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AGRO-ECOLOGY: CONCEPT, CHARACTERISTICS AND SOCIO-ECONOMIC BENEFITS

ABSTRACT

In the present context of climate change and increasing concerns to develop healthy agri-food systems, agro-ecology gains ground and visibility as a scientific discipline, sustainable approach to agriculture and social movement. There is an increased interest in terms of its multiple benefits, from climate resilience to agricultural productivity. However, its promotion in agricultural public policies, research and extension is still limited. The main objective of this study is to strengthen the theoretical knowledge base on agro-ecology, as well as on its economic, ecological and social benefits.

Key words: agro-ecology, sustainable farming practices, sustainable agriculture.

JEL Classification: Q59.

1. INTRODUCTION

Agriculture produces the food base for the world population, it represents one of the most important income, uses about half of the existing land area worldwide, supplies a significant number of goods and services necessary for the society and provides a wide range of eco-systemic services (MEA, 2005). In the last decades, agriculture modernization, the use of performant technologies and of great amounts of chemical inputs (fertilizers and pesticides) led to production maximization, but also produced negative effects upon the environment. The agro-ecology appeared as an alternative to this modernized system, being considered a sustainable production system that provides a wide range of economic, social and environmental benefits.

2. MATERIAL AND METHOD

In the recent decades, in many European countries, modern agriculture has developed starting from the traditional, natural agriculture, into extremely productive, industrial production systems. The large amounts of agricultural inputs used in the farm production system have caused a number of environmental problems such as nutrient loss, pesticide contamination, soil erosion and degradation, etc. Such intensive systems mainly target the increase of yields, which most often is not reflected in

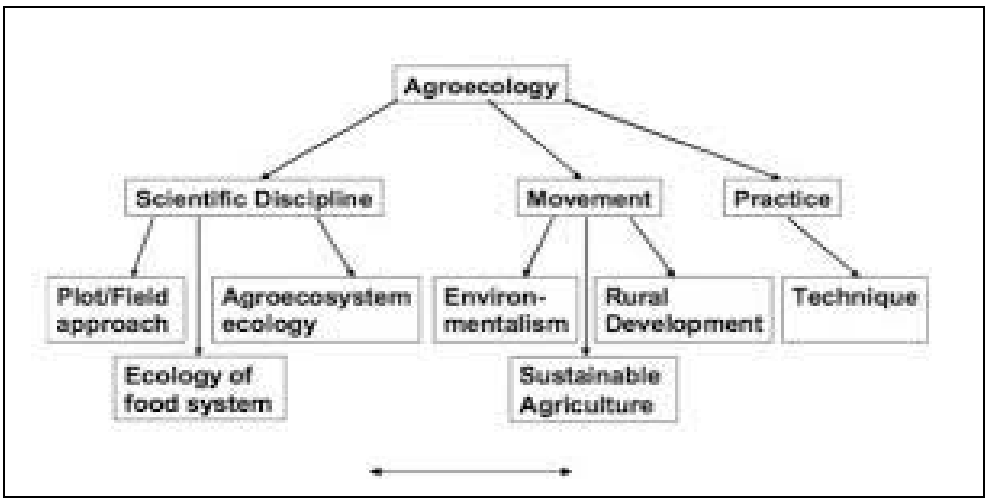
the increase of economic efficiency. In certain countries, mainly in the less-favoured areas, a stronger orientation can be noticed towards the low-input farming systems, focusing on sustainability aspects (UN, 1987): sustainable agriculture refers to the ability of a farm to produce foodstuffs on unlimited term, without irreversibly harming the ecosystem.

The main objective pursued in this paper targets the consolidation of the theoretical base of knowledge on agro-ecology. The method used is the documentation and the description/characterization of the main concepts, characteristics and social and economic benefits.

3. RESULTS AND DISCUSSIONS

In the current context of climate change and increasing concerns to sustain healthy agri-food systems, agro-ecology has been gaining ground and visibility as a scientific discipline, sustainable approach to farming practices and social movement. There is an increased interest in terms of its multiple benefits, from climate resilience to agricultural productivity.

Definitions and characteristics. Over time, the agro-ecology concept has evolved as a scientific discipline, a set of practices as well as a social movement. As a science, agro-ecology investigates how the various components of agro-eco-systems are interacting. As a set of practices, it targets those sustainable farming systems that optimize and stabilize the yields. As social movement, it targets the food security/ sovereignty and the multifunctional role of agriculture.



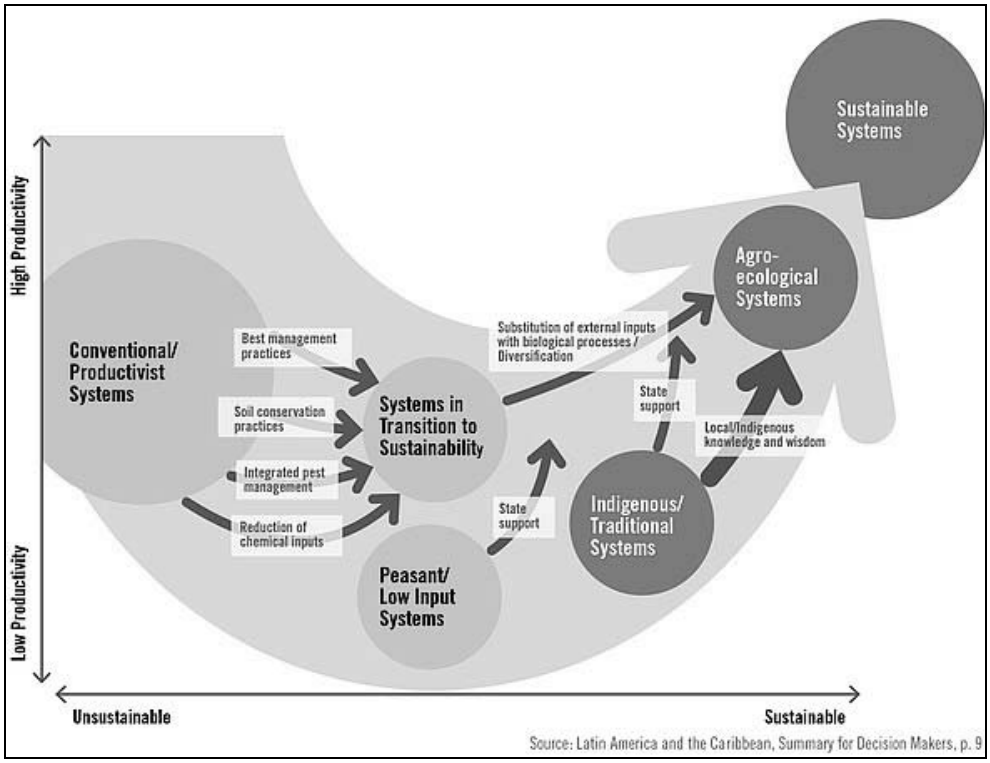
Source: http://biodistretto.net/wp-content/uploads/2018/05/1_b_National_Reports_Agroecology_Synthesis.pdf

Figure 1. Agro-ecology concept.

Experts are not always in agreement in terms of what agro-ecology is or should be. The definitions of agro-ecology are far from the specificity with which the „ecology" concept has been defined, as well as from the potential political connotations of the concept. Thus, OECD defines agro-ecology as the „study of the relation of agricultural crops and environment" (OECD, 2003).

Another common definition refers to agro-ecology as the study of interactions between crops, animals, people and environment within the farming systems. Consequently, agro-ecology is inherently multidisciplinary, including factors from agronomy, ecology, sociology and economics (Dalgaard et al., 2003).

Altieri (1995) argues that agro-ecology deals with the application of ecological concepts and principles in the design and management of sustainable agro-ecosystems. This definition captures the conceptual framework based on a set of principles and as a series of practices that can be used in different combinations to increase the resilience and sustainability of farming systems.



Source: https://www.globalagriculture.org/report-topics/agroecology.html

Figure 2. Transition to productive and sustainable agriculture.

Agro-ecology is viewed differently in different geographic locations. For instance, in South America, this concept has been attributed political connotations. The concept is most often connected to economic objectives and objectives targeting social justice; a particular attention, in this case, is given to traditional agricultural knowledge and skills of indigenous populations (www.agroeco.org/socla). On the other hand, in the countries from North America and Western Europe, agro-ecology is rather viewed as a scientific discipline with less specific and defined social objectives.

The agro-ecology evolution as scientific discipline, as set of practices and social movement, is presented in Figure 3. The agro-ecology concept appeared in literature in the 1930s, and mainly referred to the scientific study of biological interactions between the agricultural crops and different components of the agro-ecosystem. Since the 1960s, agro-ecology has gradually extended its scale of analysis (from the parcel or farm level to the entire agro-ecosystem and even to the food system) and its field of application (from ecological and agronomic analyses to an interdisciplinary approach, including socio-economic and political dimensions). In the 1980s, a conceptual framework appeared for the intense promotion of agro-ecological practices in the developed and developing countries. These practices, in their turn, inspired a series of agro-ecological movements that appeared and developed in the 1990s.

The first agro-ecology studies (from 1930 to the 1960s) were based on the biology sciences – zoology, agronomy and crop physiology – and tried to investigate the biological interactions between different elements of the eco-system and agriculture. In the ’60s and ’70s, due to the emergence of ecologist movements, and partially as a reaction to the negative effects of green revolution, the ecological analysis of agriculture within the agro-ecosystem got consolidated (Wezel et al., 2009).

In the ’70s and the ’80s, the development direction in agro-ecology began to be strongly influenced by the social component and by a new interest in the traditional farming system, viewed as an important system for natural resource management.

Starting with the 1990s, agro-ecology has been treated as a scientific discipline with a conceptual framework and well-defined methodology for the holistic study of agro-ecosystems, including social and environmental elements. According to this vision, the area utilized for agricultural production is considered a complex system where ecological processes and human activities are taking place: agro-ecology focuses on the dynamics and interconnections between them (Altieri, 1995).

Agro-ecology principles. As a result of this new approach, a series of principles lying at the basis of environmental and environmental services sustainability appeared and got consolidated (Table 1).

Agro-ecology as scientific discipline					
1920/30	**1940/50**	**1960/70**	**1980**	**1990**	**2000**
Scale: parcel/farm	Transition from descriptive to analytical	Scale: agro-ecosystem	Transition from analytical to prescriptive	Conceptual framework for the agro-system design	Increasing the scale and scope Agro-ecology as interdisciplinary study of food systems
Scope: biology/physics		Scope: ecology/agronomy			
	Increasing the scale and scope		Increasing the scale and scope		
Descriptive nature		Analytical nature			
Agro-ecology as set of practices			**Agro-ecological principles inspire agricultural practices**		
		1970	**1980**	**1990**	**2000**
		Indigenous agricultural knowledge for natural resource management	Agricultural practices implemented or developed (conservation agriculture, permaculture, organic agriculture, etc.)		Agro-ecological practices as alternative paradigm to conventional farrming
			The spreading of ecological practices intertwined with the social movements		
Agro-ecology as a social movement			**1980**	**1990**	**2000**
			Indigenous knowledge and family farms	Agricultural biodiversity and food sovereignty	Sustainable intensification of agriculture and food systems

Source: Author's adaptation based on Silici, 2014, p. 7.

Figure 3. Evolution of agro-ecology.

Table 1

Agro-ecology principles

Planning	Utilization of holistic approach for the identification, analysis and solving up problems related to agriculture: the agro-ecosystem is considered as a unit, and its health as a whole is more important than the productivity of crops taken individually; harmonization of the farming system with the productive potential and the physical limits of the surrounding landscape
Use of resources	Recycling and optimizing the use of nutrients and energy on the farm: – improving the recycling of biomass with a view to optimize the circuit of nutrients and decomposition of organic matter over time; – minimizing energy, water, nutrients and genetic resources losses, by strengthening the conservation and regeneration of soil and water resources and the agricultural biodiversity; – avoiding the use of agro-chemical products and of other technologies with a negative impact upon the environment and human health; – minimizing the use of external and non-renewable resources.
Land and landscape management	– improving the beneficial biological interactions and the synergy between the agro-biodiversity components, thus promoting ecological processes and services (avoiding the concentration on individual species); – diversification of species and genetic resources within the agro-ecosystem (e.g. at field and landscape level); – boosting the agriculture "immune system" by increasing functional biodiversity (natural enemies, antagonists, etc.); pests and diseases should be properly managed and prevented rather than controlled; – the use of local varieties and breeds to increase genetic diversity and adaptation to biotic and environmental changes; – ensuring the most favourable soil conditions for growing crops, mainly by a proper management of organic matter and intensification of soil biological activity.

Source: Silici, 2014.

In recent years, agro-ecology as a scientific discipline has evolved from a subcomponent of agronomic research to an independent science focusing on environmental sustainability: it has extended the field of its interest/application to the entire food system and has acquired an inter-disciplinary character.

Over the years, as science, agro-ecology gradually became less neutral; it became a concept that characterizes the sustainable food production and consumption, in contrast with the classical food systems that are increasingly perceived as unsustainable. Indeed, ecological agriculture can contribute to the increase of food system sustainability, both directly (through farm production resilience and sustainability) and indirectly by encouraging the practice of food waste diminution and recycling and relocation of food production and consumption (UNCTAD, 2013).

Recognizing that agro-ecology can be considered an alternative model of the present agricultural system represents an important component of sustainable food systems. Many practitioners continue to pay less attention to agro-ecology benefits. In fact, since the 1980s, the scientific discipline gradually became more prescriptive and practice-oriented. The agro-ecological practices aim at improving the agricultural

systems by imitating the natural process and by strengthening the multifunctional role of agriculture. These practices are strongly based on knowledge, on concepts developed within the scientific discipline, on farmers' knowledge and experience.

The agro-ecological practices are based on one or several (previously presented) principles and have the following main declared objectives: i) soil structure consolidation, soil health improvement, recycling of nutrients and securing local supply; ii) water resource conservation and efficient utilization; iii) supporting and improving functional diversity, both on a spatial and temporal scale (Table 2).

Table 2

Agro-ecological practices

Soil conservation	No tillage and minimum tillage improve soil structure – including ventilation and water infiltration and retention capacity, organic matter retention in soil;
Mixed cropping, intercropping, catch crops	Improve the biological complementarily, the efficiency of nutrients and agricultural inputs, the utilization of space and pest management, to increase crop yield stability;
Crop rotation and grubbing	Nutrients are preserved from season to season and the life cycles of insects, weeds and diseases are interrupted;
Cover crops and mulching	Reduce soil erosion, provide the necessary nutrients in soil and increase the biological pest control;
Integrating crop farming with stock raising	Makes it possible to obtain a larger amount of biomass and an optimum recycling of nutrients, alongside with the economic diversification;
Integrated management of nutrients	Has in view the use of compost, manure and nitrogen-fixing crops; makes it possible to reduce or eliminate the use of chemical fertilizers;
Biological control of pests, diseases and weeds	Such as integrated pest control: long-term diminution of pest incidence and lowering the impact upon the environment and health caused by the use of chemical substances for pest control;
Efficient water utilization (mainly in the dry areas)	Such as small-scale irrigation that makes it possible to use lower irrigation rates over time and to increase water use efficiency;
Crop structure orientation and crop association	Improves the water use efficiency and promotes biodiversity;
Agro-forestry	Maintains and improves soil fertility by nitrogen fixation, improves soil structure and modifies the micro-climate;
Use of local resources and renewable energy sources, composting and waste recycling	Contributes to the diminution of external input use and lowers the pressure on natural resources;
Holistic landscape management	Field margin strips (windscreens, protection belts, insect strips and hedges), on several fields (crop mosaics, land use practices) and land management – regional scale riverside buffers, forests, pastures and natural or semi-natural areas).

Source: Silici, 2014.

Most agro-ecological practices existed before the development of agro-ecology as science/concept – in fact they are part of traditional farming systems. What agro-ecology as science and social movement has done was to provide a coherent framework to conceptualize the effects of these practices.

The agro-ecological practices can be used in different combinations. For instance, the cultivation methods such as permaculture or biodynamic farming apply all the agro-ecological principles; other methods, like the rice intensification system, organic agriculture and conservation agriculture apply only certain agro-ecological principles. In certain cases, the same farmer can choose to use different cultivation methods on different parcels (e.g. the agricultural practice where large amounts of inputs are used to obtain cash crops and agro-ecological practices for the food crops). To sum up, the agro-ecological practices can be considered as a set of tools from which farmers can choose, according to their socio-economic, cultural or environmental preferences/objectives (Silici, 2014).

Socio-economic benefits of agro-ecology. The main benefits of large-scale use of agro-ecology targets a lower impact upon the environment, a higher biodiversity, landscape improvement and increasing climate resilience (Table 3).

Table 3

Agro-ecology benefits

Increasing environmental sustainability, climate resilience and agro-biodiversity	– on the long run, the ecological farming systems are resilient to climate changes, resistant to pests and adaptable to other various conditions – they are mainly based on local traditional knowledge, on crop and livestock diversification and on a high agri-food biodiversity; – the agro-ecological practices also offer other environmental benefits (diminution of greenhouse gas effects), utilization of less polluting or non-polluting inputs, increased agro-biodiversity and supply of eco-systemic services; – the agro-ecology benefits are mostly obvious in marginal environmental conditions and in unfavourable climate conditions, where the agro-ecological practices are often much more productive than in the case of conventional farming – low deterioration of agricultural land and higher agricultural biodiversity on the farm helps to minimize losses and increase the crop resistance.
Productivity increase, optimization of yields and sustainability intensification	– the yields of ecological crops are not higher than those obtained under intensive farming practice that uses significant amounts of inputs, but ecological production is based on the diversity of crops and animals, while the higher resilience to extreme weather events and the resistance to pests and other disturbing environmental factors make yields be less volatile over time. – the counting/assessment of ecosystem services could further increase the overall productivity of agro-ecological farming systems. – the agro-ecological approaches target the entire agro-ecosystem and the multiple relationships within it, rather than the separate approach by each component, like in most conventional agricultural research studies; the agro-ecological farmers have in view multifunctionality and

	the optimization rather than the maximization of yields. The system optimization is reached when farmers achieve the highest degree of „agro-ecological integration", i.e. the extent to which the agro-ecological principles are used in the management of different resources. – the utilization efficiency of inputs and other resources together with a diversified range of agricultural products and by-products (such as animal feedstuffs) should, in principle, guarantee the financial viability of agro-ecological practices. However, this hypothesis is rarely verified through accurate economic and financial analyses that should take into consideration the labour and other inputs, the commercial viability of products obtained, etc. – although the eco-system services provided by the agro-ecological farms represent a positive externalization, there is still a low consensus on their accurate evaluation modality, mainly having in view the creation of markets for environmental services, as well as a poor understanding of the way in which farmers internalize them in their considerations on the cost-benefit analysis.
Increasing the standard of living and food sovereignty	– agro-ecology has a positive impact upon farmers' living standard. It is viewed as a way of agricultural development closely linked to the right to food. – the agro-ecological practices contribute to food security by encouraging farm production diversity and increasing the nutritional value of crops. – the agro-ecological practices contribute to food sovereignty placing the farmer and his/her household at the core of decisions on food production, while avoiding the dependency on external inputs and the top-down technological transfers. – relying on their own production and on local input sources (seeds inclusively) reduces farmers' dependence on costly and often hard-to-reach products, their vulnerability to price volatility and the risk of indebtedness.
Flexibilization in adopting agro-ecological practices	– theoretically, there are significant differences between conventional and agro-ecological agriculture, yet in reality the limits are rather unclear. – the extent to which different agro-ecological practices are adopted can vary from farmer to farmer. While the farmers who use permaculture of biodynamic farming systems largely apply agro-ecological principles and have a holistic approach to the agro-ecosystem, the organic farmers or the no-tillage farmers can apply only certain agro-ecological principles. On the other hand, many „conventional" farms use certain agro-ecological practices, such as crop rotation, no-tillage or minimum tillage farming systems and apply a mix of organic and inorganic fertilizers, etc. In addition, the precision technologies make it possible for farmers to use chemical inputs more efficiently and to minimize the impact of mechanical works. – certain agro-ecology advocates view this unclear limit as beneficial, as it enables farmers with different socio-economic conditions to access only „modern technologies". Others criticize the attempts to declare agro-ecology as an option that can be used together with other practices, such as transgenic crops, fertilizer and herbicide microdosing, etc., concluding that in this way the agro-ecology concept could be emptied of meaning.

Source: Altieri, 1995.

The agro-ecological practices are supportive to food sovereignty, enabling farmers to intensify and diversify their production, to obtain stable yields and decrease their dependency on expensive inputs, which are difficult to procure. In the recent decades, the number of scientific studies on agro-ecology has steadily increased. Most of these studies approach the agronomic and ecological benefits of certain practices, such as agro-forestry, integrated pest management, no-tillage farming, pasture management, etc. Alongside with the academic literature, several international organizations launched reports proving the agro-ecology benefits.

The existing evidence on the benefit of agro-ecology is contextual. The studies conducted are often difficult to compare or aggregate, as they use different parameters, variables and analytical tools, and they rarely evaluate the economic situation viability. A few studies with a larger investigation scope are also available, but these are prior to the 1990s. The factors that influence farmers' options can be quite different, having in view the socio-economic transformations that are characteristic to farmers and rural societies nowadays. The challenge is to find common matrices to evaluate and compare the ecological services, agricultural by-products and other externalities. At the same time, the new studies should evaluate how the agro-ecological agriculture influences farmers' incomes and to compare them with other alternative income opportunities.

Furthermore, the way in which farmers manage to put into balance constraints and benefits has not been approached on a constant basis. New research studies are needed on profit, labour productivity and efficiency of resources in the agro-ecological farming practice, as well as on the motivations and factors favouring or constraining the adoption of these practices by farmers. The extent to which different combinations of agro-ecological practices contribute of a resilient and sustainable farming system depends on how farmers can balance a number of constraints – between production and the environmental objectives and between the environmental objectives. This depends on farmers' values and priorities, and also on the institutional support they receive. For the traditional farmers, maybe this is not so much a matter of trade-offs, but rather of consolidating the cultural values and of local institutions that promote traditional practices. The analysis of farmers' decisions to make an option needs a flexible analytical framework, context-specific indicators and focus on farmers' ability to make innovations rather than to adopt innovations. A long-term analysis would be also necessary, taking into consideration the socio-economic dynamics that changes the rural landscape, such as the available agricultural labour, the economic diversification and so on and so forth.

A better understanding of the role of different factors in farmers' decision-making on the agro-ecological options is a first step towards the integration of agro-ecological principles into the agricultural policies and practices. Another important step is to evaluate and balance the existing tensions between farmers' objectives and the social benefits that certain politicians increasingly expect from the agricultural sector (e.g. urban food safety, landscape conservation, soil protection, etc.). For this purpose, it is important to analyse the exogenous constraints to the

adoption of agro-ecological practices and the policy options to surmount them. Surmounting these constraints may involve innovating tools and approaches, such as participatory innovation systems, environmental service payments and landscape conservation subsidies. Relevant policy changes can also refer to ownership relations, natural resource management, support to farmers' organizations, development of local business and markets for agro-ecological products. At the same time, it is very important for all farmers to obtain high and stable yields, and the agro-ecological practices rather target the optimization than the maximization of production and profit. Measuring achievements in terms of optimization of yields and environmental benefits can be a complex activity in reality. Not only that it requires new measurement tools, but also a fundamental cultural and philosophical change – not only by farmers but also by the society as a whole – to understand the „productive" and „efficient" concepts.

4. CONCLUSIONS

Modern agriculture has developed starting from the traditional and natural agriculture towards extremely productive, industrial farming systems that use large amounts of external agricultural inputs, which harm the environment. Such intensive systems mainly focus on production increase, to the detriment of environmental protection.

In the current context of climate change and increasing concerns to support healthy food systems, agro-ecology has gained ground and visibility as scientific discipline, sustainable approach to agricultural practices and social movement. As a science, agro-ecology analyses how the different components of the agro-ecosystems are interacting. As set of practices, it targets those sustainable farming systems that optimize and stabilize the yields. As a social movement, it targets food security/ sovereignty and the multifunctional role of agriculture. Experts do not always reach an agreement on what agro-ecology is or should be. The definitions of the agro-ecology concept are far from the specificity with which the „ecology" concept has been defined, as well as from the potential political connotations of this concept.

The main benefits of the large-scale use of agro-ecology are the increase of environment sustainability, of climate resilience, agro-biodiversity and productivity, optimization of yields and sustainability intensification, alongside with the increase of the living standard and of food sovereignty.

REFERENCES

1. Altieri, M.A., (1995), *Agroecology: The Science of Sustainable Agriculture*, Boulder CO: Westview Press.
2. Codreanu, Carmen, (2007), *Conceptul de agricultură ecologică – bază importantă pentru dezvoltarea agriculturii durabile în România*, http://www.revagrois.ro/PDF/2007s_298.pdf

3. Dalgaard T. *et al*., (2003), *Agroecology, scaling and interdisciplinarity*. Agriculture, Ecosystems & Environment, Volume 100, Issue 1, November 2003: 39–51.
4. De Schutter, O., (2010), *Report submitted by the Special Rapporteur on the right to food to the Human Rights Council at the Sixteenth session of the UN General Assembly*, 20 December 2010. United Nations, New York.
5. FAO, (1998), Evaluating the potential contribution of Organic agriculture to Sustainability goals. Technical Contribution to IFOAM's Scientific Conference, Mare del Plata, Argentina, 16–19 November 1998. http://www.fao.org/docrep/003/ac116e/ac116e03.htm
6. Koohafkan, P., Altieri M.A. and Gimenez. E.H., (2012), Green agriculture: Foundations for biodiverse, resilient and productive agricultural systems. *International Journal of Agricultural Sustainability,* Volume 10, Issue 1.
7. MEA – Millennium Ecosystem Assessment, (2005), *Ecosystems and Human Well-being*, http:// www.millenniumassessment.org/documents/document.356.aspx.pdf
8. OECD, 2003, Glossary of terms, https://stats.oecd.org/glossary/detail.asp?ID=81
9. Silici, L., (2014), *Agroecology. What it is and what it has to offer*, IIED, https://www.researchgate. net/publication/264245203_Agroecology_What_it_is_and_what_it_has_to_offer
10. UNCTAD, (2013), *Trade and Environment Review 2013:Wakeup before it is too late. Make agriculture truly sustainable now for food security in a changing climate*. UNCTAD, Geneva.
11. United Nations (UN), (1987), *Report of the World Commission on Environment and Development: Our Common Future*, ttps://www.are.admin.ch/are/en/home/sustainable-development/ international-cooperation/2030agenda/un-_-milestones-in-sustainable-development/1987--brundtland-report.html
12. Wezel, A. et al., (2009), *Agroecology as a science, a movement or a practice*, A review. Agronomy for Sustainable Development 29: 503–515.
13. Wibbelmann, M. et al., (2013), *Mainstreaming Agroecology: Implications for Global Food and Farming Systems.* Centre for Agroecology and Food Security Discussion Paper. Coventry: Centre for Agroecology and Food Security.
14. www.agroeco.org/socla
15. https://www.globalagriculture.org/report-topics/agroecology.html
16. http://www.bio-romania.org/cat/evenimente/page/13/
17. https://www.ilac.org/
18. www.plantmed.bioagro.ro
19. http://www.fibl.org/en.html
20. http://www.ifoam.org/
21. http://www.fao.org/organicag/en/
22. http://ec.europa.eu/agriculture/organic/organic-farming/what-organic_en
23. http://www.madr.ro/ro/agricultura-ecologica.html
24. http://www.organic-world.net/index.php?id=254&L=0