Review n. 33 – ***Italus Hortus*** **24 (3), 2017:** 1-14 doi: 10.26353/j.itahort/2017.3.114

Agroecology as a challenge for the competitiveness of small scale agriculture

Cristiana Peano[1], Francesco Sottile[2*]
[1]Dipartiment of Agricultural, Forestry and Food Science of the University of Turin
[2]Dipartment of Architecture of the University of Palermo

Ricezione: 29 dicembre 2017; Accettazione: 26 febbraio 2018

L'agroecologia quale sfida per la competitivita' dei sistemi agricoli di piccola scala

Riassunto. L'agroecologia viene spesso presentata come un'alternativa agli attuali sistemi di produzione diffusi, sebbene ci siano molte domande sulla reale possibilità di una produzione alimentare sufficientemente elevata per una popolazione in crescita. L' analisi sviluppata in questo paper è basata sulla ricerca scientifica degli ultimi vent'anni e sulle l'attività delle ONG, dei movimenti degli agricoltori e delle organizzazioni governative di diversi contesti. L'obiettivo è quello di fornire un panorama dei principali argomenti in discussione per una transizione agroecologica dei sistemi alimentari mondiali, individuando alcune sfide prioritarie e immaginando chi saranno i partecipanti questo cambiamento. Data la complessità del tema, alcuni temi specifici non sono stati presi in considerazione (ad esempio valore nutrizionale degli alimenti, salute), invece ci siamo concentrati su quelle questioni trasversali che stanno infiammando il dibattito in contesti istituzionali e non istituzionali .

Parole chiave: agroecologia, sostenibilità, buone partiche, sistema alimentare.

Introduction

According to Gliessman (2007), agroecology is "the science of applying ecological concepts and principles to the design and management of sustainable food systems". For over thirty years, many authors (tab. 1) have further investigated these aspects, emphasizing that, however defined, the discipline proposes studies integrating ecology, sociology and economy.

The referenced definition represents an ecological coexistence of agriculture and biodiversity in the same territory, with the aim of improving agricultural systems by imitating and taking advantage of the ecosystem's natural processes (Altieri and Nicholls, 2012). In fact, within the agro-ecosystem that is being defined, beneficial biological interactions and synergies between the various components are generated in order to create and maintain a state of equilibrium, a capacity for self-regulation and the influence of biodiversity (De Schutter, 2010). Thus, its primary objective is to facilitate the interaction and productivity of the agricultural system as a whole instead of focusing on the productivity of individual crops (Silici, 2014). The resulting reduction of negative externalities is

Tab. 1 - Evolution of the definition of agroecology (Pimbert *et al.*, 2014).
Tab. 1 - Evoluzione della definizione di agroecologia (Pimbert et al*., 2014).*

Altieri, 1987	A discipline that defines, classifies and studies agricultural systems from an ecological and socio- economic perspective
Altieri, 1995	The application of ecological concepts and principles to the design and management of sustainable agroecosystems
Francis *et al.*,2003	The integrative study of the ecology of the entire food systems, encompassing ecological, economic and social dimensions
Dalgaard *et al.,* 2003	An integrative discipline that includes elements from agronomy, ecology, sociology and economics", "the study of the interactions between plants, animals, humans and the environment within agricultural systems
Wojtkowski *et al.,* 2004	The interactions among natural processes in artificial systems designed to meet human goals
Gliessman, 2007	The science of applying ecological concepts and principles to the design and management of sustainable food systems

* francesco.sottile@unipa.it

always closely connected and dependent on the context in which it operates, making it necessary to take into account the biophysical, social, cultural and economic aspects of the system.

Agroecology isn't recent, but it has become widespread during the last 20 years where it has assumed different uses and been described as a science, a set of practices and a social movement, especially where it has gained the most strength i.e. in small farms in developing countries (Wezel *et al.*, 2009).

Consulting the databases (Scopus, Web of science) that report on scientific research worldwide, it is interesting to note the evolution of the agroecology subject (fig. 1 e tab. 2).

Starting in 2010, the number of scientific articles investigating the "world" of agroecology has significantly increased and in 2017, considering that the database was consulted during the month of June, more than 200 articles were probably published.

Regarding the various disciplinary fields, it is interesting to note how the first 3 (Agricultural and Biological Sciences, Environmental Science, and Social Sciences) regard the actual application of ecology to agriculture, the environment and social sciences, showing how important the role of agroecology is as a movement. The research relative to social sciences includes considerations on political ecology, the equity of food systems, participatory processes, the empowerment of women, food sovereignty and rural development.

Furthermore, even though the scientific research is produced by many Authors from non-American universities and government research entities, it often refers to studies developed and carried out in Latin America, Asia and Africa, confirming how family and subsistence agriculture are the first to adhere to and profit from agroecologic methods. The graphic representation created by Wezel and Soldat in 2009 in an article titled A quantitative and qualitative historical analysis of the scientific discipline of agroecology appearing in the International Journal of Agricultural Sustainability is particularly interesting in this regard. Figure 2 shows the shift of attention on different scales and dimensions in the last 80 years. That is, scientific publications have gone from analysing the situations of single parcels to those of an entire agricultural business, to finally an entire region (agroecosystem) in the last 20 years. Today, the definitions of agroecol-

Tab. 2 - Number of articles published during the last 20 years, divided by discipline

Tab. 2 - Numero di articoli pubblicati negli ultimi 20 anni suddivisi per disciplina scientifica.

Agricultural and Biological Sciences	1312
Environmental Science	770
Social Sciences	653
Earth and Planetary Science	346
Energy	156
Biochemistry, Genetics and Molecular Biology	97
Economics, Econometrics and Finance	91
Medicine	63
Arts and Humanities	62
Engineering	51
Business, Management and Accounting	41
Immunology and Microbiology	41
Computer Science	28
Veterinary Science	26
Decision Sciences	24
Multidisciplinary	24
Chemical Engineering	8
Chemistry	8

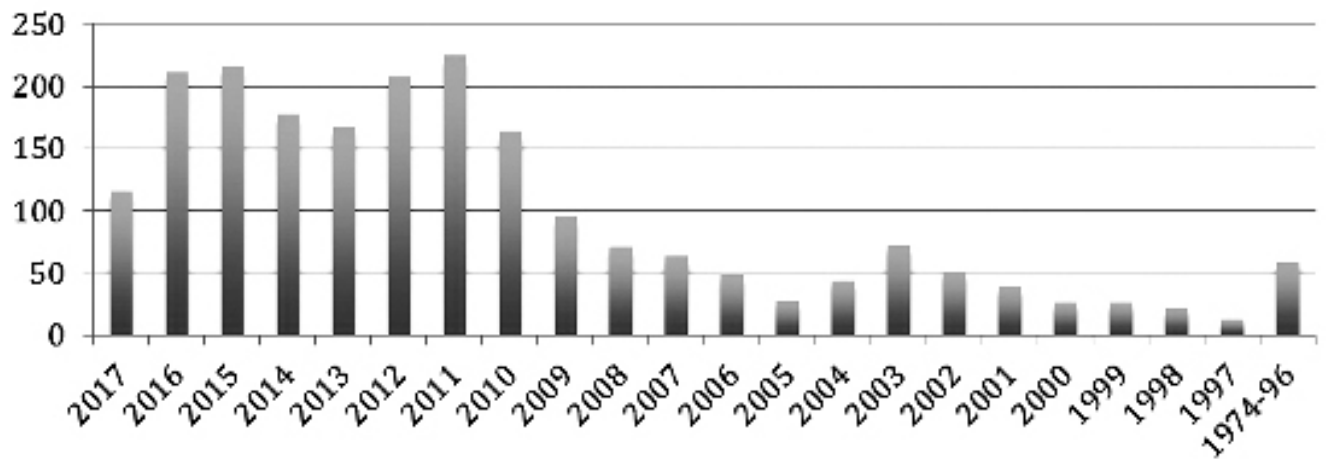

Fig. 1 - Number of articles on agroecology published during the last 40 years.

Fig. 1- Numero di articoli sull'agroecologia pubblicati negli ultimi 40 anni.

ogy given by Francis *et al.* (2003) and Gliessman (2007) from which we began, go beyond this, leaving the concrete spatial scale and entering into the dimension of the food system as a whole. This new "dimension" includes local, regional, national and global geographic scales, as well as food production systems, the society, economy and politics, that can't be directly attributed to a specific scale but that are connected and interwoven in different ways.

In the present report, we will examine the responses of agroecology to some critical issues that have strongly emerged in the current study of global food systems.

In fact, a fervent debate has begun on the subject of sustainable agriculture and on the mitigation of the negative impacts that the food system has on the environment.

If, on one hand, organic agriculture and/or sustainable intensification are often indicated as possible solutions, there are farmers' movements, NGOs and even part of the private sector that view this solution sceptically because concentrates too much on production and intensification, without taking regional issues into account.

Agroecology, organic agriculture and sustainable intensification

There are many kinds of alternative agriculture (biodynamic, organic, permaculture, natural etc.) all aimed at reducing dependence on synthetic chemical pesticides, fertilizers and antibiotics, reducing production costs and diminishing the impact of agriculture on the environment. One of these systems is organic agriculture, which is currently practiced in almost all of the countries in the world, over an area of about 30 million certified hectares (Altieri *et al.*, 2017).

Even though organic agriculture is based on the application of a set of good practices (rotations, cover-crops, biological control…), today many organic farmers pushed by market forces use a set of organic, low-energy impact "technology packages" that are really a mere substitution of synthetic and organic inputs (Rosset and Altieri, 1997). Furthermore, many of the practices currently promoted as sustainable regard making input use more sustainable through the integrated management of parasites and soil fertility but leave the monoculture system intact and don't promote a productive redesign of agricultural systems. What's more, many of the inputs used in organic agriculture are purchased, leaving farmers still dependent on external providers (Guthman, 2014).

Recently, the FAO together with other international organizations (CGIAR) have taken the path of considering Sustainable Intensification as an option where the principals of agroecology can be integrated with other approaches, including transgenic crops, conservation agriculture, fertilizer micro-dosing, and integrated pest and weed management.

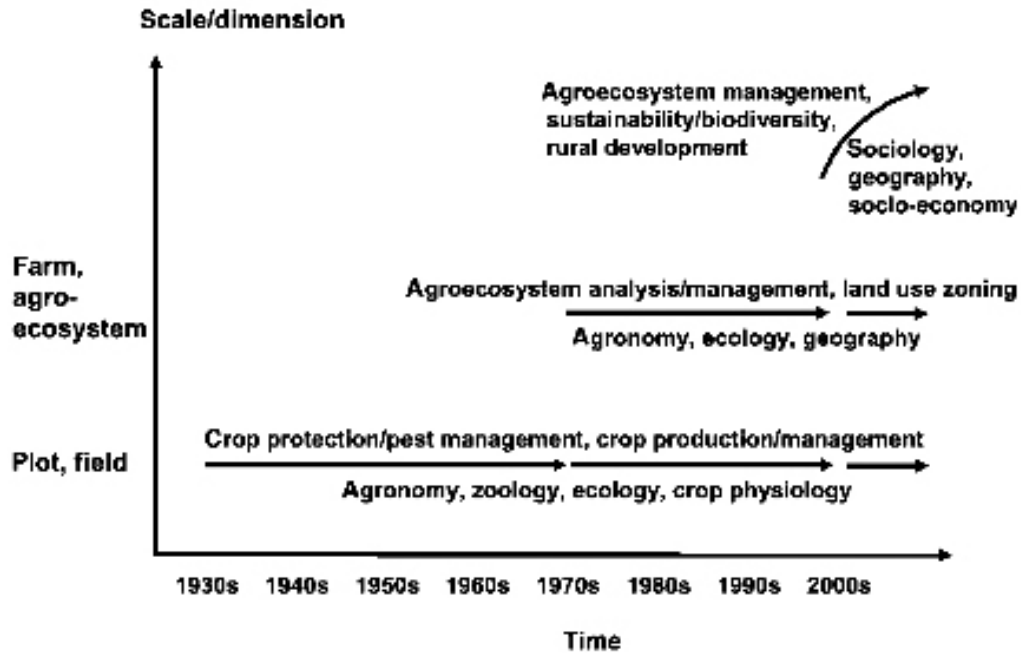

Fig. 2 - The temporal changes in the scale and dimensions of agroecology, as well as the principal arguments and the foundational disciplines applied to practical research (from Wezel and Soldat,2009).

Fig. 2 - La variazione in scala e dimensioni dell'agroecologia e i principali argomenti e le discipline fondative applicate alla ricerca applicata.

This vision makes the term agroecology insignificant, a concept without meaning, stripping it of its political and social content; Agroecology must not be combined with other approaches! (Altieri *et al.*, 2017).

In this context, agroecology is often presented as an alternative, although there are many questions about the real possibility of sufficiently increasing food production for a growing population.

Therefore, some priority issues were identified and an attempt was made to answer the most pressing questions, for example: is it possible to apply agroecology to medium-large agribusinesses? Is it possible to produce in sufficient quantities? Does the agroecological system have an impact on welfare issues? Is agroecology a real response to climate change? What is the role of the consumer and the markets in this transition?

This analysis, based on the scientific research of the last twenty years, but also in relation to the activity of NGOs, farmers' movements and government organizations of various backgrounds and contexts, aims to provide a panorama of the principal subjects in discussion for an agroecological transition of the world's food systems, identifying some priority challenges and imagining who the participants will be in this change.

Given the complexity of the subject, some specific themes weren't taken into consideration (e.g. farming practices, nutritional value of food items, health), instead we focused on those transversal issues that are currently inflaming the debate in institutional and non-institutional settings.

However, considering the increasing number of publications and participants who are interested in the subject, this analysis can't carry out a thorough study of the relevant literature and can only provide an overview of some of the issues currently being discussed.

In fact, in this context, the analysis is based on an evaluation of the agroecology transition to design and/or redesign resilient and biodiverse agricultural systems that are efficient from an energy standpoint, able to preserve natural resources (Altieri *et al.*, 2017):

- Enhance the recycling of biomass, with a view to optimizing organic matter decomposition and nutrient cycling over time.
- Strengthen the "immune system" of agricultural systems through the enhancement of functional biodiversity—natural enemies, antagonists, etc., by creating appropriate habitats.
- Provide the most favourable soil conditions for plant growth, particularly by managing organic matter and by enhancing soil biological activity.
- Minimize losses of energy, water, nutrients and genetic resources by enhancing the conservation and regeneration of soil and water resources and agrobiodiversity.
- Diversify species and genetic resources in the agroecosystem over time and space at the field and landscape level.
- Enhance beneficial biological interactions and synergies between the components of agrobiodiversity, thereby promoting key ecological processes and services.

The challenges

The farm size

The characteristic that emerges in an important way from all of the experiences around the world is agroecology's bottom-up approach and the integration of knowledge from different sectors (local, traditional as well as knowledge from the environmental and social sciences) promoted by a horizontal diffusion based on the sharing of experiences (Gliessman 2015). Agroecology research principally concentrates on highly diversified small farms. In this regard, it should be noted that small growers make an important contribution to global food production with 50% of the global agricultural production for domestic use, which rises to 80% in Asian and Sub-Saharan countries (FAO, 2012 and FAO, 2015, Altieri and Nicholls, 2012). In these contexts, agroecology involves positive interventions in the means of family subsistence thanks to reduced costs (minimizing production costs), increased returns, improving nutrition and empowering women (De Schutter, 2014). In this context, agroecology is therefore seen as a response to the needs for better food security and food sovereignty as well as a possible path to more equitable and sustainable rural development (www.foodsovereignty.org). In 2015, within the Final Report of the International Symposium on Agroecology for Food Security and Nutrition organized by FAO (www.fao.org), Gliessman summarized the role that agroecology has acquired in the world today "as a participatory action research process that leads to sustainability and resilience, as a movement of change and justice".

As emphasized by the IAASTD (www.globalagriculture.org), it is interesting to note how during an evolution towards sustainable agriculture, the role of agroecology is not just amply discussed today by the scientific community, but also by intergovernmental

agencies (for example, the Committee for World Food Security and United Nations Agencies (e.g. FAO and UNEP) and by NGOs (e.g. Oxfam, La Via Campesina).

The dominating question in the discussion of these subjects is if the agroecological approach can be applied on a vaster global scale i.e. in very large agribusinesses (De Schutter and Vanloqueren, 2011; Wibbelman *et al.*, 2013; Parmentier, 2014; Silici, 2014; Altieri *et al.*, 2017).

De Schutter and Vanloqueren (2011) emphasize that for a wider implementation of agroecology, it is necessary to focus on technical assistance services and on education in the single regions as well as on public assets such as rural infrastructure (for example roads and electricity) as well as credit and insurance against the climate related risks. It is clear that we are discussing a medium and long-term process that includes important efforts for a 'political' recognition of agroecology, greater support of the network by local, regional, national and international public institutions and an improvement in the general governance of not just agriculture, but food as a whole.

Regarding the applicability of agroecology to the large industrialized businesses, Parmentier (2014) sustains that despite its deep roots in traditional small-scale agriculture (Altieri and Toledo, 2011) it is also possible to take steps forward in different realities.

So far, various authors, with the most cited being Pretty *et al.* (2006), have demonstrated that at a small scale the application of the principals of agroecology significantly improve sustainability performance, including economic sustainability, especially due to an increase in returns and productivity per area unit.

For medium-sized farms that adopt semi-industrial systems (mechanization, hybrid seeds, synthetic chemical products), the challenge is to avoid an excessive decline in the returns and the productivity specifically due to a reduction or abandonment of synthetic inputs. In these cases, is suggested a transition period dedicated to the restoration of healthy local ecosystems before proceeding with a technical evolution on the farm. (www.manosunidasonline.org). Tittonell (2014) also emphasises the necessity of an ecological intensification that proposes landscape approaches that make an intelligent use of the natural functions that offered by ecosystems in order to design agro-ecosystems that are multifunctional and sustainable by their very nature.

Regarding the agroecological transition of large agri-businesses, there is little scientific data present in the international literature. Among these, Altieri and Nicholls (2012) emphasizes how in countries such as Chile, Argentina, and Brazil, some large plantations are now managed with a paradigm based on circular systems with reduced input and energy consumption. Although most attempts made on large agribusinesses remain focused on practices driven by an intensification program and not by a real agroecological approach, in a recent article published in Sustainability, Altieri *et al.* (2017) propose simpler diversification schemes based on two or three plant species using modern equipment. The application of intercropping, for example, involves the production of multiple crops in strips that are close enough to interact with each other but also wide enough to allow independent cultivation. In this context, a higher yield of corn (5-26% more) was shown in association with soy and there were also positive results in the case of corn / alfalfa intercropping (West and Griffith, 1992).

In any case, it is important to remember that the modified practices adopted by the large agribusinesses to reduce their use of inputs are a step in the right direction, but don't necessarily lead to the redesign of a more self-sufficient and autonomous agricultural system because the crops don't complement one another ecologically, thus the farmers still need external inputs (even though they are organic).

Some studies (www.ipes-food.org; Lithourgidis *et al.*, 2011, Wilson and Lovell, 2016) demonstrate that biodiverse farming systems (intercropping, agroforestry, integrated animal husbandry systems) also support a series of ecosystem services including parasite regulation, resilience to climate extremes, soil health, water conservation etc.). In fact, a more complex plant community has a more stable yield and fewer fluctuations in the number of unwanted organisms, i.e. by improving the functional biodiversity a fundamental goal is reached, i.e. allowing the farmers of any scale to gradually eliminate their inputs by relying on ecosystemic functions instead (Altieri *et al.*, 2015).

New agroecosystem projects, such as those that are differentiated (Kremen *et al.*, 2012), will require systemic changes guided by the application of already well defined agroecological principles applied through different practices and strategies (tab. 3), each with different effects on productivity, stability and resilience within the farm system.

Parmentier (2014) believes that the integration of agroecology into large agribusinesses can be increased, but in necessarily limited working areas. The current interest is still directed towards sustainability and, in fact, there is a debate in progress on the nature of the relationship between the size of a farm and the productivity of its outputs, such as crop yield

Tab 3 - Differentiated agricultural system practices and their agroecological effects (Altieri *et al*., 2017).
Tab. 3 - Differenti pratiche agricole e loro effetti agroecologici (Altieri et al*., 2017).*

Crop Rotations: Temporal diversity in the form of cereal-legume sequences. Nutrients are conserved and provided from one season to the next, and the life cycles of insect pests, diseases, and weeds are interrupted.
Polycultures: Cropping systems in which two or more crop species are planted within certain spatial proximity result in biological complementarities that improve nutrient use efficiency and pest regulation, thus enhancing crop yield stability.
Agroforestry Systems: Trees grown together with annual crops in addition to modifying the microclimate, maintain and improve soil fertility as some trees contribute to nitrogen fixation and nutrient uptake from deep soil horizons while their litter helps replenish soil nutrients, maintain organic matter, and support complex soil food webs.
Cover Crops and Mulching: The use of pure or mixed stands of grass legumes, e.g., under fruit trees, can reduce erosion and provide nutrients to the soil and enhance biological control of pests. Flattening cover crop mixtures on the soil surface in conservation farming is a strategy to reduce soil erosion and lower fluctuations in soil moisture and temperature, improve soil quality, and enhance weed suppression resulting in better crop performance.
Crop-livestock mixtures: High biomass output and optimal nutrient recycling can be achieved through crop-animal integration. Animal production that integrates fodder shrubs planted at high densities, intercropped with improved, highly-productive pastures and timber trees all combined in a system that can be directly grazed by livestock enhances total productivity without need of external inputs.

and biodiversity (Wibbelmann *et al.*, 2013). The agroecological integration of the large industrial agribusinesses to the greatest possible degree could be the best option for improving agricultural sustainability through adequate incentives, both positive and negative (to encourage the best and discourage the worst practices, respectively). In particular, in these sectors the adoption of agricultural practices with low external inputs in large-scale agriculture can be crucial for the future of the planet. In this interpretation, what is being proposed is the complementarity between agroecological agriculture and the use of chemical inputs during the transition period. In this context, the "minimum" or "reasonable" level of use of the chemical inputs to be used in the agroecological transitions could be understood as the optimal quantity of their use (to be decreased over time), to avoid significant losses in yields in the first years.

However, this view is not shared by many agroecology advocates and by food sovereignty movements and is often called Cooptation. In this case, agroecology would only be seen as another technological package to be proposed for a new green revolution (Holt-Gimenez and Altieri, 2012; Horlings and Mardsen, 2011). Many (www.viacampe sina.org; Altieri and Nicholls, 2012) warn against the fact that if talking about agroecology only means talking about good agricultural practices, it is reduced to its ecological bones, ignoring its social and political content.

Altieri and Nicholls (2012) warns us about this path, sustaining that: “These superficial technical adjustments are ideologically sustained by projects to redefine agroecology stripping it of its political and social content […] and promoting the erroneous notion that agroecological methods can coexist, in addition to the aggressive expansion of transgenic crops and agro-fuels”.

Productivity

In the 20th century, agriculture has seen a drastic increase in productivity: after the Second World War, North America and Europe considerably increased their yields per hectare, and the Green Revolution even led to unprecedented agricultural growth during the Sixties in some regions of Asia and Latin America. This was principally obtained through the development and the use of high-yield varieties, a greater use of synthetic chemical fertilizers, pesticides and irrigation, and large-scale monoculture systems. This has made higher productivity possible, while the work load has declined and the prices of food products have diminished in turn (Gliessman, 2015). Nonetheless, despite this large productivity increase, food security hasn’t been reached at a global or local level (Pretty *et al.*, 2006, www.globalagriculture.org).

Those who sustain agroecological approaches (Altieri *et al.*, 2017) generally agree about the necessity of increasing agricultural productivity in the regions where returns are late compared to their potential and consider a more efficient and more sustainable agricultural management fundamental. However, these same supporters are critical of the idea that a simple increase in yield per hectare can solve the hunger and food security problem, since by simply increasing the profits of small farmers, by diminishing their dependencies and reaching distributive justice (for example access to land and seeds, the same access to resources for women as for men), as well as reducing waste and post-harvest losses (www.globalagriculture.org, Altieri and Nicholls 2012, De Schutter, 2010), considerable results can be reached. This is based on the widespread doubt that small owners will not be able to afford the sophisticated technologies needed for highly developed production systems. In a press release from 2014 (Clima

Smart Agriculture),the LVC (www.viacampesina.org) emphasized how, "[…] by increasing the yield per hectare through the intensification of production, only the incomes of businesses, financial market speculators and large farmers increase ... [...] Increasingly, animal breeders and small landholders have to produce crops for the raw materials market and not for local and regional food systems".

In the same way, agroecology aims to optimize the productivity of agricultural land, reducing external input and generating healthy soils and crops (Altieri and Nicholls 2012, www.globalagriculture.org). On this subject, agroecology commonly refers to Pretty *et al.*, (2006), who conducted the study that is still the most wide reaching today, comparing the impacts of 286 prevalently agroecological projects from the beginning to the mid '90s, distributed over 37 million hectares in 57 poor countries. The results showed an increase in the average yield per hectare of 79% in 12.6 million farms, managed with a wide variety of systems and crops. In 2008, the United Nations Environmental Programme (UNEP) and the United Nations Conference on Trade and Development (UNCTAD), taking off from this collection of data, they promoted a study in Africa to investigate the yields of organic and alternative agriculture. The yields rose on average by 116% per hectare, by 128% per hectare in eastern Africa (UNEP, UNCTAD 2008), most of all in areas with degraded land. In Cuba, starting in 1991, agriculture was developed based on agroecological approaches leading to an increase in the production of food by 37% (an annual increase of 4.1%) between 1995 and 2004 (Rosset *et al.*, 2011).

Regardless of these valuable indications, often the comparison between conventional agriculture and agroecology isn't possible because the results of the research vary according to the kind of information considered and the methodologies applied.

However, emerging data exists that indicates comparable yields and the stability of raised yields in extreme meteorological conditions, as well as better profits thanks to a reduction in the costs of the inputs (Rosset *et al.*, 2011). The same authors emphasize that the greater the scope of the agroecological methods adopted, the greater the productivity.

Regarding organic methods, in the global survey of organic agriculture by Badgley *et al.* (2007), the Authors concluded that biological methods could replace conventional intensive farming maintaining and / or increasing the food supply. In this context, even if agroecology isn't explicitly referred to, systems of polyculture and intercropping were evaluated, showing a higher yield per hectare in comparison with monocultures. Finally, it is interesting to note how a debate is ongoing on whether productivity is the most important indicator to evaluate agroecology. Altieri (2000) sustains that global food security is more important than the productivity of a single species (which is the typical configuration of conventional and intensive agriculture). The research has directly regarded the productivity of Latin American agroecology, sustaining that peasant farming substantially contributes to the food security of the region, regardless of poverty conditions and low input use.

Altieri and Toledo (2011) cite proof from Brazil demonstrating that the corn and beans polyculture has produced 28% more food in comparison with corn and beans grown separately in monocultures. The same authors cite studies in the Amazon with yields over 200% more than colonial style monocultures for crops grown with agroecological practices. They also cite studies from Mexico that affirm a plot of land of 1 ha, managed agroecologically, produced as much food as a plot of 1.73 ha cultivated with a corn monoculture. Unfortunately, however, very often the data referred to regards experiments conducted at the end of the last century, showing that there is an evident lack of funds devoted to research all over the world aside from that commissioned by agribusiness (Sanderson *et al.*, 2017).

Finally, it should be emphasized that the agroecological farm must be evaluated in terms of its holistic productivity and not that of single crops, since agroecological practices have a diversified range of products during multiple seasons, they can't be compared to a business that produces a single species (Altieri and Toledo, 2011; Rosset *et al.*, 2011). What's more, even the economic evaluation of input and output are often not comparable between conventional and agroecological businesses since, for example, foods produced for subsistence are not considered to be commercial output. (Sanderson *et al.*, 2017). There is still a long road ahead for this subject and the further research with constant methodologies (and funds) still seems necessary in order to measure productivity and the sustainability so as to produce the exchange of knowledge needed to promote innovation in production practices. To carry out a role of transformation, the research must become participatory and must combine with agroecological science, as well as the knowledge of the famers and the citizen groups. These collaborative strategies must go beyond the linear stereotype in which scientists "transfer" the techniques and the farmers "apply" the research results. The opportunity and the capacity of collective

involvement is crucial in the definition of a research agenda. This is the only way that research can really contribute to reinforcing the strategies of re-localization, and sustaining the consumer support for agroecological production methods (Levidow *et al.*, 2014).

Wellness

A general tendency to abandon the land and migration of populations from rural to urban areas and an inverse trend of immigrant labour moving into these rural areas to look for manual agricultural work has led to a combination of land abandonment, land concentration in large farms and a shift from extensive to intensive farming practices (Labrianidis and Sykas, 2009).

As also emphasized by Hendrickson *et al.*, (2008), thus demography takes on an important role in the agroecological transition. In fact, in the United States as well as in the EU, "the trend of rural depopulation has a powerful effect on the human capital needed to increase the adoption of agroecological approaches, and this is exacerbated by low agricultural wages which are not conducive to labour movements into rural areas" (Wibbelmann *et al.*, 2013). Agroecological practices are therefore associated with higher demands for work than conventional agriculture (Offermann and Nieberg, 2000) even though they are always dependent on the choice of the farm's output. If agroecological production systems become more widespread, more rural employment will be created, probably more stable and less regional in respect to those offered by industrial agriculture (Timmermann and Felix, 2015).

As we have already emphasized, the agroecological literature concludes that the productivity per hectare of the total production (not just a crop) is higher in the various agroecological farming systems compared to the large industrial agribusinesses, showing an inverse relationship between dimension and productivity (Parmentier, 2014, IAASTD 2009, Altieri, 2004). Large businesses do seem to exceed small ones for one indicator, productivity per work unit instead of productivity per surface area unit: in highly mechanized specialized businesses, a worker is able to cultivate a larger area, collecting higher yields in comparison to a worker in a small heterogeneous farm without sophisticated machinery. Taking into consideration the rural unemployment and the rural exodus in many developing countries, the supporters of agroecology emphasize the positive effect of a greater demand for a workforce on the creation of employment positions (De Schutter 2010, www.globalagriculture.org).

In a recent article published in Sustainability Petersen and Silveira (2017) analysed the 2012 National Policy for Agroecology and Organic Production (PNAPO) and the successive PLANAPO I (2013) and PLANAPO II (2016) developed in the semi-arid zones of Brazil, emphasizing how these endogenous trajectories were guided by an intensification work model. This means that instead of the intensive inputs supported by the market (a characteristic typical of the conventional trajectories of agricultural intensification), the agroecological approach is based on the use of manpower specialized in promoting ecological processes at a landscape level, while contemporaneously assuring the continuous regeneration of ecosystemic services and the conversion of natural assets into a vast array of economic assets. In the presence of adequate political-institutional conditions, the more impoverished parts of family farming can become the principal agents of a dynamic or rural development, contributing to the combined achievement of various Sustainable Development Goals (SDG). This is important because while human rights law recognizes a right to adequate nourishment, the global reduction in agricultural employment hasn't led to a sufficient increase in the right to nourishment for those who don't participate in the cultivation process (Timmermann and Felix, 2015).

However, for the agroecological approach to be put into practice at ever wider social and geographical levels, it becomes necessary to strengthen institutions of participatory democracy in order to continuously improve public policies, putting active citizenship in a leading role in the governance of agro-food systems. The availability of sufficiently flexible employment, particularly in regions with rural-urban migration, and the aging of the rural population also become challenges for the greater integration between the agricultural and urban sectors, which would facilitate not only labour availability but also the development of local markets.

Finally, by reincorporating know-how and knowledge of agricultural practices, agriculture can become attractive to younger generations, even those that have always lived in the city who wish to engage in a requalified practice that can continuously evolve over time.

Climate change

The suitability of land for further agricultural use is steadily decreasing, especially in areas of the world that have been defined as marginal (Wibbelman *et al.*, 2013). The massive use of pesticides, fertilizers, irrigation, frequent tilling, and large-scale monoculture

systems have often been the cause of soil and water system degradation, erosion, salinization of some areas, and loss of biodiversity (tab. 4).

The dependency of modern agriculture on fossil fuel, the decrease in the yield growth in many countries as well as the increase in competition for land by other uses (e.g. biofuels) are other causes for worry (www.globalagriculture.org; De Schutter and Vanloqueren 2011; Horlings and Marsden, 2011). All of these phenomena are often made worse by climate change.

The increase in extreme weather events, including prolonged draughts and floods, give new value to the subject of the resilience of productive systems (Taylor, 2017). It is, in fact, possible to talk about anthropogenic climate change (www.greenacord.org) and thus change caused not just by greater bio-climatological risks, but in large part by deforestation and by the use of fossil fuels by conventional agriculture. Global agricultural systems have promoted an enormous homogenization and specialization in the last 50 years (Khoury *et al.*, 2014). Where production systems are intensified, the genetic basis of the varieties used is restricted (Pingali and Traxler, 2002) causing an improvement in yield coupled with a massive use of pesticides and fertilizers, and at great cost to environmental quality and resistance (Bennett *et al.*, 2014). In the last 50 years, global agricultural production has increased by 47%, sustained by an increase in nitrogen and phosphorous fertilizers equal to 6.6 times and 2.5 times respectively contributing to the creation of more than 400 hypoxic marine zones all over the world (Diaz and Rosenberg, 2008, Foley *et al.*, 2011). These simplified systems with a low genetic and taxonomic diversity are thus more vulnerable to climate variability caused by dependence on only one or two crops (Schlenker and Lobell 2010). The solution that is often proposed regarding the realization of new varieties resistant to environmental stress is not conclusive if the issue of diversification and management practices is not addressed.

Agroecological approaches, and in particular the topic of diversification, assures long-term productivity through the restoration of biodiversity and the entire range of ecosystemic functions that sustain food production and human wellness (i.e. clean water, the circulation of nutrients and an increase in the amount of available organic matter (Drinkwater and Snapp, 2007; Kremen *et al.*, 2012), with benefits for draught resistance and dependency on fertilizers. The restoration of perennial plants and/or multi-year crops both in rotation and bordering plots also confers resilience and substantially improves many ecosystemic functions (Smith *et al.*, 2014). For example, the small scale farmers of southern Niger, who principally cultivated of millet, are currently managing a program of natural regeneration with perennial species which has led to an improvement in both the supply and in the regulation of ecosystemic services (Sendzimir *et al.*, 2016). In the last 20 years, also thanks to the wide involvement of the community and social fabric, more than 200 million trees were planted in area spreading over 250,000 ha (Tougiani, *et al.*, 2009). Legumes are another example of a functional plant group that increase the resilience of the agroecosystem despite having co-benefits for human nutrition and the environment (Snapp *et al.*, 2010), particularly in small scale agricultural system.

Today, a discussion about agroecology is also a discussion about resilient agriculture, and thus of a system that satisfies both food needs and those of development in the short and long term, without destabilizing the earth system. It specifically seeks persistence, as well as adaptive changes or even transformations necessary to meet changing environmental conditions and human needs. To do this, agroecology challenges the relatively fixed configuration of our production and consumption systems, proposing an alternative that takes the individual characteristics of a place into maximum consideration. In fact,

Tab. 4 - Agriculture's impact from Bennett et al. (2014).
Tab. 4 - Impatto dell'agricoltura secondo Bennet et al. *(2014).*

Land use	20% of forest and 50% savannas, grasslands and shrublands have been converted. Still hig pressure
Biodiversity loss	Land cover charge for agricolture has beeen one of the key drivers of biodiversity loss anc could increase current extinction rates 100-fold over the 21th century
Radiative forcing	Agriculture is responsible for more greenhouse gas emissions than any other human activity
Freshwater	54% of the geographically and temporally accessible runoff generate by Earth's hydrologic cycle each year consumated by agriculture. Agriculture is by far the largest consumer of fresh water among human activities
Nutrients	Agriculture has greatly amplified the global nitrogen and phospurus cycles with consequences including tropospheric air pollution, human healt problems, toxic algal blooms and anoxic "dead zones" in freshwater and marine ecosystems

resilience, even in an agricultural system, indicates the capacity to continue to adapt by absorbing change (Folke *et al.*, 2010).

In synthesis, the literature, and in particular Altieri *et al.*, (2015), suggests that the small scale agroecosystem can be more resilient when inserted into a complex landscape characterized by genetically heterogeneous and diversified cultivation systems, managed with water conservation techniques on land rich with organic matter (fig. 3).

Furthermore, it is quite interesting to note how peasant and indigenous movements have substantially integrated climate change into their propositions and into the fight of the last decade, not just in response to the menace of climate change but in response to strategies based on the market that the international community puts into practice to mitigate the effects of climate change. Peasant movements didn't directly participate in the UNFCCC meetings, but used the climate topic to promote their alternative paradigm for development based on food serenity, agroecology and on farmers' rights (Claeys and Delgado Pugley, 2016). Even if the Paris agreement doesn't provide indications on land use or any financial methodologies common to agriculture, the region-agriculture-climate nexus is nevertheless clear and one of the next important questions will be the model of agricultural development to be supported by the governments. The implementation of these policies will greatly change the modality that will define a community's access to the land in the future, also understood as the ability to control its development (Ribot and Peluso, 2003).

Finally, it should be remembered that the adaptation of the agricultural system to climate change is not only crucial for small scale farmers, the rural community and economic sustainability, but also for a growing population and global food security (Schmidhuber *et al.*, 2007). In 2012, Haden *et al.*, suggested that growers translate their past climate experiences into future behaviour, especially emphasizing how these experiences can act as starting points for activating climate adaptation programs for agricultural systems, In particular, researchers, regional planners and policy makers should adopt a more interdisciplinary approach to work with the rural community and farmers, particularly the small scale ones, to evaluate the most limiting factors and the relative adaptive practices for each one, also through the proposition of new development models (Niles *et al.*, 2015).

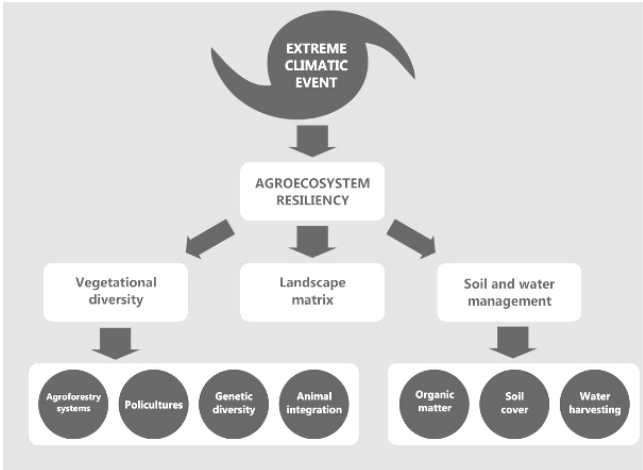

Fig. 3 - Landscape, diversity of the farm and soil and water characteristics that increase ecological resistance to extreme climate events (Altieri and Koohafkan, 2013).
Fig. 3 - Paesaggio, diversità dell'agricoltura e caratteristiche del suolo e dell'acqua che aumentano la resistenza ecologica agli eventi climatici estremi (Altieri and Koohafkan, 2013).

Consumers

The subject of partnership between producers and consumers is fundamental in the agroecological approach to food systems. LVC (www.viacampesina.org) insists on the importance of developing transparent relationships between these two stakeholders in the food system and, according to Gliessman (2007), it is principally the connection between farmers and consumers in the alternative food system that allows for the development of social and environmental equity and consequentially a renewed interest in the subject of food servantly.

Beuchelt and Virchow (2012) also put particular emphasis on the interaction between rural development and food serenity that "aim has been to strengthen peasants and their smallholder agriculture in order to enhance . . . their autonomy, and to contribute towards rural development, poverty eradication and food security".

There are many authors (Lockeretz, 1986; Hinrichs, 2000; Francis *et al.*, 2003; Gliessman, 2012) who sustain that reducing the distance between growers and consumers can facilitate the communication and the understanding of a food system based on agroecological principals.

At this point, it is important to go back to talking about the application scale of the principals of agroecology and in particular to introduce the subject of agroecological territories (Wezel *et al.*, 2016). Both UNEP 2008 as well as other authors (Lovell *et al.* 2010; Méndez *et al.*, 2017) have shown the necessity for a sustainable system to be able to operate in a way that connects activities at an agricultural scale with a landscape approach integrating agricultural and non-agricultural activities in a larger area. In this integra-

tion, all of the aspects of a food system must also be considered (Dalgaard *et al.*, 2003, Francis *et al.* 2003, Gliessman, 2007, Wezel and David 2012; Méndez *et al.*, 2017; Wezel *et al.*, 2016). Starting from the concept of territory as a zone under the responsibility of local authorities such as the cities, the provinces and the regions (Elden, 2010), Wezel *et al.*, (2016) use a wider approach in which agriculture isn't the only driver in a determinate area (Sebillotte, 2000), but an approach in which the valorisation of regional resources acquires great importance. Therefore, a concept of an agroecological territory like the one put forward by Wezel offers a specific framework for conceptualizing a transition toward sustainable agricultural and food systems. In these contexts, the food systems can be described as socio-technical networks that connect the people, natural elements and constructions that interact with food subjects. The processes of characterizing and valorising products such as those sold directly to the consumer or with a designated geographic origin are of real interest for re-examining the roles of consumers and quality standards in the evolution of farming practices and in integrating a wider reaching approach to ecological questions in agroecosystems. Regarding transition towards a sustainable food system incorporated into a territory, it is useful to consider the potentiality of local products used in food services, for sale in supermarkets and local stores and the possibility of growers to organize, together with consumer buyer groups, "crates", community supported agriculture (CSA) or other forms of direct sale (Wezel *et al.*, 2016).

The relatively small-medium dimensions of the agroecological farms existing today makes it possible to think of supplying regional food markets. It should be taken into account that in this kind of market, consumers will find themselves "trying out" a greater seasonal variety in their diet due to a greater tie to the seasonality of crops, along with the consumption of less processed foods.

The dimensions of the single business and the differentiation pushed by the agroecological model in terms of production could create logistical and management problems for their commercialization that can be overcome through associations.

If in fact we are discussing "agroecological districts", it means that inside a cooperative territory, producer and farmer associations can be a central hub for representing the interest of growers in the food supply chain. In fact, Pretty (1997) sustains that the importance of local organizations and institutions has often been neglected, although both are essential for the adoption of agroecological practices.

Even though the centralized supply systems and/or those of the crops destined for export contrast with the models of alternative markets it might also be desirable to incorporate agroecological production into the existing food chain with the aim of benefitting from scale and efficiency opportunities and of satisfying the needs of consumers. One of the possible examples is that of the Fair-Trade certificate (www.fairtrade.net) or others related to coffee where it is evident that the small owners can't access certifications or their benefits without the support of grower organizations (Pinto *et al.*, 2014; Wollni and Zeller, 2007). The farmer organizations aren't just intermediaries between the different decisions relative to the certifications, but are also based on principals including solidarity and social responsibility (Chloupkova and Svendsen, 2003).

Conclusions

The subject of sustainable agriculture and food security is present in the political agenda all over the world and is widely discussed by a series of participants including governments, intergovernmental agencies, the scientific community, environmental development organizations as well as the private sector. It can be said that no aspect has ever been discussed in agriculture for so many years on a global scale.

Today, the most widespread model of agriculture hasn't even been able to make a decisive impact on food security and so the moment has arrived to think of a new paradigm for agriculture. As emphasized by many (UNCTAD, 2013) however, the approach in discussion is still directed towards the expansion of industrial agriculture even if its effects on the environment should be mitigated by the practices of sustainable intensification (www.ifad.org).

Even though it has been known and studied for many decades, today agroecology is an innovative field with evolving definitions and ideas on environmental, social and political-economic subjects.

Its roots can be found in the Latin-American agroecological movement (farmers, technicians, researchers, and associations) that were the first to face the subjects of crop processing and the consumption of foods from a view of democratization of the food system (low input, personal consumption, local sale, and food serenity).

Today, throughout the world, agroecology criticizes and challenges modern systems, which often dominated by large corporations, market ideologies and governments. The role of agroecology as an important element in the search to transform the glob-

al food system must be a step towards the recognition and integration of its three forms i.e. transdisciplinary knowledge (science), interdisciplinary agricultural practices (practice) and social movements (movements) (Nicholls *et al.*, 2016). In this way, the path towards the transformation of the food systems according to the objectives of sustainability, justice and of serenity require everyone to take responsibility (governments and nongovernment organizations) to improve food access by a world population that is in constant growth. At the same time, the focus on agroecology should recognize the valuable role played by farmers and the need to conserve the resource base of that natural capital on which the system and society depends (Altieri *et al.*, 2017).

In such a complex time, a commitment to ensure increased access by farmers from all over the world to resources such as land, water, seeds and a fair market that gives local communities, and especially women, to be in the best position to produce and consume sustainable products is of fundamental importance. Finally, the importance of going beyond the study and discussion of a new paradigm for agriculture is paramount; it is also necessary to take the issues of distribution and consumption into maximum consideration for a new paradigm of the food system as a whole.

Abstract

Agroecology is often presented as an alternative to current widespread production systems, although there are many questions about the real possibility of a sufficiently high food production for a growing population. The analysis developed in this paper is based on the scientific research of the last twenty years and on the activities of NGOs, farmers' movements and government organizations from different contexts. The aim is to provide an overview of the main topics under discussion for an agroecological transition of global food systems, identifying some priority challenges and imagining who will be the participants of this change. Given the complexity of the topic, some specific themes have not been taken into consideration (eg nutritional value of food, health), but we have focused on those cross-cutting issues that are sparking the debate in institutional and non-institutional contexts.

Key words: agroecology, sustainability, best practices, food chain

Acronyms

IAASTD: International Assessment of Agricultural Knowledge, Science and Technology for Development
FAO: Food and Agriculture Organization
LVC: LA Via Campesina
OXFAM: Oxford committee for Famine Relief
UNEP: United Nations Environment Programme

References

Altieri M., 2004. *Agroecology versus ecoagriculture: balancing food production and biodiversity conservation in the midst of social inequality*. CEESP Occasional Papers, IUCN Commission on Environmental, Economic and Social Policy 3:8–28.

Altieri M.A., 1987. *Agroecology: the Scientific Basis of Alternative Agriculture.* Westview Press, Boulder, CO, USA, 227 p.

Altieri , M.A.1995 - *Agroecology: the Science of Sustainable Agriculture*. Westview Press, Boulder, CO, USA, 433 p.

Altieri M.A., 2000. *Multifunctional dimensions of ecologically-based agriculture in Latin America.* The International Journal of Sustainable Development & World Ecology, 7: 62–75.

Altieri M.A., Koohafkan P., 2013. *Strengthening resilience of farming systems: a key prerequisite for sustainable agricultural production.* In: Wake up before it is too late: make agriculture truly sustainable now for food security in a changing climate. UNCTAD, TER13 Report, Geneva.

Altieri M.A., Toledo M., 2011. *The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants.* Journal of Peasant Studies, 38(3): 587–612.

Altieri M.A., Nicholls C., 2012. *Agroecology scaling up for food sovereignty and resiliency.* Sustainable Agriculture Reviews, 11:1–29.

Altieri M.A., Nicholls C., Henao A., Lana M.A., 2015. *Agroecology and the design of climate change-resilient farming systems*. Agronomy for Sustainable Development, 35: 869–890.

Altieri M.A., Nicholls C., Montalba R., 2017. *Technological Approaches to sustainable agriculture at a crossroads: an agroecological perspective.* Sustainability, 9(3), 349 doi:10.3390/su9030349.

Astier M., García-Barrios L., Galván-Miyoshi Y., González-Esquivel C.E., Masera O.R., 2012. *Assessing the sustainability of small-farmer natural resource management systems. A critical analysis of the MESMIS program (1995–2010)*. Ecology and Society 17(3): 25. doi:10.5751/ES- 04910-170325.

Badgley C., Moghtader J., Quintero E., Zakem E., Chappell M.J., Aviles-Vazquez K., Samulon A., Perfecto I., 2007. *Organic agriculture and the global food supply.* Renewable Agriculture and Food Systems 22: 86–108.

Bennett E., Carpenter S., Gordon L.J., Ramankutty N., Balvanera P., Campbell B., Cramer W., Foley J., Folke C., Karlberg L., 2014. *Toward a more resilient agriculture*. Solutions 5: 65–75.

Beuchelt T., Virchow D., 2012. *Food sovereignty or the human right to adequate food: Which concept serves better as international development policy for global hunger and poverty reduction?* Agriculture and Human Values, 29: 259-273.

Bernard B., Alexandra L., 2017. *How to feed the world sustainably: an overview of the discourse on agroecology and sustainable intensification.* Regional Environmental Change 17(5): 1279–1290.

Chloupkova J.S., Svendsen G., 2003. *Building and destroying social capital: the case of cooperative movements in Denmark*

and Poland. Agriculture and Human Values 20: 241–252.

Claeys P., Delgado Pugley D., 2016. *Peasant and indigenous transnational social movements engaging with climate justice.* Canadian Journal of Development Studies / Revue canadienne d'études du développement, 38(3): 325–340.

Dalgaard T., Hutchings N.J., Porter J.R., 2003. *Agroecology, scaling and interdisciplinarity.* Agriculture, Ecosystems and Environment 100: 39–51.

De Schutter O., 2010. *Report of the Special Rapporteur on the right to food: Agroecology and the right to food, Document A/HRC/16/ 49*. United Nations, New York.

De Schutter O., 2014. *Report of the Special Rapporteur on the right to food, final report: the transformative potential of the right to food, Document A/HRC/25/27.* United Nations, New York.

De Schutter O., Vanloqueren G., 2011. *The new green revolution: how twenty-first-century science can feed the world*. Solutions 2(4): 33–44.

Diaz R.J., Rosenberg R., 2008. *Spreading dead zones and consequences for marine ecosystems.* Science 321: 926–929.

Drinkwater L.E., Snapp S.S. 2007. *Nutrients in agroecosystems: rethinking the management paradigm*. Advances in Agronomy 92: 163–186.

Elden S., 2010. *Land, terrain, territory*. Progress in Human Geography 34(6): 799–817.

FAO, 2011. *Save and grow - a policymaker's guide to the sustainable intensification of smallholder crop production.* United Nations, Rome.

FAO, 2015. *Final report of the international symposium on agroecology for food security and nutrition*. 18-19 Sept 2014, Rome.

Foley J.A., Ramankutty N., Brauman K.A., Cassidy E.S., Gerber J.S., Johnston M., Mueller N.D., O'connell C., Ray D.K., West P.C., Balzer C., Bennett E.M., Carpenter S.R., Hill J., Monfreda C., Polasky S., Rockström J., Sheehan J., Siebert S., Tilman D., Zakset D.P.M., 2011. *Solutions for a cultivated planet.* Nature 478: 337–342.

Folke C., Carpenter S. R., Walker B., Scheffer M., Chapin T., Rockström J., 2010. *Resilience thinking: integrating resilience, adaptability and transformability.* Ecology and Society 15(4): 20.

Francis C., Lieblein G., Gliessman S., Breland T.A., Creamer N., Harwood R., Salomonsson L., Helenius J., Rickerl D., Salvador R., Wiendehoeft M., Simmons S., Allen P., Altieri M., Porter J., Flora C., Poincelot R., 2003. *Agroecology: the ecology of food systems*. Journal of Sustainable Agriculture 22: 99–118.

Gliessman S.R., 2007. A*groecology: the ecology of sustainable food systems.* ed.CRC Press, Boca Raton.

Gliessman S.R., 2012. *Agroecology and shifting paradigms*. Journal of Sustainable Agriculture, 36(5): 499.

Gliessman S.R., 2015. *Agroecology: the ecology of sustainable food systems,* 3d ed. CRC Press, Raton.

Guthman J., 2014. *Agrarian Dreams. The Paradox of Organic Farming in California*. University of California Press: Berkeley, CA, USA.

Haden V.R., Niles M.T., Lubell M., Perlman J, Jackson L.E., 2012. *Global and local concerns: what attitudes and beliefs motivate farmers to mitigate and adapt to climate change?* PLoS ONE 7(12): e52882.

Hendrickson J.R., Liebig M.A., Sassenrath G.F., 2008. *Environment and integrated agricultural systems.* Renewable Agriculture and Food Systems 23(4), 304–313.

Hinrichs C.C., 2000. *Embeddedness and local food systems: notes on two types of direct agricultural market.* Journal of Rural Studies 16: 295–303.

Holt-Gimenez E., Altieri M.A., 2012. *Agroecology, food sovereignty, and the green revolution*. Agroecology, Food Sovereignty, and the New Green Revolution 37: 90–102.

Horlings L.G., Marsden T.K., 2011. *Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernization of agriculture that could 'feed the world'*. Global Environmental Change 21:441–452.

IAASTD, 2009 . *Synthesis report with executive summary: a synthesis of the global and sub-global* .

Khoury C.K., Bjorkman A.D., Dempewolf H., Ramirez-Villegas J., Guarino L., Jarvis A., Rieseberg L.H., Struik P.C., 2014. I*ncreasing homogeneity in global food supplies and the implications for food security*. Proceedings of the National Academy of Sciences 111: 4001–4006.

Kremen C., Iles A., Bacon C., 2012. *Diversified farming systems: an agroecological, systems-based alternative to modern industrial agriculture.* Ecology and Society 17(4): 44.

Labrianidis L., Sykas T., 2009. *Migrants, economic mobility and socio-economic change in rural areas: the case of Greece.* European Urban and Regional Studies 16: 237–256.

Levidow L., Pimbert M., Vanloqueren G., 2014. *Agroecological research: conforming or transforming the dominant agro-food regime?* Agroecology and Sustainable Food Systems 38 (10): 1127–1155.

Lithourgidis A.S., Dordas C.A., Damalas C.A., Vlachostergios D.N., 2011. *Annual intercrops: an alternative pathway for sustainable agriculture*. Australian Journal of Crop Science 5: 396–410.

Lockeretz W., 1986. *Urban consumers' attitudes towards locally grown produce.* American Journal of Alternative Agriculture 1(2): 83–88.

Lovell S., Desantis S., Nathan C.A., Breton Olson M., Méndez V.E., Kominami H.C., Erickson D.L., Morris K.S., Morris W., 2010. *Integrating agroecology and landscape multifunctionality in Vermont: An evolving framework to evaluate the design of agroecosystems.* Agricultural Systems 103:327–341.

Méndez V.E., Caswell M., Gliessman S.R., Cohen R., 2017. *Integrating agroecology and participatory action research (PAR): lessons from Central America*. Sustainability 9: 705.

Nicholls C.I., Altieri M.A., Vazquez L., 2016. *Agroecology: Principles for the conversion and redesign of farming systems.* Journal of Ecosystem & Ecography 2016: S5.

Niles M.T., Lubell M., Brown M., 2015. *How limiting factors drive agricultural adaptation to climate change*. Agriculture, Ecosystems and Environment 200: 178–185.

Offermann F., Nieberg H., 2000. *Economic performance of organic farming in Europe.* Economics and Policy Volume 5. ed. by Dabbert, S., Lampkin.

Parmentier S., 2014. *Scaling-up agroecological approaches: what, why and how? Discussion paper.* Oxfam-Solidarity, Belgium.

Petersen P.F., Silveira L.M., 2017. *Agroecology, public policies and labor-driven intensification: alternative development trajectories in the brazilian semi-arid region.* Sustainability 9(4): 535.

Pinto L.F.G., Gardner T., Mcdermott C.L., Ayub K.O.L., 2014. *Group certification supports an increase in the diversity of sustainable agriculture network– rainforest alliance certified coffee producers in Brazil.* Ecological Economics 107: 59–64.

Pimbert M, Schmutz U, Wright J., 2014. *Mainstreaming agroecology: implications for global food and farming systems.* http://www. soilassociation.org/motherearth/viewarticle/articleid/7159/main streaming-agroecology-implications-for-global-food-and-farm ing-systems. Accessed 15 june 2017

Pingali P.L., Traxler G., 2002. *Changing locus of agricultural research: will the poor benefit from biotechnology and privatization trends?* Food Policy 27: 223–238.

Pretty J.N.,1997. *The sustainable intensification of agriculture.* Natural Resources Forum 21:247–256.

Pretty J.N., 2008. *Agricultural sustainability: concepts, princi-*

ples and evidence. Philosophical Transactions of the Royal Society B 363:447–465.

PRETTY J.N., NOBLE A.D., BOSSIO D., DIXON J., HINE R.E., PENNING DE VRIES F.W., MORISON J., 2006. *Resource-conserving agriculture increases yields in developing countries.* Environmental Science & Technology 40:1114–1119.

RIBOT J. C., PELUSO N.L., 2003. *A theory of access*. Rural Sociology 68 (2): 153–81.

ROSSET P.M., ALTIERI M.A., 1997. *Agroecology versus input substitution: a fundamental contradiction of sustainable agriculture.* Society & Natural Resources 10: 283–295.

ROSSET P.M., MACHIN SOSA B., ROQUE JAIME A.M., ÁVILA LOZANO D.R., 2011. *The campesino-to-campesin agroecology movement of ANAP in Cuba: social process methodology in the construction of sustainable peasant agriculture and food sovereignty.* Journal of Peasant Studies 38: 161–191.

SANDERSON BELLAMY A., IORIS A., 2017. *Addressing the knowledge gaps in agroecology and identifying guiding principles for transforming conventional agri-food systems*. Sustainability : 9(3), 330.

SCHLENKER W., LOBELL D.B., 2010. *Robust negative impacts of climate change on african agriculture*. Environmental Research Letters 5(1):1–9.

SCHIPANSKI M.E., MACDONALD G.K., ROSENZWEIG S., CHAPPELL M.J., BENNETT E.M., BEZNER R. K, BLESH J., CREWS T., DRINKWATER L., LUNDGREN J., SCHNARR C., 2016. *Realizing resilient food systems.* BioScience 66 (7):600–610.

SCHMIDHUBER J., FRANCESCO N., TUBIELLO F.N., 2007. *Global food security under climate change*. Proceedings of the National Academy of Sciences of the United States of America. 104 (50): 19703–19708.

SEBILLOTTE M., 2000. *Des recherches pour le développement local: partenariat et transdisciplinarité.* Revue D Economie Regionale Et Urbaine 3 : 535–556.

SENDZIMIR J., REIJ C.P., MAGNUSZEWSKI P. 2016. *Rebuilding resilience in the Sahel: regreening in the Maradi and Zinder regions of Niger.* Ecology and Society 16 (3): 1-29.

SILICI L., 2014. *Agroecology: what it is and what it has to offer*. IIED Issue Paper, London.

SMITH T.E., KOLKA R.K., ZHOU X., HELMERS M.J., CRUSE R.M., TOMER M.D., 2014. *Effects of native perennial vegetation buffer strips on dissolved organic carbon in surface runoff from an agricultural landscape*. Biogeochemistry 120: 121–132.

SNAPP S.S., BLACKIE M.J., GILBERT R.A., BEZNER-KERR R., KANYAMA-PHIRI G.Y., 2010. *Biodiversity can support a greener revolution in Africa.* Proceedings of the National Academy of Sciences 107: 20840–20845.

TAYLOR M., 2017. *Climate-smart agriculture: what is it good for?* The Journal of Peasant Studies 45(1): 89–107.

TITTONELL P., 2014. *Ecological intensification of agriculture - sustainable by nature.* Current Opinion in Environmental Sustainability 8:53–61.

TIMMERMANN C., FÉLIX G.F., 2015. *Agroecology as a vehicle for contributive justice.* Agriculture and Human Values 32:523–538.

TOUGIANI A., GUERO C., RINAUDO T., 2009. *Community mobilisation for improved livelihoods through tree crop management in Niger.* GeoJournal 74:377–389.

UNCTAD UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT, 2013. *Trade and environment review 2013: Wake up before it's too late*. United Nations, Geneva.

UNEP, UNCTAD, 2008. *Organic agriculture and food security in Africa.* United Nations, New York, Geneva.

WEST T.D., GRIFFITH D.R., 1992. *Effect of strip intercropping corn and soybean on yield and profit.* Journal of Production Agricolture 5: 107–110.

WEZEL A., SOLDAT V., 2009. *A quantitative and qualitative historical analysis of the scientific discipline of agroecology*. International Journal of Agricultural Sustainability 7(1): 3–18.

WEZEL A., BELLON S., DORE´ T., FRANCIS C., VALLOD D., 2009. *Agroecology as a science, a movement and a practice*. Agronomy for Sustainable Development 29:503–515.

WEZEL A., BRIVES H., CASAGRANDE M., CLÉMENT C., DUFOUR A. P., 2016. *Agroecology territories: places for sustainable agricultural and food systems and biodiversity conservation.* Agroecology and Sustainable Food Systems 40 (2): 132-144.

WIBBELMANN M., SCHMUTZ U., WRIGHT J,. UDALL D., RAYNS F., KNEAFSEY M., TRENCHARD L., BENNETT J., LENNARDSSON M., 2013. *Mainstreaming agroecology: implications for global food and farming systems. Discussion Paper.* Centre for Agroecology and Food Security, Coventry.

WILSON M.H., LOVELL S.T., 2016. *Agroforestry - the next step in sustainable and resilient agriculture.* Sustainability 8(6): 574.

WOLLNI M., ZELLER M., 2007. *Do farmers benefit from participating in specialty markets and cooperatives? The case of coffee marketing in Costa Rica.* Agricultural Economics 37 (2): 243–248.

WOJTKOWSKI P.A. 2004. *Landscape Agroecology*. New York: Food Products Press p. 321

Siti Web

www.ifad.org: IFAD [International Fund for Agricultural Development]. 2012. Statement by Kanayo F. Nwanze, President of IFAD at the food security 2012 conference. Sustainable Intensification: Miracle or Mirage?

www.ipes-food.org: IPES-Food. From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems. International panel of experts on sustainable food systems.

www.fairtrade.net: fairtrade international, 2011. history of fairtrade retrieved.

www.fao.org: FAO. 2012. Smallholders and family farmers.

www.fao.org : FAO. 2015. Sustainable crop production intensification in FAO.

www.foodsovereignty.org: wp-content/uploads/2015/10/NYELENI-2015-ENGLISH-FINAL-WEB.pdf interna

www.greenaccord.org

www.manosunidasonline.org:/redes/documentos_publicos/AgriculturaySeg.Alimentaria/Nexus_Final_Trocaire.pdf.

www.viacampe sina.org: LVC, 2014, un-masking climate smart agriculture.