Agroecology and Circular Bioeconomy

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CHAPTER 2

ABSTRACT

Results provided by a panel of experts reveal that some of the vital challenges facing Agroecology in the near future involve its contribution to Climate Action, to increasing biodiversity or to the co-creation of knowledge by researchers and farmers, as well as the application of criteria of Circular Bioeconomy to agro-food production and distribution. Other noteworthy challenges refer to the design of agroecosystems at landscape scale or the creation of agroecological local food systems enabling an upscaling of production and consumption.

KEYWORDS

agroecology | agroecosystems | agricultural landscapes | climate action | biodiversity | circular bioeconomy | co-creation of knowledge | local agro-food systems | upscaling

CHAPTER 2

AGROECOLOGY AND CIRCULAR BIOECONOMY

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EXECUTIVE SUMMARY

Agroecology involves a transdisciplinary scientific approach that attempts to conduct holistic research of the interrelations among the agronomic, biophysical, ecological, social, cultural, economic and political components of agroecosystems. It integrates three dimensions, as a research discipline: (i) the first of these is of a technical-productive nature and focuses on the design of agroecosystems, with Ecology as a scientific reference framework and in harmony with peasant knowledge; ii) a second dimension addresses the cultural and socioeconomic analysis of the agro-food system from a territorial perspective; and iii) a third political dimension, food sovereignty, attempts to reinterpret the analysis of power (economic, decisional, etc.) in the agro-food system. The Circular Bioeconomy, which results from a symbiosis between Ecology and Economy, adopts a series of principles that it shares with Agroecology: using renewable resources, maximising efficiency in the use of resources and maximum possible reutilisation of waste.

A methodology produced by a panel of experts specifies and defines the challenges to which Agroecology and the Circular Bioeconomy must respond in the near future. These challenges are classified in six main axes: i) the design of sustainable agroecosystems at landscape scale; ii) Agroecology and Climate

Action; iii) Circular Bioeconomy in agro-food systems; iv) Agroecology and promotion of biodiversity; v) co-production and dissemination of agroecological knowledge; vi) agroecological local food systems and upscaling.

There exists a need to promote the transdisciplinary confluence of researchers specialised in the different areas pertaining to the Environmental, Agronomic, Food and Social Sciences, in order to address the current socioeconomic and environmental issues relating to agriculture and sustainable food production. At the present time, the CSIC avails of no institute or department specialised in Agroecology or in the Circular Bioeconomy, following the disappearance in 2010 of the Agroecology Dept. of the former Centre of Environmental Sciences of Madrid. Nonetheless, with regard to the challenges put forward, the institution does avail of groups and experts in different fields who could work in coordinated research teams in Agroecology and the Circular Bioeconomy, if a nexus were to exist for scientific articulation at the platform, programme or project levels.

1. INTRODUCTION AND GENERAL DESCRIPTION

Agroecology involves a transdisciplinary scientific approach that attempts to investigate in a holistic manner the interrelations among the agronomic, biophysical, ecological, social, cultural, economic and political components of agroecosystems. Agroecology attempts to analyse agro-food activities from an ecological stance, but it also provides a transversal vision to the analysis of local agro-food systems, which interrelates several different disciplines belonging to the agronomic, environmental and social sciences.

Agroecology, as a research approach, integrates three dimensions (López and Álvarez, 2018): (i) the first of these is of a technical-productive nature and focuses on the design of agroecosystems, with Ecology as a scientific reference framework and in harmony with peasant knowledge; ii) a second dimension addresses the cultural and socioeconomic analysis of the agro-food system from a territorial perspective; and iii) a third political dimension, food sovereignty, attempts to reinterpret the analysis of power (economic, decisional, etc.) in the agro-food system.

Apart from constituting a scientific approach, Agroecology involves the application of a series of practices aimed at sustainable growth and production of foodstuffs, and at constituting a social movement that demands better objective conditions for farmers (and small rural agro-industries) and attempts to make sustainable and healthy food a basic right of all citizens. This triple vision, as a discipline, a combination of agro-food practices and a social movement, is broadly covered in the literature (Wezel et al., 2009). This vision clearly promotes the eminently empirical nature of learning in Agroecology, which, as a specific disciplinary feature, results from the hybridisation between peasant knowledge and scientific knowledge.

The international literature defines a series of principles to which agroecological practices must respond (Altieri, 1995; Gliessman, 2015; Guzmán et al., 2000; Nicholls et al., 2015). The increase in functional biodiversity of agroecosystems strengthens their “immune system”, making them more resilient to changing patterns of precipitation and temperature. Based on the principle of closure of biogeochemical cycles, improvements in biomass recycling and soil fertility also constitute key elements in agroecological praxis, for which there is a need to optimise the decomposition of organic matter, recycling of nutrients and balance of moisture occurring in agriculture and livestock farming. Conservation and enhancement of genetic resources, energy, nutrients and water is essential for the sustainable functioning of agroecosystems. Promoting the biological interactions and the synergies existing between the components of agricultural diversity constitutes another fundamental principle of agroecological farming. Another objective involves a drastic reduction of external inputs and energy dependence, which means that producers start by reducing their level of economic vulnerability.

With regard to the principles governing practices other than those relating to farming (commercial, organisational, etc.), agroecological initiatives usually involve marketing in commercially and geographically short chains, in an attempt to reduce the large amount of materials and non-renewable energy consumed by the current food system, which is largely based upon long-distance food chains. Promoting reconnection between producers and consumers has always been a priority in the ideology of agroecological experiences: farmers' wellbeing is considered to constitute an attribute in consumers' preferences. Local agroecological initiatives tend to adopt models of flexible organisation, proposing a functioning that responds to criteria of self-organisation, participatory democracy and bottom-up decision-making systems. Other common features of many agroecological experiences involve promoting links with the local culture or creating local networks for dissemination of knowledge among producers, consumers, activists and academics.

Bioeconomy, as a scientific approach resulting from a certain symbiosis between Ecology and Economy, makes a significant change in the economic paradigm because, rather than exclusively optimising competitiveness or company profitability, it prioritises conservation of biological resources beyond the production cycle itself, as well as ecological optimisation in the use of resources. This discipline aims to study the series of economic activities that make use of biological resources as basic elements: this includes agriculture, forestry, fisheries, food production and paste and paper production, as well as certain parts of the chemical, biotechnological and energy industries. Consequently, a significant segment of the bioeconomic activities involves agriculture and livestock farming, forestry or food production. A governing principle of Bioeconomy entails replacing fossil-based materials and energy with renewable alternatives, a concept fully incorporated into the agroecological paradigm.

Furthermore, the Circular Economy attempts to reduce consumption of resources by promoting a more efficient use of materials and energy through reuse and recycling of waste. Agroecology aims to close cycles at a maximum geographical scale, such as that of agriculture and livestock farming. In summary, the goals of the Circular Bioeconomy (D'Amato et al., 2017; World Business Council for Sustainable Development, 2019) are shared by Agroecology: utilization of renewable resources, maximising the efficient use of resources and maximum possible reuse of waste, all of which leads to an improvement in the emissions balance by the agro-food system as a whole. The challenges in research in the Circular Bioeconomy referring to agriculture, livestock farming, forestry and food production, could be deemed to be included within the scope of the challenges facing Agroecology. Nevertheless, the fact that it appears explicitly in the denomination "Agroecology and Circular Bioeconomy" serves to highlight the importance of employing renewable and circular resources in the future of agriculture and food production.

In order to define and develop the principle challenges for the future in the fields of Agroecology and the Circular Bioeconomy, a panel of experts was created, comprising two coordinating researchers and twelve other investigators. The experts were selected in such a way that they all possessed a transversal vision close to that of Agroecology and the Circular Bioeconomy, from different areas of specialisation (within spheres such as Agronomy, Ecology, Food Sciences or the Social Sciences): soils, plant biodiversity, agroforestry systems, extensive livestock farming, composting and waste recycling, biogeography, archaeobiology, history, economy, anthropology and sociology. Eleven of the panel members were researchers from the CSIC and three were external. The latter were chosen to participate due to being renowned experts in Agroecology with vast experience in the transdisciplinary work inherent to this discipline.

Two rounds of consultation were extended in writing to the experts. In the first of these, they were requested to indicate the three main challenges they considered science was facing in the scope of Agroecology and the Circular Bioeconomy, with a brief justification of their choices. Having compiled and integrated all their answers, the coordinators drew up an initial report that grouped the proposed challenges in a rational manner into six main challenges, in turn subdivided into sub-challenges. This report constituted the basis for the second round of consultations, which entailed asking the experts to develop and specify further the sub-challenges indicated; additionally, they were also asked to provide information on the vision and the research resources of the CSIC concerning the different challenges and sub-challenges. Moreover, the coordinators contacted the specific experts on the panel on several occasions to develop or clarify specific aspects of the project. Lastly, the preliminary version of the project was reviewed by the experts.

2. IMPACT ON BASIC SCIENCE AND POTENTIAL APPLICATIONS

Basic science is conceived as fundamental research conducted without any immediate practical application; it is intended to bolster our knowledge of the fundamental principles of nature or of reality. On the contrary, Agroecology and the Circular Bioeconomy are considered to fall within the general scope of the applied sciences. Agroecology, due to its transdisciplinary nature, serves to articulate a relational structure between the Basic Sciences, such as Biology, Agronomy or Economy, among others, and therefore makes use of innovations from these disciplines. The co-production of scientific and peasant knowledge means that the conceptual development of Agroecology is based on results provided by an empirical reality. The comparative analysis of multiple empirical experiences becomes a necessary input with regard to formulating a theoretical analysis, because local agroecosystems and agro-food local systems respond to an environment with high multivariable diversity, a fact that implies different combinations of environmental, agrologic, agro-industrial, cultural or socioeconomic variables.

The challenges facing Agroecology and the Circular Bioeconomy proposed in the present chapter are in line with the scientific-technical, social and innovation objectives and priorities of CHALLENGE 2 of the Spanish Strategy for Science, Technology and Innovation 2013-2020, denominated *Food safety and quality, productive and sustainable agriculture, sustainability of natural resources, marine, maritime and inland waterway research*. This challenge highlights the particular relevance for Spain of aspects related to sustainable management and protection of agricultural, livestock farming and forestry resources, as well as the need to promote innovation and collaboration with small companies in the agro-food sector, in order to adopt a production model that is sustainable and efficient in relation to resources. The challenges put forward can also contribute to respond to some of the thematic priorities of CHALLENGE 5 *Climate Action and efficiency in the use of resources and raw materials*, which highlights climate change as one of the major threats to our society, and calls for efforts to strengthen our scientific knowledge of the causes and effects in Spain, due to the high climatic vulnerability of the country. Specifically, the challenges are in line with the goals of Challenge 5 that involve adaptation to climate change of agricultural and forestry systems, reduction of erosion and desertification risks, and conservation of biodiversity and natural heritage.

Within the European framework, the research challenges proposed will contribute to complying with the objectives and commitments identified in the

European Green Deal (*European Green Deal,* COM/2019/640 final), which constitutes the EU's major strategy for management and conservation of natural resources, aimed at rendering the EU climatically neutral by 2050. Specifically, this deal encompasses the Strategy for Biodiversity for 2030 (*Bring nature back into our lives*), which considers a Nature Recovery Plan whose objectives include a significant extension of agroecological objectives, an increase of the percentage of agricultural land managed under organic agriculture systems, and the promotion of local employment. Likewise, the Commission proposes that 10% of agricultural land be re-occupied by highly diverse landscapes, emphasising the need to reconcile agricultural production and biodiversity conservation, which is in accordance with the principles of Agroecology. The challenges addressed in the present chapter are also intended to help promote other major strategy included in the European Green Deal, called the *From farm to fork strategy*, aimed at creating healthy and sustainable food systems. The goals of this strategy include the development of an integrated plan of nutrient management intended to reduce the use of fertilisers and to promote the recycling of organic waste, as well as a plan of organic agriculture that stimulate both supply of and demand for organic products. All these aspects are considered in the following scientific challenges.

3. SCIENTIFIC CHALLENGES

3.1. Design of sustainable agroecosystems at landscape scale

In order to strengthen the sustainability of agroecosystems, on one hand there is a need to enhance the quality of its biophysical components, which have been transformed over time because of certain interrelations with the cultural and socioeconomic environment. On the other hand, however, agroecosystems must become capable of maintaining long-term biomass production without increasing external energy inputs, and this can only be achieved through a change in land management aimed at closing the main biogeochemical cycles at landscape scale. Research methodologies based upon participatory planning proposed from an agroecological perspective are essential to address the design at the landscape scale, and to make advances in the co-production of systems of indicators that allows comparing among highly diverse regions and local agro-food systems. Advances in this kind of methodologies would be very useful for the land management policies of local and regional administrations; an example of this involves the optimum location of nodes for last mile logistics.

3.1.1. Enhanced quality of fund elements of biophysical, socioeconomic and cultural nature

The flow-fund model is an analytical method of Ecological Economics devoted to study the process of production (Georgescu-Roegen, 1971). Funds are those elements that enter and leave the process, providing certain services over a given period, but they are never physically incorporated into the product (Vitucci Marzetti, 2010). Soil, biodiversity or the water cycle are biophysical fund elements of the agroecosystem.

Redesigning the uses of a territory's biomass under agroecological criteria means that the flows of energy, nutrients and water that sustain agricultural production must enable reproduction of biophysical fund elements. There is still a need for research based upon agroecological criteria on aspects such as correcting soil erosion, the risk of desertification or soil fertility. In this context, the application of methods of bio-intensification and of extensification can provide a wide range of versatile adaptive solutions. Furthermore, there is a need for more legume crops in our agroecosystems due to the role they play in providing nitrogen and restoring soil fertility.

Additionally, there is a need to improve the quality of the socioeconomic and cultural fund elements of the agroecosystem, as these are closely linked to the biophysical factors. Farmers and small and medium-sized agro-industries are usually price takers in the conventional globalized food system. Therefore, gaining control of the information flows of the food chain or being capable of deciding on food prices become crucial socioeconomic fund elements. Control of suitable genetic material for sowing, which involves exchanging and freely marketing traditional seeds, is an aspiration of producers in order to attain economic independence. A vital mission in Agroecology involves working on improving farmers' participation in research programs, since autochthonous varieties of crops and livestock races possess information flows that are adapted to local agro-environmental conditions.

3.1.2. Research on closing of biogeochemical cycles at landscape scale

Conventional intensive agriculture has simplified and degraded the quality of agricultural landscapes, a fact that has given rise to a loss of biodiversity and of biocultural heritage. There is a need to promote basic environmental services from within the agroecosystems, because functions such as conservation of genetic diversity, control of pests and diseases, or restoration of soil fertility are generally provided from outside the system. Optimum provision of these services requires, besides sustainable management of farms, a redesigning of agricultural landscapes, which calls for a balanced series of commitments and collective agreements by local societies.

Nonetheless, land design and management on a larger scale than that of farms require the application of an articulated body of empirical agroecological knowledge, which has just started to be generated in the last decades. To address this challenge, there is a need to consolidate and extend an agroecological proposal that is rooted in the Landscape Sciences, the geographical scope of which also includes agronomic, food, environmental, cultural, social and economic approaches. This objective, which is coherent with the commitment of the European Commission to the Circular Bioeconomy, corresponds to the third priority of the five strategies defined in the *European Strategy for Agricultural Research and Innovation:* this emphasises the need for "integrated ecological approaches from the farm to the landscape level".

3.2. Agroecology and Climate Action

Climate change implies an increase in temperatures, less rainfall, a higher frequency of extreme climatic events, and longer-lasting and more severe fires. All these factors will seriously affect the productivity of agriculture, forestry and livestock farming systems, which could cause a drastic change or even the disappearance of production and socioeconomic systems. Indeed, the Intergovernmental Panel on Climate Change (IPCC) has stated that Mediterranean ecosystems will become some of the world's most vulnerable systems in the coming years. A priority challenge therefore involves researching the role of Agroecology with regard to adaptation of Mediterranean agroecosystems to future climatic scenarios, as well as to their capacity to mitigate climate change.

3.2.1. Design of strategies for adaptation to future climate scenarios

It is a world priority to design farming strategies that involve less and more efficient use of water resources, in view of a hotter and drier future climate. To this end, there is a need to prioritise the use of crop species and varieties with a conservative water use strategy, giving a leading role to dry-farming crops and to livestock breeds that are adapted to the Mediterranean climate. Appropriate selection of species and varieties must be accompanied by a whole series of agroecological practices aimed at improving water storage in soils, such as slope correction using terraces, increase of soil organic matter, use of cover crops, or the establishment of agroforestry systems that take advantage of the benefits provided by trees (i.e. higher infiltration, less erosion, improved microclimate). There is a vital need to promote research into the adaptation of the different agroecological systems to lower water consumption.

3.2.2. Design of agroecological strategies for mitigating climate change

The agro-food system is one of the main sources of greenhouse gas (GHG) emissions. According to the last National Inventory of GHG emissions (Ministry of Ecological Transition 2020, data from 2018), the agriculture and livestock farming sectors alone represent 12% of total national emissions. In the European Union, agriculture and livestock farming are responsible for 10% of the GHG emissions (European Environment Agency, data from 2017), a percentage which at global level is 10.8 % (FAOSTAT, data from 2017). However, this figure only contemplates direct emissions from lands used for agriculture and livestock farming. If we also consider the emissions associated with transport and logistics of agricultural raw materials and food, the food industry, the transformation of forests to croplands, or with the energy used to produce agricultural inputs and machinery, we will see a sharp rise in the percentage of emissions corresponding to the agro-food system as a whole. Indeed, FAOSTAT estimates that by 2017 and at global level, if we include the emissions only from agriculture, livestock farming, forestry and certain other land uses (i.e. ploughing of forests), then the agro-food system represents 19.8% of the GHG emissions.

Agroecology aims to turn agriculture into a carbon sink to compensate for the emissions generated by the rest of the agro-food system, which in turn needs to be minimised (Altieri et al. 2005, Aguilera et al. 2020). Within this strategy, there is a need to investigate, promote and measure the agroecological practices that minimise emissions of GHG, which in turn entails maximising the capacity of agricultural soils to act as carbon sinks by means of, for instance, reusing organic waste or increasing biodiversity. Several international organizations are becoming increasingly interested in research on reserves and territorialised alternatives for carbon sequestration in agricultural soils: one of the initiatives with the clearest repercussions is the 4x1000 initiative, launched in the COP-21 by the French government and to which numerous countries have adhered, including Spain. This challenge is of a clearly political and economic nature, and it can be channelled by means of direct subsidies for agroecological practices promoting carbon sequestration without increasing emissions of N2O or CH4.

3.2.3. Interaction between climate change and other biotic stress factors: pests and diseases

Climate change can affect primary production not only in a direct manner by altering precipitation and temperature patterns, but also indirectly through its impacts on pests and diseases. A challenge involves evaluating the indirect consequences of climate change for primary production resulting from foreseeable losses associated with a higher incidence of pathogens. It is also a priority to base possible solutions upon a holistic approach, which goes beyond the conventional study of isolated interactions between host and pathogen, and which considers the health of the ecosystem as a whole. This approach should contemplate aspects such as conserving the diversity of trophic interactions, or the role played by the microbiome as a regulator and promoter of plant and animal health under stress conditions.

3.3. Circular Bioeconomy in agro-food systems

The concept of circularity proposes to make advances towards a state of "zero waste" for the entire agro-food system, through the re-circulation of water and the nutrients contained in the waste generated in the different phases of the food chain (manure and organic waste from agriculture, the agro-food industry, food distribution and consumption). Carbon, nitrogen, phosphorous, potassium or sulphur (CNPKS) constitute vital macronutrients that play a crucial role in plant nutrition and agricultural production. This re-circulation of nutrients is essential in order to substitute synthetic fertilisers. Some of these nutrients, like phosphorous, are extracted by non-renewable mining and others, like nitrogen, require a huge amount of energy to be obtained, thus causing numerous environmental problems such as aquifer pollution or N2O emissions. The broader challenge therefore involves identifying and disseminating the best techniques and practices for recycling bio-waste materials and recovering the respective nutrients, as well as investigating their corresponding socioeconomic implications and opportunities.

3.3.1. Making estimations of circularity at territorial scale

Any model of circular economy that is to persist in time on a planet with limited resources will have to address the behaviour of the CNPKS flows, and must ask how they are obtained and at what cost. In this sense, researchers propose to calculate the amounts of organic matter and nutrients entering and exiting a given geographic space, as in the case of large or small urban areas. Agro-food inputs account for a substantial proportion of the flows entering the metabolism of any territory. As for the flows exiting the territory, several main routes have been distinguished, such as bio-waste from agriculture, livestock farming and the food industry, excrements produced by the inhabitants and channelled through drainage systems to purifying plants, and the biomass from pruning and mowing in agricultural and public parks. The entry and exit flows of organic matter and nutrients can be estimated with the use of sociodemographic information at a municipal level. In this sense, the principal challenge involves in-depth research into the design of quantitative estimation models to calculate the entry and exit flows in a territory, using mechanisms for monitoring of real CNPKS flows. This will become essential to design local policies aimed at promoting circularity of materials and nutrients. This type of research would provide information on the advantages of different production options in a territory in terms of energy consumption or reduction of GHG emissions.

3.3.2. Establishing new uses for waste from agriculture, livestock farming and the food industry

It is highly necessary to investigate new uses for waste and sub-products from agriculture, livestock farming and the food industry, in order to diversify agro-food activities in a more economically and ecologically efficient manner, and to broaden the range of most commonplace uses (composting on the farm or the collection of organic matter for centralised compost production). We can highlight the following research lines: i) optimisation of the use of energy obtained from waste, such as anaerobic digestion, enzymatic hydrolysis or thermal treatments including pyrolysis or hydrothermal carbonisation; ii) production of fertilisers from organic waste by means of new bio-nanotechnological processes (those employing microorganisms, insects and annelids), extraction of phosphorous from wastewaters and ash, or the use of membranes for extracting nutrients from sludge and; iii) the use of organic waste for feeding invertebrate farms that produce protein for animal consumption. An evaluation of the eco-efficiency of all the former research lines must be made:

3.4. Agroecology and promotion of biodiversity

The strategies of intensification and specialisation in food production have caused a drastic reduction of specific and genetic biodiversity of agriculture, forestry and livestock farming. This is not only due to the generalised use of increasingly fewer agricultural or forestry varieties, or livestock breeds; it also results from the elimination of other species native to these agroecosystems that were considered to be competing with the species exploited for agricultural production. There exists scientific evidence that more diverse systems are more resilient to disturbances such as extreme climatic events, pests or diseases. The challenge here therefore involves restoring and conserving the general and cultivated biodiversity of agroecosystems.

3.4.1. Promotion of biodiversity of the past

Current environments are the result of a long evolution of former anthropic activity. Therefore, Archaeology and History are disciplines of particular interest with regard to addressing the processes of change and evolution of agricultural systems and landscapes, by observing our past through analysis of remains (whether biological, material or written). Archaeobiology enables us to explore, from a broad diachronic perspective, the different behaviours, motivations and decisions of human populations, which have brought human societies to resist or adapt to changing conditions, and even to survive drastic crises and impacts such as famines, pests or economic crises: The challenge consists of understanding how recovering the agriculture and livestock farming management systems that historically shaped the landscape, could help to reconcile primary production and biodiversity conservation. For instance, there is a vital need to prevent the loss of biodiversity associated with the traditional landscape mosaics, resulting from rural abandonment.

3.4.2. Promotion of biodiversity of the present

With regard to current biodiversity, our society must attempt to prevent the disappearance of our great diversity of agriculture, livestock farming and forestry. There is a need to go beyond the phase of conserving species in seed banks, thus cultivating and reproducing traditional crop and forest varieties and livestock breeds in experimental farms, and promoting their use. Crop diversification constitutes a fundamental challenge with regard to increasing crop resistance to pests and pathogens, as well as to droughts and extreme climatic events associated with climate change. These strategies were recommended at global level in the Nagoya Treaty (2014), complementary in themes of agriculture and livestock farming to the Convention on Biological Diversity, and by UE Regulation 2018-848 referring to materials of plant reproduction. Experimental research with pollination is starting to provide promising results for Agroecology.

3.5. Co-production and dissemination of agroecological knowledge

As has been stated, a particular feature of Agroecology is the co-production of knowledge by producers, consumers, scientists and the public administration. In the first place, it is of vital importance to continue to promote coordinated networks involving the different types of stakeholders in order to address specific, localised, changing and dynamic issues for the dissemination of agroecological knowledge. In Agroecology, scientific knowledge and praxis must not only be sequenced in one single direction, but rather bi-directionally.

Co-creation of hybrid knowledge by peasants and scientists is essential with regard to researching the mechanisms needed to promote biodiversity throughout history. A challenge facing Agroecology involves fully incorporating historical and cultural knowledge into research on local food production, cultivated biodiversity or local agroecosystems. Archaeobiology, Agricultural History, Ethnography or Anthropology do not only provide a diachronic view of the evolution of traditional practices and knowhow; they also provide information on the origin of the species, their uses, practices and appropriate technologies in different environmental and cultural scenarios.

Furthermore, given that climate change presents a whole range of uncertainties for farmers, thus diminishing their capacity for short-, medium- and long-term planning, another significant challenge refers to generating flows of information relating to agroecological practices and climate change, which, beyond the scientific scope, serves to send clear messages to the farmers.

Moreover, of particular interest for Agroecology is the challenge of promoting co-production of knowledge between producers and consumers. The consumers acquire information on the production logic of the agroecological approach, becoming empowered with the producers and with their personal situation. In turn, the producers acquire information on consumers' needs and desires, which enables them to adapt their supply to the demand.

Addressing this kind of challenge means that investigation should be accompanied by the implementation of public policies. In this sense, an important challenge involves promoting agreements on experimentation in agroecological cropping methods between the local or regional Administration and the farmers; the wide range of environmental conditions and typologies of crops, varieties, species and livestock breeds contrasts with the extremely low number of public or community facilities in Spain in this area. Another challenge lies in investigating, from the Social Sciences, how to enhance social recognition of the policies for conservation of agricultural biodiversity, which are often costly and quite unknown by citizens.

Additionally, a priority objective involves making the population aware of the concepts of Agroecology and the Circular Bioeconomy, local food identity, agricultural landscapes or short food chains, among many other themes. In many segments of society there exists quite a positive perception of the values inherent to Agroecology (ecological, local, etc.), but this has not yet materialised in a concrete demand for products from alternative production and marketing networks. The Cities' Strategies for Sustainable Food, issued by the 2015 Milan Urban Food Policy Pact, constitute a significant example of strategies for awareness, empowerment and participation of citizens in activities of sustainable food production, distribution, consumption and culture.

3.6. Agroecological local food systems and upscaling

3.6.1. Concept and design of agroecological local food systems

Many initiatives of social innovation do not provide the expected social benefits due to a lack of economies of scale and scope. A basic principle of Agroecology involves placing the idea of cooperation at the core of the analysis and the action, rather than competition, among the different stakeholders operating closely and belonging to the different phases of the food chain (farmers, food-processing industries, wholesalers, and retailers). Establishing synergies deriving from collective action among stakeholders who are territorially close and who possess an agroecological vocation, constitutes the principal solution to the isolation and fragmentation habitually occurring in many innovative experiences.

This poses the theoretical and empirical challenge of developing a new concept of "agroecological local food systems" (ALFS): a diffused and specialised local network of farms, food-processing industries and other agroecologically-oriented companies. The following elements should be jointly considered by stakeholders as criteria to be optimised: the territorial factors associated with the territorial specificity and local identity of the food products, and the agroecological principles such as closure of biogeochemical cycles, promotion of biodiversity, enhancement of the biophysical capital, or marketing based upon short food chains.

An aim of the ALFS is to supply healthy local food products; these should be accessible to the population, in terms of price and purchase location, and should be sustainably grown, with fair prices paid to the farmers. The ALFS also aim to recover cultural uses linked to diet as a way of actively preserving a territory's cultural heritage. There exist a consolidated body of literature on local food systems that combine territorial approaches with supply-chain analysis (Sanz-Cañada, 2016), but there have been no proposals defining or propagating criteria for the agroecological orientation of these systems. The task of systematising, defining and classifying experiences of ALFS constitutes a huge conceptual and methodological challenge that will probably be very helpful in the design of public policies and civil society actions.

3.6.2 Agroecological food hubs: collective action, governance and upscaling

There have been numerous experiences in alternative production and consumption, presenting an unequivocal agroecological orientation, in recent years in Spain. These alternative networks, however, frequently linked to social movements, have often been relatively short-lived or have shown insufficient growth, failing to involve the population on a broader scale. In this sense, the challenge facing Agroecology is to scale-up, broadening the scale of both production and consumption. If this change of scale is led by the collective action of small producers, not only economies of scale can be generated in farming and in food processing in the medium term, but significant logistic and distribution synergies as well. Nonetheless, the most serious obstacles for achieving the upscaling come from the logistics and physical distribution of food, which currently respond to a fragmented model of storage, picking or transport, at high costs and with a big carbon footprint. Strategies aimed at optimising transport must not only affect flows of food from the farm to the table; inversely, they should involve flows of domestic bio-waste to agro-composting plants.

In this context, one of the biggest challenges, in relation both to research and to policies, involves the creation of food hubs, or associative centres of small producers, processors and retailers of local and organic food. The food hubs aim not only to set up centres for optimal storage and exchange of products, but also to cooperatively integrate a whole range of functions aimed at reducing costs and the carbon footprint or increasing customer portfolios, such as the following ones: transport sharing; joint promotion and marketing; joint planning of production in the case of fruit and vegetables farmers; or the collective organisation of inverse logistics of bio-waste. As these experiences are innovative, it would be advisable to investigate, for instance, aspects such as forms of organisation, governance systems, strategies aimed at reducing the carbon footprint, or collective involvement in marketing functions. The models of organisation, logistics and distribution must be flexible and scalable, in order to be adaptable to demands like the public purchase of hospitals, schools or universities.

CHAPTER 2 REFERENCES

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SUMMARY FOR EXPERTS

6A. CHALLENGES IN AGROECOLOGY AND CIRCULAR BIOECONOMY

Agroecology: a transdisciplinary scientific approach that attempts to investigate in a holistic manner the interrelations existing among the agronomic, biophysical, ecological, social, cultural, economic and political components of agroecosystems. It is intended to serve as a connection among the basic sciences to address issues of agro-food sustainability

1. Design of sustainable agroecosystems at landscape scale	• *1.1. Enhanced quality of fund elements of biophysical, socioeconomic and cultural nature* • *1.2 Research on closing of biogeochemical cycles at landscape scale*
2. Agroecology and Climate Action	• *2.1 Design of strategies for adaptation to future climatic scenarios* • *2.2. Design of agroecological strategies intended to mitigating climate change* • *2.3 Interaction between climate change and other biotic stress factors: pests and diseases*
3. Circular Bioeconomy in agro-food systems	• *3.1 Making estimations of circularity at territorial scale* • *3.2 Establishing new uses for waste from agriculture, livestock farming and the food industry*
4. Agroecology and promotion of biodiversity	• *4.1 Promotion of biodiversity of the past* • *4.2 Promotion of biodiversity of the present*
5. Co-production and dissemination of agroecological knowledge	•*Co-production of knowledge: i) scientific and peasant; ii) incorporating historical and cultural knowledge; iii) between producers and consumers* •*Promoting networks of local stakeholders for disseminating knowledge* •*Promoting agreements on experimentation in agroecological cropping methods* •*Enhancing social recognition of the policies for conservation of agricultural biodiversity*
6. Agroecological local food systems and upscaling	• *6.1 Concept and design of agroecological local food systems* • *6.2 Agroecological food hubs: collective action, governance and upscaling*

SUMMARY FOR THE GENERAL PUBLIC

6A. CHALLENGES IN AGROECOLOGY AND CIRCULAR BIOECONOMY

What is Agroecology?

Transdisciplinary research approach to interrelations among the agronomic, biophysical, ecological, social, cultural, economic and political components of agroecosystems

What are the challenges?

Agroecology to cool the planet: Climate Action

Bio-waste reuse and recycling: Circular Bioeconomy

Promoting biodiversity

Co-production of hybrid knowledge among scientists and farmers

Upscaling of production and consumption for better and cheaper distribution

Promotion of sustainable landscapes

How do we achieve them?

- Promoting biodiversity of the present and the past
- Increasing biological interactions and synergies among the plant, animal and microbial components of the agroecosystem
- Reducing the use of external energy inputs for agriculture and livestock farming
- Closing biogeochemical cycles
- Promoting mutual knowledge and relationships between producers and consumers
- Marketing on commercially and geographically short chains
- Promoting local networks for disseminating knowledge
- Promoting synergies derived from local-scale cooperation among farmers, agro-industries, cooperatives, consumers and local institutions involved in agroecology