or policies to mitigate or adapt to climate change (Niles, T. et Al, 2013, p. 1752)

The method for the development of the research included the application of mail survey and interviews with 572 Yolo County farmers in California's Central Valley. The Yolo County is an agricultural region with over 80% of the land targeted for agriculture and was chosen for its diversity of crops and livestock.

The results of the paper suggest that climate risk policies need to be more appropriately considered in assessing the changes in attitudes and behaviors of the target audience. Some suggestions are: climate risk policies need to be better perceived by farmers through training for intervention actions; programs of technical assistance or of compensation to change the practices can be a positive opportunity for farming communities on climate change; and the way in which farmers realized past policies influence the future policies, so it is necessary to involve the community more in the definition of policies so that they realize the benefits.

“Prioritizing Climate Change Adaptation Needs for Food Security in 2030” David B. Lobell, Marshall B. Burke, Claudia Tebaldi, Michael D. Mastrandrea, Walter P. Falcon, Rosamond L. Naylor

The article studied underscores the importance of investments for the adaptation of agriculture to climate change. An analysis was carried out in twelve regions that presented climate risks related to food insecurity; the regions are groups of countries with similar diets and similar agricultural production systems; it also presents a notable percentage of undernourished people in the world, according to the FAO, in order to identify adaptation measures, based on statistical models and climate projections for 2030.

The focus of the study is the forecast for 2030, considered a relevant period for major agricultural investments. The date was selected according to several criteria, such as, according to the authors:

First is the importance of the crop to a region's food-insecure human population [hunger importance (HI)]. Second is the median projected impact of climate change on a crop's production by 2030 (indicated by C50), assuming no adaptation. For this analysis, we generate multiple (i.e., 100) projections of impacts based on different models of climate change and crop response, in order to capture relevant uncertainties. The projections are then ranked, and the average of the 50th and 51st values are used as the median. A third

criterion is the fifth percentile of projected impacts by 2030 (where C₀₅ indicates the fifth value of the ranked projections), which we use to represent the lower tail or “worst case” among the projections (Lobell et al., 2008, p. 607-608).

Adaptation is the essence for the design of the future, in view of the high seriousness of the impacts of climate change on food production, and therefore the priorities depend on substantial investments on the part of farmers, governments, scientists and development organizations.

Impacts vary according to regions, mainly due to the provisions of natural resources and management. This study aimed to present the main areas of concern in the scope of climate change vulnerability and food security. Moreover, there are different crops, so different adaptation measures become necessary, according to each region.

“Review of greenhouse gas emissions from crop production systems and fertilizer management effects” C.S. Snyder, T.W. Bruulsema, T.L. Jensen, P.E. Fixen

This article aimed at presenting a literature review to assess the best management practices in relation to greenhouse gas mitigation potential associated with the use of fertilizers in tillage systems.

For Snyder et. al. (2009, p.248):

Fossil fuel combustion is considered responsible for more than 75% of human-caused CO₂ emissions. Land use change (primarily deforestation) is responsible for the remainder. Human activities are thought to have more than doubled the rate of emission of CH₄ over the last 25 years. Atmospheric concentrations of N₂O are reported to have risen from about 270 parts per billion (ppb) during the pre-industrial era to 319 ppb in 2005.

The implementation of intensive management of tillage practices with the use of ecological intensification principles in order to achieve effective and efficient absorption with high productivity has been identified in the article as the main way to achieve the reduction of greenhouse gas, meeting the demands for food production.

Cultures and high performance can mitigate greenhouse gas emissions by increasing the storage of C (carbon) in the soil provided by good management practices.

The current scientific stage indicates the following practices: i) appropriate use of N-based fertilizers can help increase the production of biomass that helps keep carbon levels in the soil; ii) Good management practices regarding N-based fertilizers play an important role in minimizing soil nitrate; iii) tillage practices that reduce soil weakening keeps the crop residue into the soil and can increase the level of carbon; iv) differences between N fertilizers that give origin to N₂O emissions depend on the specific conditions of the location and climate; v) the intensification in agricultural practices do not increase, necessarily, the emission of greenhouse gas in proportion to the increase in production.

“Sequestering carbon in soils of agro-ecosystems” Rattan Lal

This article aimed to describe the C (carbon) sequestration potential in soils of agroecosystems through recommended practices of agricultural management. The strategy is to increase the resilience of the soil, improving the ability to adapt to extreme events and, consequently, mitigating climate change by offsetting emissions through sequestration of C in the soil.

There is a strong link between food security, soil degradation and climate change due to a continuous cycle of degradation which can be minimized with the restoration of carbon levels in the soil.

The author R. Lal (2011, p.533) states that:

(...) an important option is sequestration of carbon (C) in agroecosystems, especially in agricultural soils. Soils depleted of SOC not only yield less but also have low use efficiency of added inputs, and are able to sequester less atmospheric CO₂.

Approximately 90% of the nearly 1 billion people in situations of food insecurity are concentrated in regions where the soil is severely damaged (642 million in the Asia-Pacific region and 265 million in Sub-Saharan Africa).

With the appropriate level of C and other nutrients, the soil can act in the absorption of CO₂ and CH₄ in the atmosphere from increased agricultural activity. Increased agricultural activity prevents the increase in atmospheric temperature caused by greenhouse gases, which further improves the water supply on the planet as well as the reduction of energy consumption.

In summary, the use of soil management techniques to maintain the appropriate level of organic components may be one of the most effective measures of absorption of CO₂ from the atmosphere. Restoring carbon in the soil by more than 10% in the 21st century may mean a reduction of 110 ppm of CO₂ in the atmosphere. If the soil is not properly handled, the crops will suffer even with the presence of rain, hunger will perpetuate even with the use of biotechnology and genetic modification, and civil war and political instability will be common in developing countries. Political stability and global peace are threatened because of land degradation, food insecurity and despair. Such a chaotic scenario can be mitigated through appropriate measures of soil management that enable the appropriate maintenance of carbon and other nutrients in the soil.

“Shaping agricultural innovation systems responsive to food insecurity and climate change” Sally Brooks and Michael Loevinsohn

Currently, the climate change crises, concomitant with environmental, demographic, social and economic factors, are causing significant structural vulnerability in the agro-food sectors, generating impacts that affect mainly family farms and environments with poorer populations.

This article presents the knowledge generated from adaptation and innovation experiences of some selected countries due to food safety. For this, an analysis of three cases of operational innovation systems is carried out and contrasted with regional socio-economic and agro-ecological contexts, which, according to the authors, are:

(i) Recognition of the multifunctionality of agriculture and opportunities to realize multiple benefits; (ii) access to diversity as the basis for flexibility and resilience; (iii) concern for enhancing capacity of decision makers at all levels; and (iv) continuity of effort aimed at securing the well-being of those who depend on agriculture (Brooks, Loevinsohn, 2011, p.185).

The purpose of this study is to analyze factors that encourage innovation and adaptation of agricultural systems, to ensure food safety, in the context of a scenario of constant climate changes and vulnerability. However, to achieve this goal it is necessary to implement some crucial areas, such as offering professional qualifications, reforming the curriculum of universities, and encouraging organizations and private enterprise structures in addition to policies, which are essential in the process of innovation induction.

“Soil management in relation to sustainable agriculture and ecosystem services” D.S. Powlson, P.J. Gregory, W.R. Whalley, J.N. Quinton, D.W. Hopkins, A.P. Whitmore, P.R. Hirsch, K.W.T. Goulding

The aim of this article is to highlight some key questions about the functioning of the soil. That requires research, considering the increase in food production needed to meet the demand of 9 billion people by 2050. For some cases the article presents the need to implement policies that ensure the application of current knowledge; for other cases, further research is needed to promote a new understanding of soil management improvements.

According to Powlson et. al., (2011, p. 573) one must understand the behavior of the soil, of the crops and the possible management techniques:

Utilizing soil for agriculture inevitably leads to changes in soil properties such as nutrient status, pH, and organic matter content and physical characteristics. In many cases changes that are beneficial for food production are detrimental for other ecosystem services, so there is a tension between the different functions of soils.

The article proposes a series of actions and policies for the proper management of the land in order to reduce the emission of greenhouse gases. Among the actions are: encouraging practices to maintain C in the soil; providing energy in rural areas to reduce the burning of organic matter as fuel; encouraging minimum tillage to minimize the changes in land use, especially fires; long-term commitment to scientific research; implementing soil management practices that reduce erosion; implementing practices of planning and management of nutrients in the soil; for the case of N, adopting practices that reduce N₂O; studying the behavior of the roots in order to avoid controlling the absorption of water and nutrients in the soil.

“The Dynamics of Rural Vulnerability to Global Change: The Case of Southern Africa” Robin M. Leichenko and Karen L. O’Brien

Climate change and globalization are changing the conditions of production and commercialization of agricultural products, and this paper presented a dynamic of the agricultural vulnerability to global change based on the example of Southern Africa.

This study proposes a work of dynamic vulnerability, which consists of incorporating traditional notions of vulnerability in a socioeconomic and environmental context, influencing the capacity of the regions, sectors, ecosystems and social groups to respond to natural and socioeconomic impacts.

Dynamic vulnerability incorporates traditional notions of vulnerability, but places these notions within a rapidly changing socioeconomic and environmental context – a context that transforms the static ‘snapshots’ of vulnerability. In other words, dynamic vulnerability considers how global and macro-scale changes are being played out at regional and local scales, including the effects that these changes have on traditional measures of vulnerability (Leichenko, O’Brien, 2002, p.3).

The conclusion is that the confluence between climate change and economic changes indicates a need for the investigation of adaptation strategies for climate change that should be considered in the context of economic globalization, and how it continually reshapes rural vulnerability.

“Toward a whole-landscape approach for sustainable land use in the tropics” Ruth S. DeFries Cynthia E. Rosenzweig

The article analyzed examines the cost-benefit relationship between food production and climate change mitigation through the presentation of a collection of articles focused on four main themes: the contribution to increased emissions of greenhouse gases by the inappropriate use of land in forests and cropping areas; the increase in farmland in tropical forests with increased CO₂ emissions because of land clearance and that have no direct relation with the increase of food production; the existence of synergistic opportunities to increase food production and mitigate climate change from the diversification of agricultural production on land already prepared, carbon restoration in the soil; the synergistic opportunities to increase production and mitigate climate change.

The increase in arable lands has diminished the forests in tropical regions with deforestation techniques that contribute to the increase in CO₂ emissions in the atmosphere. On the other hand, the deforesting techniques used and the lack of knowledge in intensive farming techniques do not result in a sufficient increase in food production on a global scale.

Thus, the article concludes that in this regard, one must try to take advantage of already occupied lands and of intensive agricultural production management techniques. DeFries and Rosenzweig (2010, p.19627) remember that:

Whereas reducing deforestation caused by agricultural expansion is a focus for climate mitigation in the tropics, agricultural intensification (increased output per area) is the primary focus for increasing food production. Seventy percent of the increase in crop production in developing countries over the last four decades has occurred through intensification from highyield seed varieties, synthetic fertilizer and other chemical inputs, irrigation, mechanization, multiple cropping, and shorter fallow periods.

The article presents a synergistic opportunity to increase food production and mitigate climate change with the shift from agricultural production to already cleaned areas.

The four themes that emerge from the article reinforce the need for an integrated and comprehensive proposal for land use in tropical areas. The increased investment for intensive agriculture in tropical areas already occupied in order to contribute to the future demand for food should be the platform that can equate the trade-off between climate change and food insecurity. Allied to this strategic platform, it is proposed the creation and implementation of appropriate policies on a local, national and global scale to ensure the adoption of synergistic action in this context of competition between food production and climate change.

Data analysis

The thirteenth step of this study is the presentation and analysis of data from 25 pre-selected articles and the value of which corresponds to the three databases used, namely: Scopus; Web of Science e Science Direct.

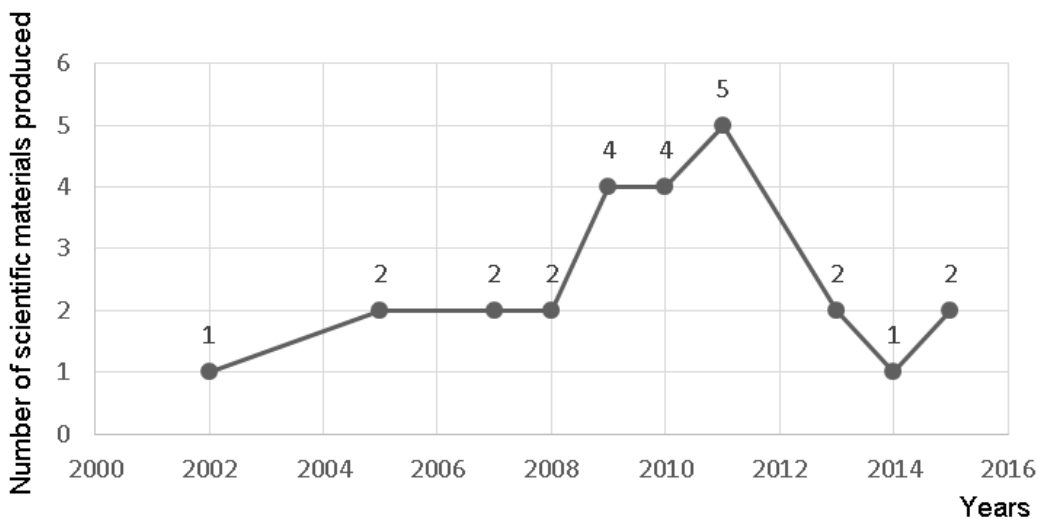


Figure 2. Number of yearly publications between 2000-2015. Source: elaborated by the authors, 2015.

According to the researched and exposed data in Figure 2 above, it is possible to observe that year 2002, when compared to the others, had the lowest number of publications found with the keywords applied in this study. It is noteworthy that 2011 yielded the highest number of publications, totaling five articles. However, this index decreased again in 2014. It should be noted that the year 2015 has only two published articles, considering that the searches were applied to the period from June of the same year. This implies that later this period may be new changes in the data.

From the 25 publications that remained after the filters were applied, the number of countries that have made publications on the subject remained small. The greatest interest on this research line are from the United Kingdom and the United States of America, as shown in the following table.

Table 9 - Number of published papers and scientific material by countries from 2000 to 2015. Source: Elaborated by authors, 2015.

| Country | Number of Papers Published | % |
|----------------|----------------------------|------|
| United Kingdom | 9 | 36% |
| USA | 9 | 36% |
| Netherlands | 6 | 24% |
| Germany | 1 | 4% |
| Total | 25 | 100% |

An observation has also been made to the journals with the highest number of publications on the question addressed in this study, and the journal "Proceedings of the National Academy of Sciences of the United States" stands out with 20% of 25 selected publications, besides the fact it obtained the higher percentage of impact factor.

Table 10 - Numbers and percentages of three most cited papers published in journals. The countries and impact factor of each journal. Source: Elaborated by authors, 2015.

| Journal | Number | % | Journal Country | Impact Factor |
|---|--------|--------|-----------------|---------------|
| Proceedings Of The National Academy Of Sciences Of The United States Of America | 5 | 20.00% | USA | 9,674 |
| Philosophical Transactions of the Royal Society B: Biological Sciences | 2 | 8.00% | United Kingdom | 7,055 |
| Science | 2 | 8.00% | USA | 6,280 |
| Agriculture, Ecosystems and Environment | 2 | 8.00% | Netherlands | 3,402 |
| Mitigation and Adaptation Strategies for Global Change | 2 | 8.00% | Netherlands | 2,669 |
| Food Policy | 2 | 8.00% | United Kingdom | 1,799 |
| Conservation Letters | 1 | 4.00% | USA | 7,241 |

| | | | | |
|--------------------------------------|----|---------|----------------|-------|
| Proceedings Of The Nutrition Society | 1 | 4.00% | United Kingdom | 5,273 |
| Global Environmental Change | 1 | 4.00% | United Kingdom | 5,089 |
| Climatic change | 1 | 4.00% | Netherlands | 3,430 |
| Journal of Environmental Psychology | 1 | 4.00% | United Kingdom | 2,640 |
| Climate Research | 1 | 4.00% | Germany | 2,496 |
| Natural Resources Forum | 1 | 4.00% | United Kingdom | 1,146 |
| Euro Choices | 1 | 4.00% | United Kingdom | N/A |
| Global Food Security | 1 | 4.00% | Netherlands | N/A |
| Worldwatch Paper | 1 | 4.00% | USA | N/A |
| Total | 25 | 100.00% | | |

For a detailed analysis, it was observed how often keywords, along with their idiomatic translations, appeared in the 25 selected articles. In relation to this aspect, the findings showed that "Climate Change" stood out with 37 appearances.

Table 11 – Number of keywords found in the 25 articles analyzed

| Keywords | Number |
|----------------|--------|
| Climate change | 37 |
| Agriculture | 26 |
| Soil | 16 |
| Mitigation | 13 |
| Food | 8 |
| Total | 100 |

Conclusion

Food security, climate change and agriculture are intrinsically connected and interdependent areas. The understanding of these interconnected fields depends on the balance between international relations and the worldwide struggle against starvation. Climate change, caused by greenhouse gas emissions increases global average temperatures, which influences the food availability scenario around the globe.

This study aims at analyzing the contributions of the scientific community to understand the issue of food security in the context of mitigation strategies of climate changes. The most relevant scientific publications

were studied in the period between 2000 and 2015, through a systematic literature review and a quantitative meta-analysis - bibliometric method.

The methodology used in the research, involved the study of scientific publications from three databases chosen for their relevance to other studies on academic performance, as Scopus, with over 21 million titles, Web of Science (WoS), with approximately 2,6 million publications and Science Direct with over 13 million publications.

Through the keywords Food Security, Mitigation, Climate Change and Agriculture, individual searches and their combinations were conducted in order to identify the most relevant articles within the subject under study. The combination with the highest number of publications was Food Security and Agriculture, especially in the Science Direct database. The Mitigation and Climate Change combination was underscored, with balanced numbers of publications in the three databases. At the end of this methodological step, the combination of the four keywords was executed, as this combination responds more precisely to the guiding research question previously exposed.

Then, temporal order filters were applied to the databases, cutting the scientific publications of the last 15 years (2000-2015) by subareas of interest within the subject being studied in the databases. Also with regard to the types of publications found, such as articles, conference papers, chapters of books, books, printed articles, and others. Finally, after the selection of 56 publications, another filter was applied to select the 10 most relevant publications of each searched database, obtaining a total of 25 articles that were systematically analyzed by the authors. These articles, according to the bibliometric study methodology, represent the most relevant research carried through over the past 15 years by the international scientific community within the subject.

The period between the years 2009 to 2011 was the most productive, with four publications per year. The article with the highest number of citations (1,206 times), Prioritizing Climate Change Adaptation Needs for Food Security in 2030, Lobell et.al., 2008, urged the scientific community to study the theme of Food Security in the context of Climate Changes. This is considered a key publication in the area of study.

The journal with the highest number of publications on the subject addressed in this study was the Proceedings of The National Academy of Sciences of the United States, with 20% of the analyzed publications. Countries that had excelled in delivering results in scientific journals were the United Kingdom and the United States, followed by the Netherlands and Germany.

According to the results of the systematic analysis of 25 articles obtained from the bibliometric study methodology, a top priority that was defined was the implementation of effective policies to mitigate the impacts on the environment caused by entropic action.

Policies should create a global awareness concerning the problem of Food Security and Climate Change, in order to ensure the adoption of synergistic actions. Furthermore, these policies should involve the participation of governments, the productive sector, the scientific community and development organizations worldwide in order to meet human needs for food in the coming years.

Moreover, the implementation of actions driven by food security policies and climate change mitigation requires investment in sectors such as science and technology. Altogether with this sectors, improvements in efficiency in agricultural production in deforested areas can be generated, contributing to the future demand for food; investment in professional training; curriculum reform in the universities, and investments to adapt agriculture to equate the trade-off between climate change and food insecurity.

To adapt agriculture to a future scenario of food insecurity is necessary: proper management of the land, of food production systems, genetic manipulation to make more resistant crops and the use new species of plants, as well as new techniques of tillage and management.

The change in the diet of individuals, favoring the consumption of foods with less meat, should contribute to the reduction of methane (CH₄) and help fix carbon (C) in the soil. One of the biggest challenges of food production due to climate changes is the inclusion of appropriate adaptation and mitigation solutions through the integration of insights from physics, biophysics and social sciences.

The scientific community must be mobilized and study in depth the issues of climate change and mitigation to face a future of food insecurity in the world. The development of more accurate models of prediction and assessment of future scenarios in food production is urgent for climate science - especially when climate is a vital resource for agriculture and innovation. For that reason, the development of more intensive agriculture is necessary, aiming at minimizing changes in land use due to deforestation and burning.

Therefore, it is concluded that it is necessary to create a global awareness on the part of governments, the productive sector, decision makers and the scientific community altogether to prioritize efforts to overcome the issue of food insecurity in the world due to climate change.

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