The term **agroecology** can be used in multiple ways, as a science, as a movement and as a practice [1] . Broadly stated, it is the study of the role of agriculture in the world. Agroecology provides an interdisciplinary framework with which to study the activity of agriculture. In this framework, agriculture does not exist as an isolated entity, but as part of an ecology of contexts. Agroecology draws upon basic ecological principles for its conceptual framework.

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// Ecological strategy

Agroecologists study a variety of agroecosystems, and the field of agroecology is not associated with any one particular method of farming, whether it be organic, conventional, intensive or extensive. Furthermore, it is not defined by certain management practices, such as the use of natural enemies in place of insecticides, or polyculture in place of monoculture.

Additionally, agroecologists do not unanimously oppose technology or inputs in agriculture but instead assess how, when, and if technology can be used in conjunction with natural, social and human assets [2] . Agroecology proposes a context- or site-specific manner of studying agroecosystems, and as such, it recognizes that there is no universal formula or recipe for the success and maximum well-being of an agroecosystem.

Instead, agroecologists may study questions related to the four system properties of agroecosystems: productivity, stability, sustainability and equitability [3] . As opposed to disciplines that are concerned with only one or some of these properties, agroecologists see all four properties as interconnected and integral to the success of an agroecosystem. Recognizing that these properties are found on varying spatial scales, agroecologists do not limit themselves to the study of agroecosystems at any one scale: farm, community, or global.

Agroecologists study these four properties through an interdisciplinary lens, using natural sciences to understand elements of agroecosystems such as soil properties and plant-insect interactions, as well as using social sciences to understand the effects of farming practices on rural communities, economic constraints to developing new production methods, or cultural factors determining farming practices.

Various approaches to agroecology

Agroecologists do not always agree about what agroecology is or should be in the long-term. Different definitions of the term agroecology can be distinguished largely by the specificity with which one defines the term “ecology,” as well as the term’s potential political connotations. Definitions of agroecology, therefore, may be first grouped according to the specific contexts within which they situate agriculture. Agroecology is defined by the OECD as “the study of the relation of agricultural crops and environment.” [4] This definition refers to the "-ecology" part of "agroecology" narrowly as the natural environment. Following this definition, an agroecologist would study agriculture's various relationships with soil health, water quality, air quality, meso- and micro-fauna, surrounding flora, environmental toxins, and other envirnomental contexts.

A more common definition of the word can be taken from Dalgaard et al., who refer to agroecology as the study of the interactions between plants, animals, humans and the environment within agricultural systems. Consequently, agroecology is inherently multidisciplinary, including factors from agronomy, ecology, sociology and economics [5] . In this case, the “-ecology” portion of "agroecology is defined broadly to include social, cultural, and economic contexts as well.

Agroecology is also defined differently according to geographic location. In the global south, the term often carries overtly political connotations. Such political definitions of the term usually ascribe to it the goals of social and economic justice; special attention, in this case, is often paid to the traditional farming knowledge of indigenous populations [6] . North American and European uses of the term sometimes avoid the inclusion of such overtly political goals. In these cases, agroecology is seen more strictly as a scientific discipline with less specific social goals.

Fred Buttel [7] makes a more academic distinction of the various approaches within the field, separating it into five broad categories:

Ecosystems agroecology

This approach is driven by the ecosystems biology of **Eugene Odum**. This approach is based in the hypotheses that the natural systems, with its stability and resilience, provide the best model to mimic if sustainability is the goal. Normally, ecosystems agroecology is not actively involved in social science; however, this school is essentially based on the belief that large-scale agriculture is inappropriate. The work of Steve Gliessman is prototypical of this approach.

Agronomic ecology

The basic approach in this branch is derived mostly from agronomy, including the traditional agricultural production sciences. This approach also does not actively involve social sciences in the agroecological analysis, but uses social sciences to understand the processes by which agriculture became unsustainable. Chuck Francis, Richard Hardwood, Ricardo Salvador, and Matt Liebman are exemplars of this approach.

Ecological political economy

The driving force behind this form of agroecology is a political-economical critique of modern agriculture. The school believes that only radical changes in political economy and the moral economy of research will reduce the negative costs of modern agriculture. The works of Miguel Altieri (ecosystem biologist), John Vandermeer (population ecologist), Richard Lewontin, and Richard Levins provide examples of this politically charged and socially-oriented version of agroecology.

Agro-population ecology

This approach is derived from the science of ecology primarily based on population ecology, which over the past three decades has been displacing the ecosystems biology of Odum. Buttel explains the main difference between the two categories, saying that “the application of population ecology to agroecology involves the primacy not only of analyzing agroecosystems from the perspective of the population dynamics of their constituent species, and their relationships to climate and biogeochemistry, but also there is a major emphasis placed on the role of genetics.” [7] David Andow and Alison Power are cited as examples of professionals espousing this view.

Integrated assessment of multifunctional agricultural systems

This approach focuses on the multifunctionality of the landscape, instead of focusing solely on the agricultural enterprise. Agriculture and the food system are considered parts of an institutional complex that relates to and integrates with other social institutions. Scholars adopting this highly integrated approach, mostly Europeans, do not consider any one discipline the leader of agroecology.

Holon agroecology

First introduced in 2007 by the soil scientist William T. Bland and the environmental sociologist Michael M. Bell of the University of Wisconsin–Madison, [8] holon agroecology draws on Koestler's notion of a "holon" which is both part and whole and develops it with ideas of narrative, intentionality, and incompleteness or unfinalizability, within an ever-changing "ecology of contexts". In contrast to systems thinking, holon agroecology stresses seeing the agricultural endeavor as an unfinished accomplishment that is constantly adjusting itself to its many contexts and their conflicts and incommensurabilities. The farm holon represents a kind of "holding together" in order to persist through change, but a holding together that is never fully unified and worked out.

History of agroecology

Pre-WWII

The notions and ideas relating to crop ecology have been around since at least 1911 when **F.H. King** released *Farmers of Forty Centuries*. King was one of the pioneers as a proponent of more quantitative methods for characterization of water relations and physical properties of soils [9]. In the late 1920s the attempt to merge agronomy and ecology was born with the development of the field of crop ecology. Crop ecology's main concern was where crops would be best grown [10]. Actually, it was only in 1928 that agronomy and ecology were formally linked by Klages [9] [11].

1928 was the first mention of the term agroecology, with the publication of the term by Bensin in 1928 [12]. The book of Tischler (1965), was probably the first to be actually titled 'agroecology' [13]. He analysed the different components (plants, animals, soils and climate) and their interactions within an agroecosystem as well as the impact of human agricultural management on these components. Other books dealing with agroecology, but without using the term explicitly were published by the German zoologist Friederichs (1930) with his book on agricultural zoology and related ecological/environmental factors for plant protection [14] and by American crop physiologist Hansen in 1939 [15] when both used the word as a synonym for the application of ecology within agriculture [5].

Post-WWII

Gliessman mentions that post-WWII, groups of scientists with ecologists gave more focus to experiments in the natural environment, while agronomists dedicated their attention to the cultivated systems in agriculture [10]. According to Gliessman [10], the two groups kept their research and interest apart until books and articles using the concept of agroecosystems and the word agroecology started to appear in 1970 [12]. Dalgaard [5] explains the different points of view in ecology schools, and the fundamental differences, which set the basis for the development of agroecology. The early ecology school of **Henry Gleason** investigated plant populations focusing in the hierarchical levels of the organism under study.

Friederich Clement's ecology school, however included the organism in question as well as the higher hierarchical levels in its investigations, a "landscape perspective". However, the ecological schools where the roots of agroecology lie are even broader in nature. The ecology school of **Tansley**, whose view included both the biotic organism and their environment, is the one from which the concept of agroecosystems emerged in 1974 with Harper [5] [16] .

In the 1960s and 70's the increasing awareness of how humans manage the landscape and its consequences set the stage for the necessary cross between agronomy and ecology. Even though, in many ways the environmental movement in the US was a product of the times, the Green Decade spread an environmental awareness of the unintended consequences of changing ecological processes. Works such as *Silent Spring*, and *The Limits to Growth*, and changes in legislation such as the Clean Air Act, Clean Water Act, and the National Environmental Policy Act caused the public to be aware of societal growth patterns, agricultural production, and the overall capacity of the system [5] .

Fusion of agronomy and ecology

After the 1970s, when agronomists saw the value of ecology and ecologists began to use the agricultural systems as study plots, studies in agroecology grew more rapidly [10] . Gliessman describes that the innovative work of Prof. Efraim Hernandez X., who developed research based on indigenous systems of knowledge in Mexico, led to education programs in agroecology. [17]

In 1977 Prof. Efraim Hernandez X. explained that modern agricultural systems had lost their ecological foundation when socio-economic factors became the only driving force in the food system [9] . The acknowledgement that the socio-economic interactions are indeed one of the fundamental components of any agroecosystems came to light in 1982, with the article Agroecologia del Tropico Americano by Montaldo. The author argues that the socio-economic context cannot be separated from the agricultural systems when designing agricultural practices [9] .

In 1995 Edens et al. in Sustainable Agriculture and Integrated Farming Systems solidified this idea proving his point by devoting special sections to economics of the systems, ecological impacts, and ethics and values in agriculture [9] . Actually, 1985 ended up being a fertile and creative year for the new discipline. For instance in the same year, Miguel Altieri integrated how consolidation of the farms, and cropping systems impact pest populations. In addition, Gliessman highlighted that socio-economic, technological, and ecological components give rise to producer choices of food production systems [9] . These pioneering agroecologists have helped to frame the foundation of what we today consider the interdisciplinary field of agroecology.

Publications in agroecology

[18]

Year	Author(s)	Title
1928	Klages	Crop ecology and ecological crop geography in the
1939	Hanson	Ecology in agriculture
1956	Azzi	Agricultural ecology
1965	Tischler	Agrarökologie
1973	Janzen	Tropical agroecosystems
1974	Harper	The need for a focus on agro-ecosystems
1976	Loucks	Emergence of research on agroecosystems
1977	Hernanez Xolocotzi	Agroecosistemas de Mexico
1978	Gliessman	Agroecosistemas y tecnologia agricola tradicional
1979	Hart	Agroecosistemas: conceptos básicos
1979	Cox & Atkins	Agricultural ecology: an analysis of world food prod
1980	Hart	Agroecosistemas
1981	Gliessman, Garcia & Amador	The ecological basis for the application of tradition
1982	Montaldo	Agroecologia del trópico americano
1983	Altieri	Agroecology
1984	Lowrance, Stinner & House	Agricultural ecosystems: unifying concepts
1985	Conway	Agroecosystems analysis
1987	Altieri	Agroecology: the scientific basis of alternative agri
1990	Allen, Dusen, Lundy, & Gliessman	Integrating social, environmental, and economic is
1990	Gliessman	Agroecology: researching the ecological basis for s
1990	Carroll, Vandermeer & Rosset	Agroecology
1990	Altieri & Hecht	Agroecology and small farm development
1991	Caporali	Ecologia per l'agricultura
1991	Bawden	Systems thinking in agriculture
1993	Coscia	Agricultura sostenible
1998	Gliessman	Agroecology: ecological processes in sustainable a

2001	Flora	Interactions between agroecosystems and rural co
2001	Gliessman	Agroecosystem sustainability
2002	Dalgaard, Porter & Hutchings	Agroecology, scaling, and interdisciplinarity
2003	Francis et al.	Agroecology: The Ecology of Food Systems
2004	Clements, Shrestra	New Dimension in Agroecology
2007	Bland and Bell	A Holon Approach to Agroecology
2007	Gliessman	Agroecology: The Ecology of Sustainable Food Sy
2007	Warner	Agroecology in Action
2009	Wezel, Soldat	A quantitative and qualitative historical analysis of
2009	Wezel et al.	Agroecology as a science, a movement or a practi

Applications of agroecology

To emit a point of view about a particular way of farming, an agroecologist would first seek to understand the contexts in which the farm(s) is(are) involved. Each farm may be inserted in a unique combination of factors or contexts. Each farmer may have their own premises about the meanings of an agricultural endeavor, and these meanings might be different than those of agroecologists. Generally, farmers seek a configuration that is viable in multiple contexts, such as family, financial, technical, political, logistical, market, environmental, spiritual. Agroecologists want to understand the behavior of those who seek livelihoods from plant and animal increase, acknowledging the organization and planning that is required to run a farm.

How agroecologists might see organic and non-organic milk production

Because organic agriculture proclaims to sustain the health of soils, ecosystems and people [19], it has much in common with Agroecology; this doesn't mean that Agroecology is the same as organic agriculture or that Agroecology sees organic farming as the right way of farming, though. Also, it is important to point out that there are large differences in organic standards among countries and certifying agencies.

Three of the main areas that agroecologists would look at in farms, would be: the environmental impacts, animal welfare issues, and the social aspects.

Environmental impacts caused by organic and non-organic milk production can vary significantly. For both cases, there are positive and negative environmental consequences.

Compared to conventional milk production, organic milk production tends to have lower eutrophication potential per ton of milk or per hectare of farmland, because it potentially reduces leaching of nitrates (NO_3^-) and phosphates (PO_4^-) due to lower fertilizer application rates. Because organic milk production reduces pesticides utilization, it increases land use per ton of milk due to decreased crop yields per hectare. Mainly due to the lower level of concentrates given to cows in organic herds, organic dairy farms generally produce less milk per cow than conventional dairy farms. Because of the increased use of roughage and the, on-average, lower milk production level per cow, some research has connected organic milk production with increases in the emission of methane [20] .

Animal welfare issues vary among dairy farms and are not necessarily related to the way of producing milk (organically or conventionally).

A key component of animal welfare is freedom to perform their innate (natural) behavior, and this is stated in one of the basic principles of organic agriculture. Also, there are other aspects of animal welfare to be considered - such as freedom from hunger, thirst, discomfort, injury, fear, distress, disease and pain. Because organic standards require loose housing systems, adequate bedding, restrictions on the area of slatted floors, a minimum forage proportion in the ruminant diets, and tend to limit stocking densities both on pasture and in housing for dairy cows, they potentially promote good foot and hoof health. Some studies show lower incidence of placenta retention, milk fever, abomasums displacement and other diseases in organic than in conventional dairy herds [21] . However, the level of infections by parasites in organically managed herds is generally higher than in conventional herds [22]
.

Social aspects of dairy enterprises include life quality of farmers, of farm labor, of rural and urban communities, and also includes public health.

Both organic and non-organic farms can have good and bad implications for the life quality of all the different people involved in that food chain. Issues like labor conditions, labor hours and labor rights, for instance, do not depend on the organic/non-organic characteristic of the farm; they can be more related to the socio-economical and cultural situations in which the farm is inserted, instead.

As for the public health or food safety concern, organic foods are intended to be healthy, free of contaminations and free from agents that could cause human diseases. Organic milk is meant to have no chemical residues to consumers, and the restrictions on the use of antibiotics and chemicals in organic food production has the purpose to accomplish this goal. But dairy cows in organic farms, as in conventional farms, indeed do get exposed to virus, parasites and bacteria that can contaminate milk and hence humans, so the risks of transmitting diseases are not eliminated just because the production is organic.

In an organic dairy farm, an agroecologist could evaluate the following:

1. can the farm minimize environmental impacts and increase its level of sustainability, for instance by efficiently increasing the productivity of the animals to minimize waste of feed and of land use?

2. are there ways to improve the health status of the herd (in the case of organics, by using biological controls, for instance)?

3. does this way of farming sustain good quality of life for the farmers, their families, rural labor and communities involved?

Agroecologists' view of no-till farming

No-tillage is one of the components of conservation agriculture practices and is considered more environmental friendly than complete tillage [23] [24] . Due to this belief, it could be expected that agroecologists would not recommend the use of complete tillage and would rather recommend no-till farming, but this is not always the case. In fact, there is a general consensus that no-till can increase soils capacity of acting as a carbon sink, especially when combined with cover crops [23] [25] .

No-till can contribute to higher soil organic matter and organic carbon content in soils [26] [27] , though reports of no-effects of no-tillage in organic matter and organic carbon soil contents also exist, depending on environmental and crop conditions [28] . In addition, no-till can indirectly reduce CO_2 emissions by decreasing the use of fossil fuels [26]

[29]

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Most crops can benefit from the practice of no-till, but not all crops are suitable for complete no-till agriculture [30] [31] . Crops that do not perform well when competing with other plants that grow in no-tilled soil in their early stages can be best grown by using other conservation tillage practices, like a combination of strip-till with no-till areas [31] . Also, crops which harvestable portion grows underground can have better results with strip-tillage, mainly in soils which are hard for plant roots to penetrate into deeper layers to access water and nutrients.

The benefits provided by no-tillage to predators may lead to larger predator populations [32] , which is a good way to control pests (biological control), but also can facilitate predation of the crop itself. In corn crops, for instance, predation by caterpillars can be higher in no-till than in conventional tillage fields
[33]

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In places with rigorous winter, no-tilled soil can take longer to warm and dry in spring, which may delay planting to less ideal dates [34] [35] . Another factor to be considered is that organic residue from the previous years crops laying on the surface of no-tilled fields can provide a favorable environment to pathogens, helping to increase the risk of transmitting diseases to the future crop. And because no-till farming provides good environment for pathogens, insects and weeds, it can lead farmers to a more intensive use of chemicals for pest control. Other disadvantages of no-till include underground rot, low soil temperatures and high moisture.

Based on the balance of these factors, and because each farm has different problems, agroecologists will not atest that only no-till or complete tillage is the right way of farming. In fact, these are not the only possible choices regarding soils preparation, since there are intermediate practices such as strip-till, mulch-till and ridge-till, all of them - just as no-till - categorized as conservation tillage. Agroecologists, then, will evaluate the need of different practices for the contexts in which each farm is inserted.

In a no-till system, an agroecologist could ask the following:

1. Can the farm minimize environmental impacts and increase its level of sustainability; for instance by efficiently increasing the productivity of the crops to minimize land use?

2. Does this way of farming sustain good quality of life for the farmers, their families, rural labor and rural communities involved?

Agroecology by region

The principles of agroecology are expressed differently depending on local ecological and social contexts.

Latin America and agroecology

Main article: Agroecology in Latin America

Latin America's experiences with North American Green Revolution agricultural techniques have opened space for agroecologists. Traditional or indigenous knowledge represents a wealth of possibility for agroecologists, including "exchange of wisdoms." See Miguel Alteiri's *Enhancing the Productivity of Latin American Traditional Peasant Farming Systems Through an Agroecological Approach* for information on agroecology in Latin America.

Madagascar and agroecology

Main article: Agroecology in Madagascar

Most of the historical farming in Madagascar has been conducted by indigenous peoples. The French colonial period disturbed a very small percentage of land area, and even included some useful experiments in sustainable forestry. Slash-and-burn techniques, a component of some shifting cultivation systems have been practised by natives in Madagascar for centuries. As of 2006 some of the major agricultural products from slash-and-burn methods are wood, charcoal and grass for Zebu grazing. These practices have taken perhaps the greatest toll on land fertility since the end of French rule, mainly due to overpopulation pressures.

See also

Agriculture | Agriculture in Concert with the Environment | Agroecological restoration | Agroecosystem
|
Agroecosystem analysis
|
Agronomy
|

Agrophysics
|
applied ecology
|
biodynamics
|
biological pest control
|
Community-supported agriculture
|
Conventional agriculture
|
dynamic equilibrium
|
Ecology
|
Ecology of contexts
|
Edaphology
|
Environmental economics
|
Environmental impact assessment
|
Extensive farming
|
Farmer Field School (FFS)
|
forest gardening
|
food desert
|
Food sovereignty
|
food security
|
Food systems
|
Genetic Erosion
|
Homeodynamic agriculture
|
Intercropping
|
industrial agriculture
|

Integrated Pest Management
|
intensive farming
|
Landscape Ecology
|
Life cycle analysis
|
Malnutrition
|
Managed intensive grazing
|
Masanobu Fukuoka
|
Permaculture
|
pollinator decline
|
Polyculture
|
Monoculture
|
organic agriculture
|
Rural Sociology
|
secondary succession
|
Shifting cultivation
|
Sociology
|
Soil Science
|
Traditional Knowledge
|
Urban Agriculture

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- Soil Organic Matter in Sustainable Agriculture (Advances in Agroecology) by Fred Magdoff and Ray R. Weil (Hardcover - May 27, 2004)
- Agroforestry in Sustainable Agricultural Systems (Advances in Agroecology) by Louise E. Buck, James P. Lassoie, and Erick C.M. Fernandes (Hardcover - Oct 1, 1998)
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