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Global Food Security: An Agricultural Perspective

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Abstract: Food security has always been very crucial issue to human civilizations through the ages. In the last decades there is a growing concern about the impacts of economic development/crisis and population growth on global food security and food production. The objective of this review was to systematically summarize the food security definitions, global food security concept and finally to highlight the role that agriculture has to play not only in feeding the world but also in sustainability and ecosystem services at global scale. To identify articles relevant to our topic we searched three scientific databases -Pub Med, Scopus and Science Direct- for English-language publications from January 2000 to April 2013. A review of the literature identified 1945 articles, but after screening by titles, abstracts and full papers, only 35 papers were selected. These papers identified a wide range of factors associated with food security and agriculture. It is a great challenge to feed nine billion people in the world and this challenge requires changes not only in agriculture production but also in global food security agenda for the next decades.
Keywords: Food security, agriculture sustainability, agriculture, nutrition

1. Introduction

Food security and the role of food in health security and in human security has always been very crucial issue to human civilizations through the ages (Andersen 2009, Wahlqvist 2009). In the last decades there is a growing concern about the impacts of economic development and population growth on global food security and food production. The growth of population size to nine billion people in the middle of the century means more demand for food production. And more food production means that mankind must change the use of land, water and soil resources (Godfray et al. 2010b; Schneider et al. 2011).

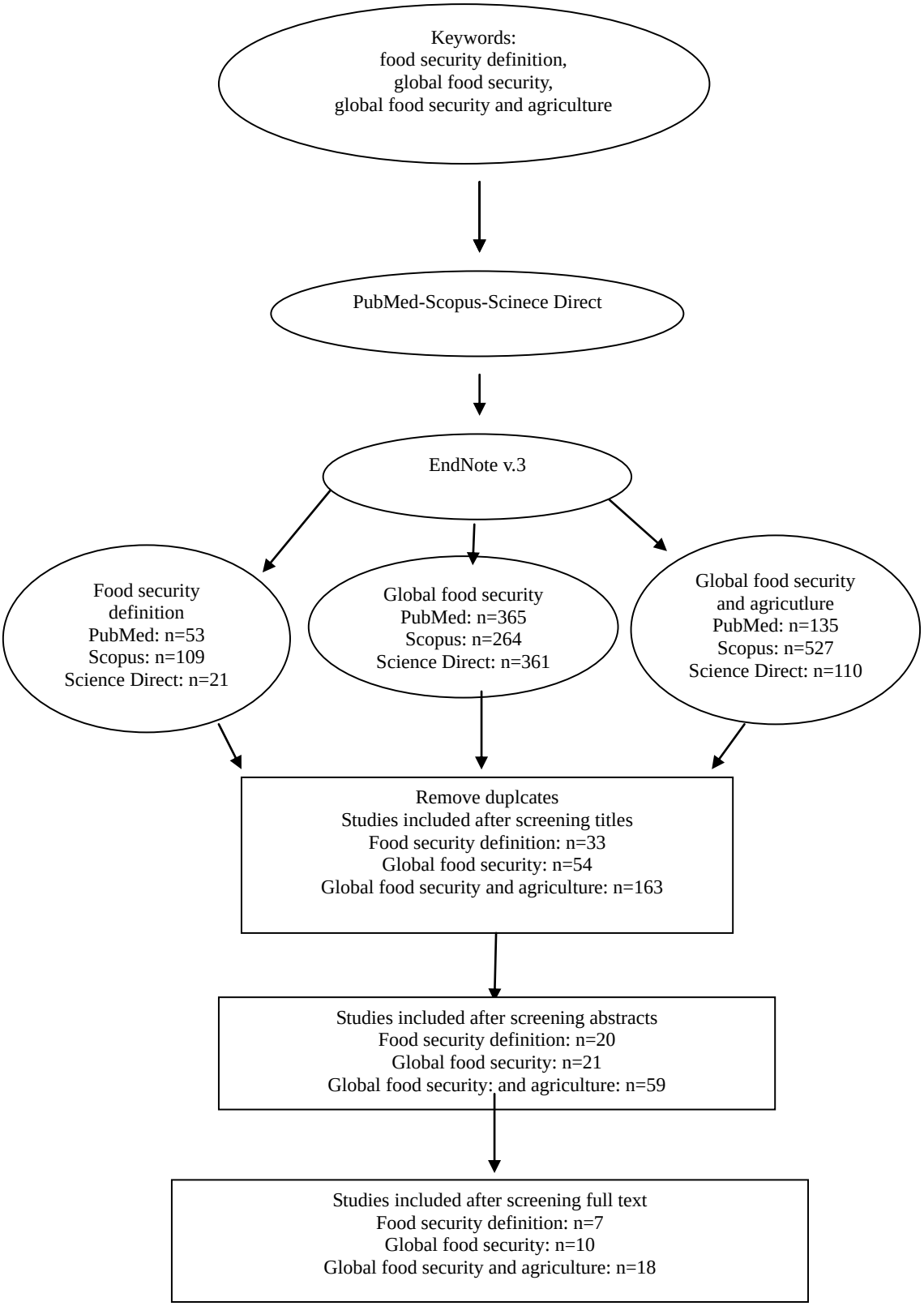
It is a great challenge to feed nine billion people in the world and this challenge requires changes in agriculture production in terms of high yields, adaptation of cropping systems to climate change, genetic improvement of plant varieties, pest management and new farm practices. This challenge not only disclose the role of agriculture, but also more specific areas as landscape management, biodiversity issues and food waste which their impacts are vital and play a key to new food security policies (Abumhadi et al. 2012). Moreover, changing lifestyles and diets in developing countries have changed the demand for meat and dairy products (Godfray et al. 2010a). Almost one-third of global cereal production is fed to animals (FAO 2006) and that has led to a ~1.5-fold increase in the numbers of cattle, sheep, and goats, with equivalent increases of ~2.5- and ~4.5-fold for pigs and chickens, respectively (FAOSTAT 2009). It is obvious that demand for more and more food will increase the competition for land, making food security and access to adequate and safe food one of the main topics in public agenda (Erkan 2012).

In this review we report current thinking to food security definitions, global food security concept and finally we highlight the role that agriculture has to play not only in feeding the world but also in sustainability and ecosystem services at global scale.

2. Methods - Literature strategy, eligibility criteria and data collection

To identify articles relevant to our topic we searched three scientific databases -Pub Med, Scopus and Science Direct -for English- language publications from January 2000 to April 2013. The following search terms were used: “food security definition, global food security, global food security and agriculture.” The type of articles that were retrieved was full-text articles, reviews and editorials. Articles were excluded when we didn't have access to them or when they were related to climate change or case studies to specific countries or regions since they addressed a different outlook of global food security and agriculture, which was beyond the scope of this review. (Figure 1)

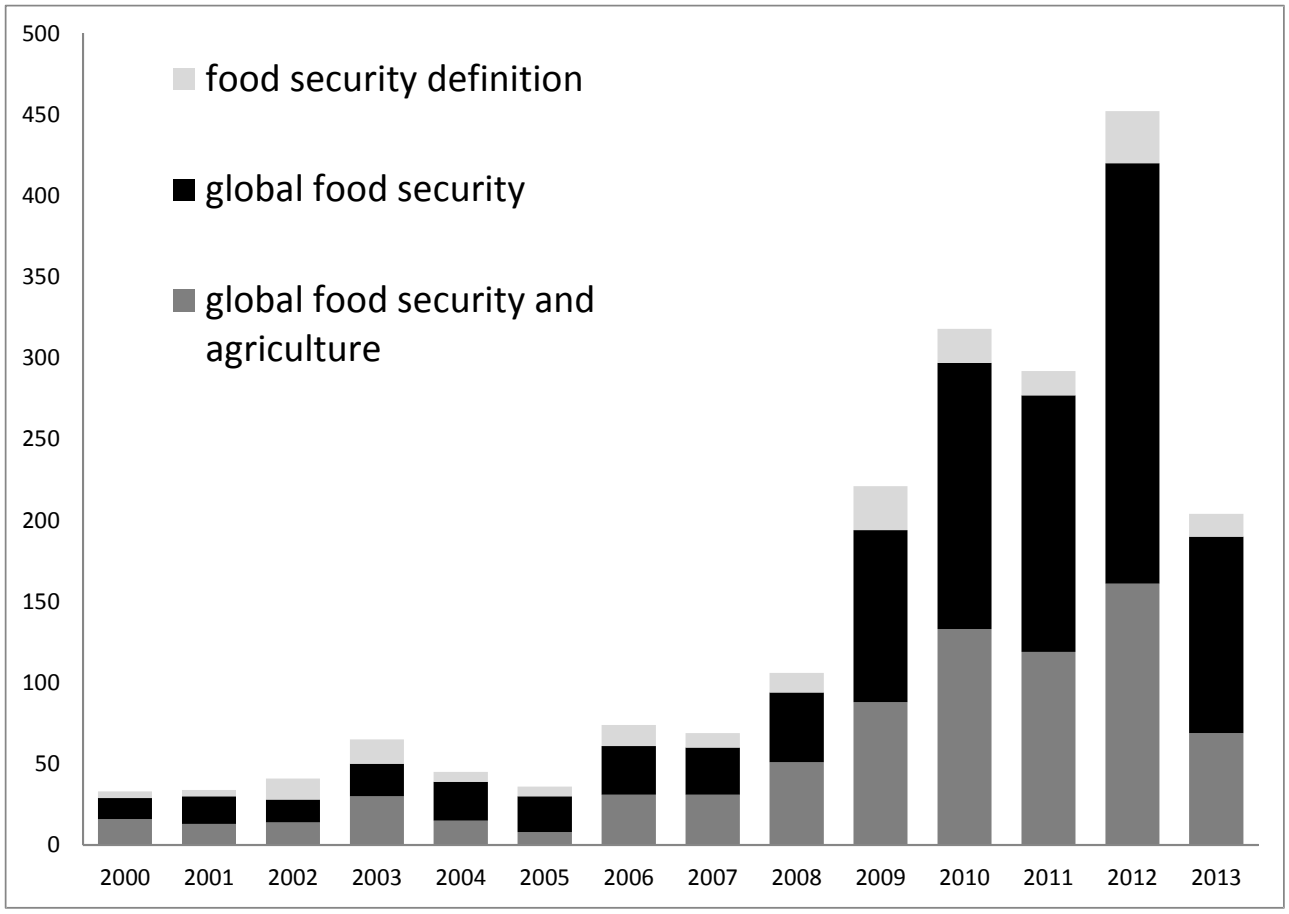
Fig 1. Flow diagram of study selection process in this review. 'n' represents the number of records identified through PubMed, Scopus and Science Direct searching



3. Results and Discussion

All articles were extracted into a bibliographic citation management software, EndNote library v.3, (Thomson Reuters. EndNote v.3, 2009), duplicates were discarded and exclusion criteria were applied by screening titles, abstracts and full papers. The search identified 1945 articles but after screening by title *n= 250,* abstract *n= 100,* full text *n= 35* (Figure 2).

Fig 2 Number of articles in 3 databases by year (2013 contains Jan-Apr)



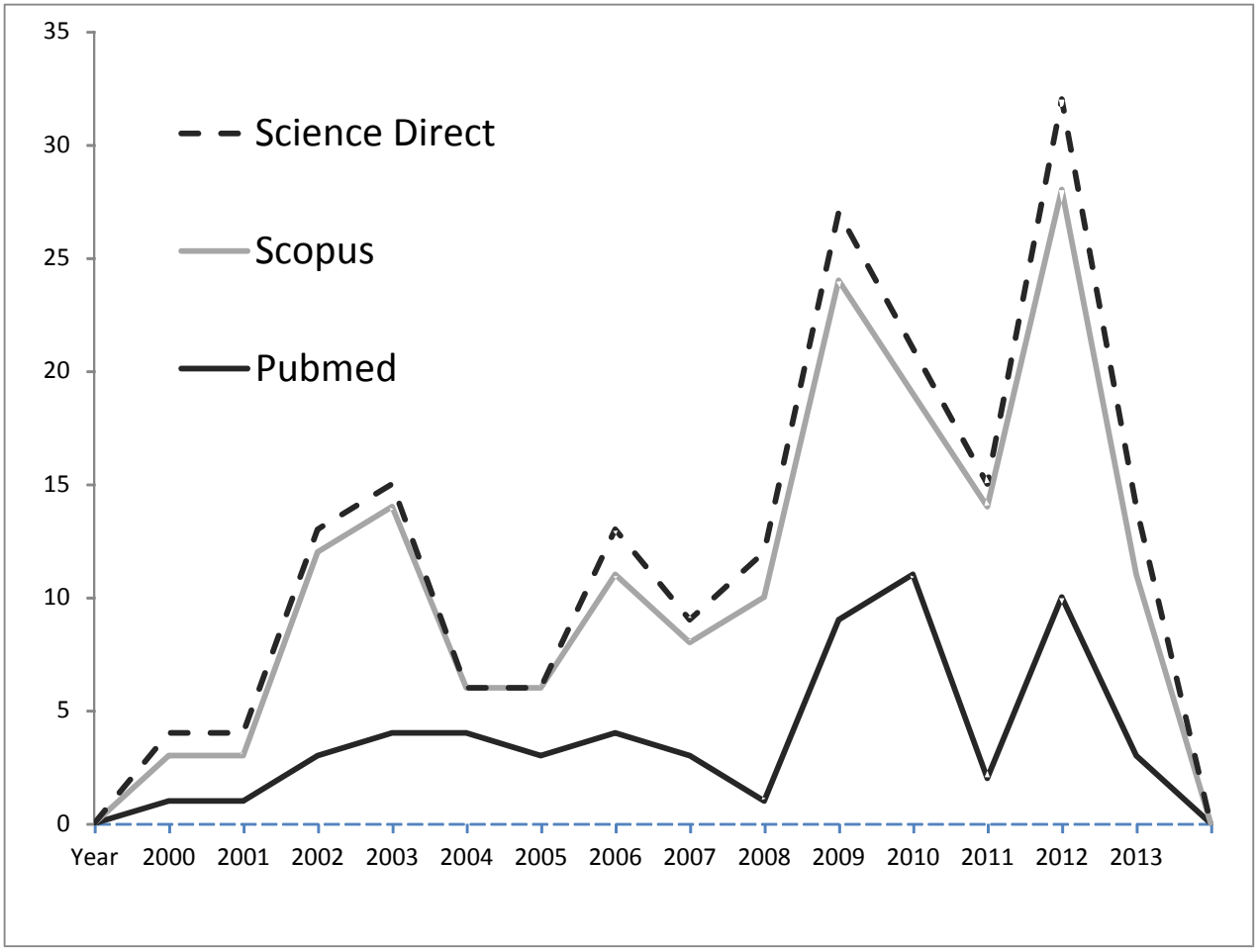
3.1 Food security definition

Seven articles were evaluated for food security definition. Five were research articles and two reviews. Figure 3 illustrates the upward trend in the number of articles that included the term "food security definition" from 2000 to 2013 (until April) and the lines show the steady increase of the records that appeared as search results for food security definition at each database.

There are several definitions for food security that changed over time in the last 40 years. 191 articles were retrieved from the databases. After screening by title we include 33, by abstract 20 and finally we choose seven articles.

The first definition was given in 1974 by World Food Summit as: "availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (UN 1975). This definition focuses on the availability of food and reflects the problems of food production and supplies of the world food crisis in the mid-1970s (Hadley and Crooks 2012). This crisis was the result of supply–side factors and led to new policies focusing on stable global food supply. The same authors state that a number of institutions as the World Food Program (WFP), the Consultative Group on International Agricultural Research (CGIAR), the International Fund for Agricultural Development (IFAD), and the Global Information and Early Warning Systems (GIEWS) developed to monitor world food situation (Hadley and Crooks 2012).

Fig 3 Search results (No of articles) in 3 databases for food security definition by year (2013 contains Jan-Apr).



But food availability does not necessary provide access to food to all people. The issue of access and the issue of supply were emerged and in the next decade FAO expanded the definition in 1983 with the sentence "Ensuring that all people at all times have both physical and economic access to the basic food that they need" (FAO 1983). From 1983 to 1996 there were more than 194 different definitions of food security (Renzaho and Mellor 2010) but in 1996 the Word Food Summit revised the definition of food security by adding two more dimensions, food safety and

access to the food preferred (FAO 1996).

With the phrase "safe and nutrition" and "food preference", which are both included in the latter definition, Word Food Summit highlighted the issue of composition and access to enough food and pinpointed some other factors which appeared like utilization and stability which started to incorporate to food security definitions in the decade of 1990s and revealed the other side of the same coin, food insecurity (Hadley and Crooks 2012, Andersen 2009). Furthermore, it was more obvious by the definition of food security by the World Food Summit "'Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996) that it was the time to interconnect food security with public health, especially since the global agenda of food security would be reestablished in the next decade (Dowler et al. 2011, p. 405-406, Wahlqvist 2009).

From 2000 to 2013 (until April) the concept of food security includes political, economical and social characteristics (Touzard and Templez 2012). Although food security has the same impacts on people in both developing and developed countries, different social and political factors influence the availability, stability, utilization and access to food (Hadley and Crooks 2012, pp. 73-74; FAO 2006). Moreover, the concept of food security remained complex and multidimensional and new factors like food price spikes, energy crops, financial crisis were debated whether they reflect changes to food security understanding and measurement or not (Renzaho and Mellor 2010, p.1).

Finally, the most common used definitions of food security are: "'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." and "access by all people at all times to enough food for an active, healthy life and includes at a minimum: a) the ready availability of nutritionally adequate and safe foods, and b) the assured ability to acquire acceptable foods in socially acceptable ways (e.g., without resorting to emergency food supplies, scavenging, stealing, and other coping strategies)" (Vink

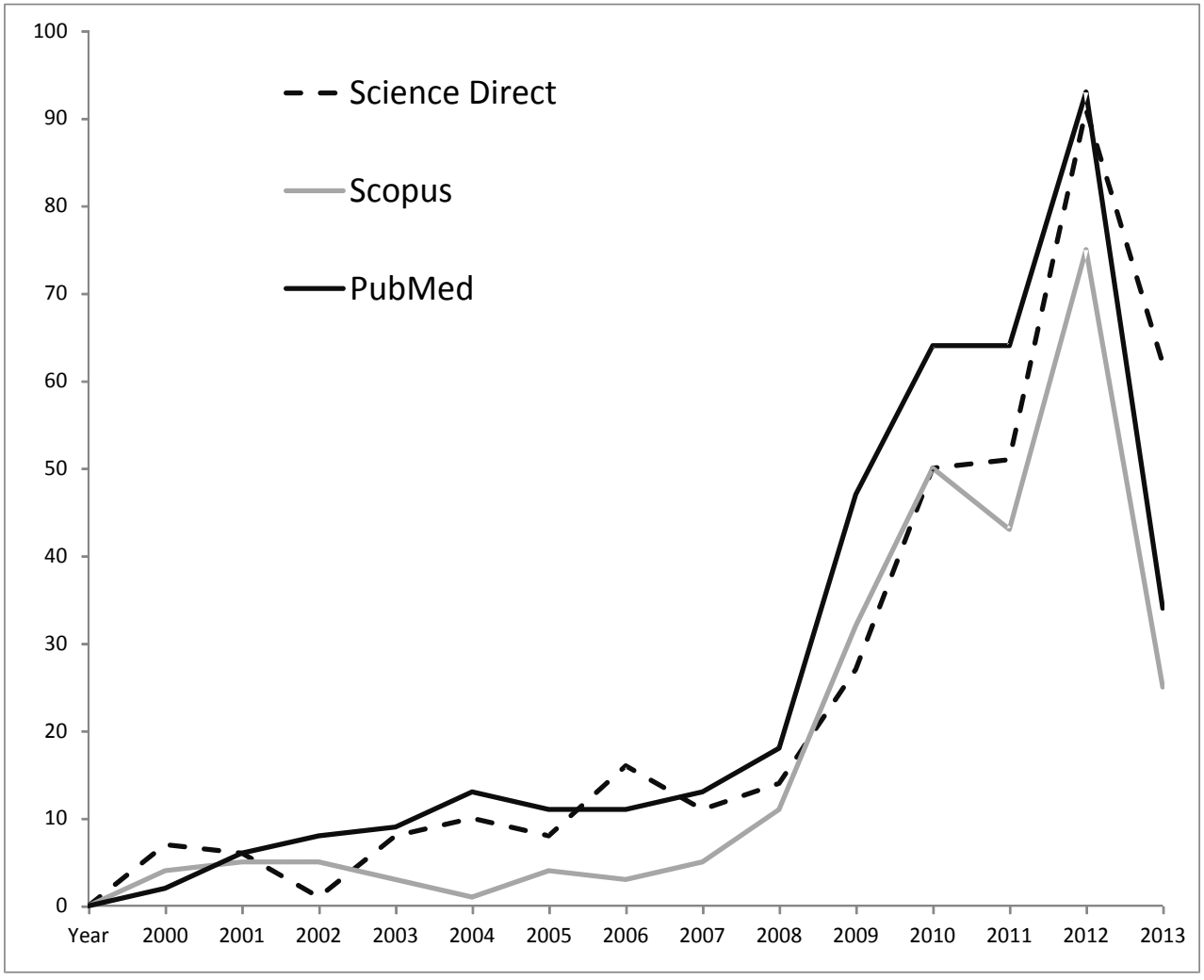
2012, p. 158; Renzaho and Mellor 2010, p. 3).

3.2 Global food security

10 articles were selected to explore the global view of food security concept. Six were research articles, two editorials and two reviews. Figure 4 presents again the upward trend in the numbers of articles that included the term and the lines show the suddenly increase of the number of records for global food security in the last 13 years. It is noticeable that even in 2013 which actually includes only four months there are published more articles with that term that in 2008.

All of the authors have the same starting point about global food security. That despite the fact that global food production is ahead of global demand; almost one billion people are underfed (Charles et al. 2010). Furthermore, population growth, global environmental change, new policies about the reduce in food waste in developed and developing countries and other socio-economic issues may bring multiple changes to global food security status. Growing competition for land, water, and energy, in addition to the overexploitation of Earth's natural resources, will affect our ability to produce food according to Charles et al. (2010).

Fig 4 Search results (No of articles) in 3 databases for global food security by year (2013 contains Jan-Apr).



Food security is a complex issue with different environmental, political and economical determinants. Although Ingram (2011) in his article analyzes some examples of how food systems approaches interact with food security and global environmental change, he highlights that more production of food will not satisfy the society's needs. Access to food, afford-ability foodstuffs and other food system activities like producing, storing, processing and packaging, are also very important

issues (Ingram 2011, p. 428).

The impact of globalization on food production and availability is discussed by two researchers. McMichel (2001, pp. 216-217) criticizes the change of social diets in north hemisphere and the increase of meat consumption and animals protein. He emphasizes the 'global epidemic of malnutrition', in which the one billion underfed are matched by the one billion overfed and finally he point out that globalization of food markets it may not give the solutions to malnutrition (McMichel 2001, p. 217). The other author tried to give an holistic approach of global food security in the future. Crucial factors like trends in population size, global foods demands, urbanization and globalization, food prices and future investments in agricultural research are reviewed (Godfray et al. 2010b). Godfray et al. (2010b, p. 2776) stress that food security status requires a multi-disciplinary approach involving the social sciences and economics to reduce the risks of rise hunger.

Four research articles, one editorial and three research articles focus on the interactions of global environmental change and food security. The impact of climate change on agriculture production or the impact on land use is only one aspect of global environmental change and food security (Ericksen 2009, pp. 373-374). For example, drought in Australia continent, growing demand for meat in Asia, bio-fuel policy in U.S.A., in Latin America and in Europe and speculation on global food commodities underline the complex and composite nature of global food security (Ericksen 2009, pp. 373-374). Biodiversity loss, water extraction and greenhouse gas emissions are major environmental impacts in all stages of food production, distribution, retailing and processing (Garnett 2013). Additionally, climate change will affect all four factors of food security (food access, availability, stability of food supply and food utilization), yet the seriousness will differ across regions and will depend on the overall socio-economic status that a country has accomplished as the effects of climate change set in and inevitably will affect global food security (Schmidhuber and Tubiello 2007, p. 19708)

Many environmental stresses had direct and indirect impacts on food

production systems and these stresses may produce conflicts between global food security goals and sustainable environmental management (Ericksen et al. 2009). As Polly J. Ericksen (2008, p. 234) mentioned in his paper "global environmental change, in the context of social, political and economic changes, may bring unprecedented stresses to bear on food systems and food security".

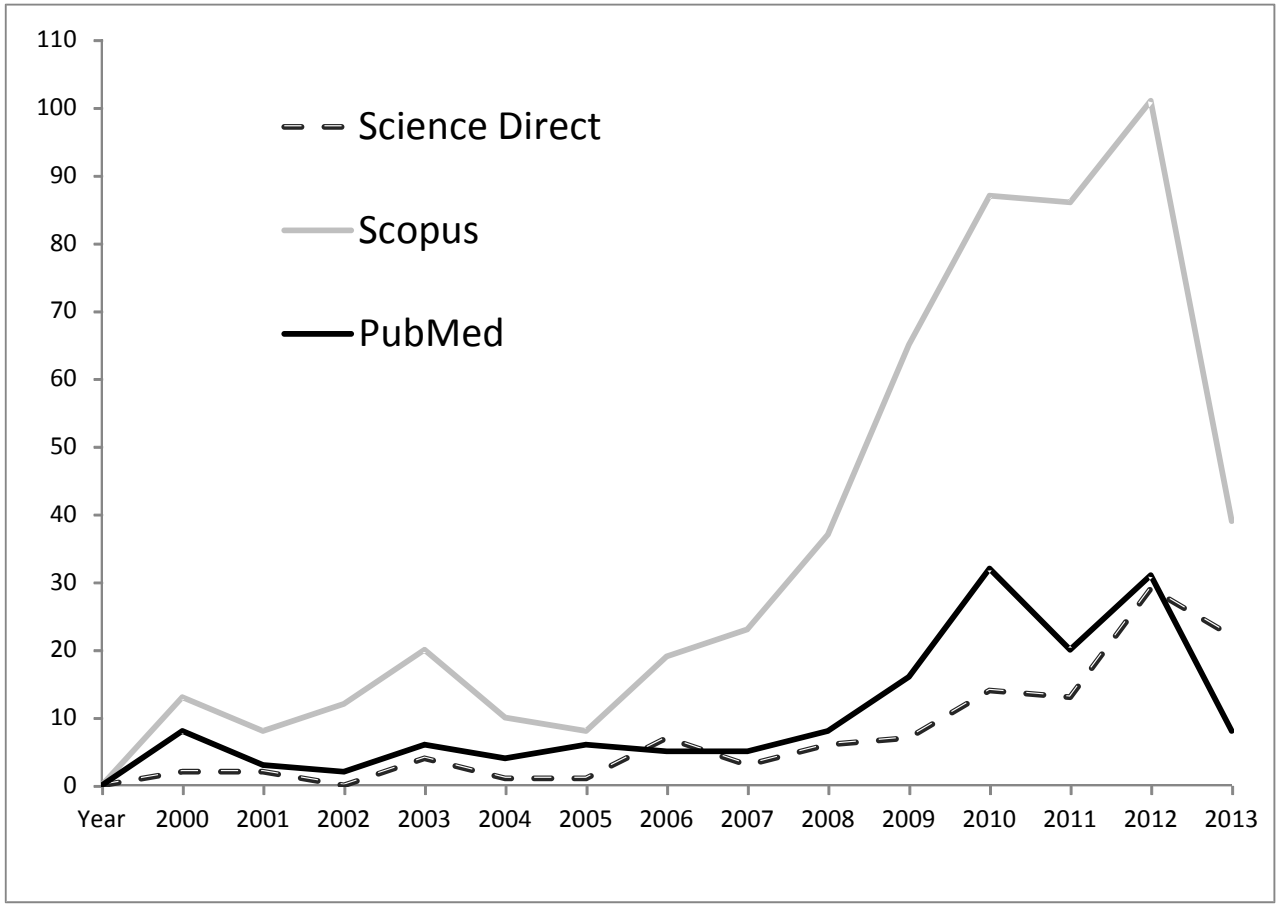
Finally, Cassman (2012) and Misselhorn et al. (2012) justify the need to act immediately to ensure food security to all people. High economic growth rates in developed countries, the decrease rate of crop yields in major cereal production areas, urbanization and competition between crops for food and energy (Cassman 2012), the use of frontier technologies in all sectors of food systems and limits in food access are key factors, among others, to create the global food security agenda for the next decades. (Cassman 2012; Misselhorn et al. 2012).

3.3 Global food security and agriculture

Figure 5 presents again the upward trend in the numbers of articles that included the term ”global food security and agriculture’ ’and the lines show the gradually increase of electronic records for global food security and agriculture in the last 13 years in each database, especially after the middle of the previous decade.

The role of agriculture in global food security is essential and multidimensional. We will focus on two main challenges that agriculture has to face in the next decades to guarantee global food security. The first is how research, biotechnology and innovation in agriculture productivity can ensure food security and the second is how agriculture can achieve food security at global scale, using natural resources in a sustainable way.

Fig 5 Search results (No of articles) in 3 databases for global food security and agriculture by year (2013 contains Jan-Apr).



I) Research, biotechnology and innovation

To ensure global food security new research approaches in agriculture productivity are needed to increase crop yields. Public investments are crucial to reinforce agricultural productivity via yield-increasing and environmentally friendly production technology and yet to focus on small farmers and poor people of developing countries (Andersen and Cohen 2000). Substantial, these investments and economical plans from the agricultural sector must be coherent and part of

overall national plans that are clearly spelt out in the budget for economic development, food security and poverty reduction in any country (Adenle 2011, p. 92). Parry and Hawkesford (2010) suggested that scientific developments in plant growth that focus on photosynthesis and an increase in water productivity can make the difference.

Ruanne and Sorino (2011, p. 359) stress the importance of agricultural biotechnology and the utilization of tools, for the diagnosis of plant diseases of both viral and bacterial origin, and immunodiagnostic techniques as well as DNA-based methods. The use of "omics" to achieve global food security is also discussed by Boggess et al. (2013). Genomics, proteomics and metabolomics will produce agriculture productivity in many ways. Among others, the discovery of new proteins and enzymes can enhance disease and pest resistance, reduce need for chemical control of weeds and pests and finally can reduce the need for fertilizers and supplemental nutrients (Boggess et al. 2013, p. 16).

Another two articles underline the role of agriculture biotechnology to raise crop yields. Innovation on plant genetics like transgenic crops, insect-resistance crops, herbicide-crops and viral-resistance crops are crucial factors to raise global yields with a responsible management of biotechnology for sustainable agriculture production (Abah et al. 2010; Ronald 2011).

Additionally, three more authors suggest that we can increase food availability and production by shifting crop production away from non-food applications like bioenergy crops (Foley et al. 2011, p. 340) and by recording and measuring pre- and post- harvest crop losses (Flood 2010, pp. 218-220). At last but not least, using pesticides by a more enlightened approach combining integrated pest management (biological pest control) with the use of the best scientific applications of biotechnology to build pest resistance into crops must be a priority to reduce food insecurity (Andersen 2002, p. 1208).

II) Sustainable and ecological agriculture

Eight articles were selected to discuss sustainable agriculture, food security and natural resource management. Ecological agriculture or agroecology can be defined as the utilization of ecological concepts and principles to the design, formulation and management of sustainable food systems. This definition is representative of a renovated approach to agriculture that aims at reconciling resource use and food production, in support of local, small-scale farming, while relying on modern ecological knowledge and theories to achieve sustainability in agriculture according to Borsari (2011).

Another four papers from the previous eight underline the "ecoagriculture approach". Eco-agriculture approaches may be relevant to some extent in all agricultural landscapes, in light of their focus on improving landscape performance vis-a´-vis three goals: agricultural production, biodiversity conservation and livelihoods (Scherr and McNeely 2008, p. 482). This approach assumes that biodiversity at the landscape level is pivotal to sustain both agricultural production and the provision of ecosystem services (Brussaard et al. 2010, p. 35). Furthermore this approach must target to achieve food security, sustainability and ecosystem services at regional and global scale on a costeffective way and guide the choice of crop species and cultivars to be grown in a target environments and regions (Spiertz 2012, p. 1, p. 7). The link between biodiversity, natural resources and hunger reduction requires well informed solutions and polices to provide the level and quality of ecosystem services necessary to support agriculture in the future (Hazell and Wood 2008, p. 513; Tscharntke et al. 2012, pp. 53-56).

Finally, two authors examine two different perspectives and relationships between food security, agriculture productivity and sustainability. Acevendo (2011, pp. 159-163) suggests that new research methods and new agricultural management and farming practices must be applied to increase water and food productivity. New monitor tools like GIS and remote sensing, biotechnological and precision agriculture technologies may contribute to increased productivity and properly linked with interdisciplinary models, will ultimately achieve sustainable

food production increases that maintain environmental quality and conservation (Acevendo 2011, p. 165).

Toledo A and Burlingam B (2006, p. 478) underline the correlation between food composition and analysis with biodiversity and nutrition. They claim that biodiversity management plays a significant role in the development of sustainable agricultural development practices and strategies against malnutrition and if nutrient analysis and data dissemination of the different food species and intra-species diversity is undertaken systematically, national information systems for food and agriculture can be strengthened and used to form the basis for priority setting and international policy-making (Toledo and Burlingam 2006, p. 478, p. 481).

4. Conclusions and Recommendations

In conclusion, this study features food security definitions, the global food security concept and the role that agriculture has to play in the next decades to guarantee global food security. Plant biotechnology and innovation systems in agricultural practices, sustainable agriculture productivity, social sustainability and finally the ecological use of natural resources must ensure food production in a sustainable way, ecosystems services and biodiversity (Beddington 2010). The challenge for the agricultural sector is no longer simply to maximize productivity and feed nine billion people until 2050 without significant increase in food prices but also to ensure food access, distribution and social justice to all people (Schneider et al. 2011, Pretty et al. 2012).

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The author declares that he has no conflict of interest.

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