Drones and Geographical Information Technologies in Agroecology and Organic Farming

Contributions to Technological Sovereignty

Editors
Massimo De Marchi
Alberto Diantini
Salvatore Eugenio Pappalardo

CRC Press
Taylor & Francis Group
A SCIENCE PUBLISHERS BOOK

Drones and Geographical Information Technologies in Agroecology and Organic Farming

Contributions to Technological Sovereignty

Editors

Massimo De Marchi
Climate Justice, Jean Monnet Center of Excellence
Department of Civil Environmental Architectural Engineering
University of Padova, Padova, Italia

Alberto Diantini
Postdoc Researcher, Department of Historical and
Geographic Sciences and the Ancient World
University of Padova, Padova, Italy

Salvatore Eugenio Pappalardo
Laboratory GIScience and Drones 4 Good
Department of Civil Environmental Architectural Engineering
University of Padova, Padova, Italy

Climate Justice
Jean Monnet
Centre of Excellence

With the support of the
Erasmus+ Programme
of the European Union

CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business
A SCIENCE PUBLISHERS BOOK

Cover credits: Francesca Peroni and Daniele Codato

First edition published 2022
by CRC Press
6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742

and by CRC Press
4 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

Library of Congress Cataloging-in-Publication Data (applied for)

ISBN: 978-0-367-14638-2 (hbk)
ISBN: 978-1-032-15355-1 (pbk)
ISBN: 978-0-429-05284-2 (ebk)

DOI: 10.1201/9780429052842

Typeset in Times New Roman
by Innovative Processors

Acknowledgement

This book has been made available open access thanks to the funding of three initiatives implemented at the Department of Civil Environmental and Architectural Engineering at the University of Padova:

(1) the Advanced Master on "GIScience and Unmanned System for the integrated management of the territory and the natural resources - with majors"
(2) the International Joint Master Programme on "Climate Change and Diversity - Sustainable Territorial Development" (CCD - STeDe)
(3) the "Climate Justice Jean Monnet Center of Excellence" with the support of Erasmus + Programme of the European Union, call for proposals EAC/A02/2019 – Jean Monnet Activities; Decision number 620401; Project number: 620401-EPP-1-2020-1-IT-EPPJMO-CoE.

Disclaimer

Taylor & Francis
Taylor & Francis Group
http://taylorandfrancis.com

Preface

The United Nations decade of ecosystem restoration (2021-2030), the Glashow Climate Pact (November 2021) reaffirms the role of Nature Based Solutions in the fight against climate change and in building shared adaptation solutions. The Glashow Climate Pact highlights the importance of ensuring the integrity of all ecosystems, the protection of biodiversity "recognized by some cultures as Mother Earth, the importance for some of the concept of 'climate justice', when taking action to address climate change".

In April 2020 Boaventura de Souza Santos published the "Cruel Pedagogy of Virus" focusing on how the COVID pandemic/syndemic has arrived at the end of six decades of uneven development and highlights the global predatory capitalism and patriarchy embodied in many development discourses, consolidating social exclusion, resource extraction, human and nature domination, environmental injustice, and accumulation by dispossession.

Deconstructing development, sustainable development, sustainable growth asks for recognizing practices of critical development, alternative development, alternatives to development, post-development to embrace what Max-Neef called "the development at human scale".

Change starts from new practices, challenging the menu of globalizing universalizing development theories and initiatives to inhabit pluriverses of words and worlds.

Agroecology, as young science that is about to turn a century, can contribute in various ways to the current challenges of facing environmental and climate emergency, halting biodiversity loss, pursuing just food systems.

The indigenous, peasant, and environmental movements of active citizenship, inspired by agroecology, promote food sovereignty, just food systems, the collaboration between food producers and consumers, the renewed alliance between natural, agricultural and urban ecosystems, technological sovereignty, innovation attentive to human rights.

This book explores the challenges posed by the new geographic information technologies in agroecology and organic farming. It discusses the differences among technology-laden conventional farming systems and the role of technologies in strengthening the potential of agroecology and organic farming. In conventional thinking, the use of new technologies is an almost exclusive domain

of precision agriculture. Traditions and links with the past are typical western urban images of agroecology compared with modern industrial agriculture, based on mechanization and evolving technology use. The many agriculture 4.0 and sustainable agricultures are still adopting a productive paradigm rooted in yield and profit of farm (as firm), innovation is something universally coming from specialized centers, local knowledge is negligible.

There is a profound connection between social and technological innovation and the multiscale dimension of innovation, especially in the place-specific agroecosystem. Farmers and citizens are themselves innovators; they should have the agency to govern technologies and to develop appropriate place-based institutional-technological innovation.

Technology can not be a commodity, it is common. Traditional agricultural systems are not statics: 9000 years of agriculture in Mexico or several thousand years of Amazon polyculture have required knowledge and ability to care for complex territories (agroecosystems) granting the reproduction of human societies and the evolution of ecosystems.

In the perspective of "technologies for all" there is a basket of promising open applications consolidating agroecology and its plural dimensions of innovation based on knowledge-intensive approaches, knowledge sharing, co-creation of knowledge, common goods and heritages of humanity at different scales.

We want to recall the Kamunguishi Declaration issued by Zapara nationality, a disappearing Amazon population having their oral heritage and cultural manifestation recognized by UNESCO in the list of intangible heritage. Kamunguishi is *the house of the forest for continuous rebirth*:

the world is ony one (*Nukaki)*
the world is forest (*Naku)*
we are forest!

Massimo De Marchi
Alberto Diantini
Salvatore Eugenio Pappalardo

Contents

CHAPTER
12

Agroecological Transitions in the Era of Pandemics: Combining Local Knowledge and the Appropriation of New Technologies

Miguel Angel Altieri[1], Alberto Diantini[2]*, Salvatore Eugenio Pappalardo[3] and Massimo De Marchi[4]

[1] University of California, Berkeley, CA, USA
[2] Research Programme Climate Change, Territory, Diversity – Department of Civil Environmental Architectural Engineering – Postdoc Researcher at the Department of Historical and Geographic Sciences and the Ancient World, University of Padova
[3] Laboratory GIScience and Drones 4 Good, University of Padova
[4] Director Advanced Master on GIScience and Unmanned Systems for Integrated Management of Territory and Natural Resources, Department of Civil Environmental Architectural Engineering, University of Padova

During the preparation of this book, the editors organized a conference to reflect, in the context of the Covid pandemia, about the relationship between agroecological knowledge and the appropriation of new technologies of geographic information. The conference was coordinated by Massimo De Marchi with the intervention of Miguel Angel Altieri, as keynote speaker, and two discussants: Alberto Diantini and Salvatore Eugenio Pappalardo. The event was part of the annual kick-off seminar of the International Joint Master Degree on Sustainable Territorial Development, Climate Change Diversity Cooperation (STeDe - CCD). Considering knowledge and academic work as a common good, the conference was not only part of an academic activity but was opened and shared online to a wide public.

We collect in these pages, maintaining the structure of the dialogue, the interaction among the speakers and the debate with the participants.

*Corresponding author: alberto.diantini@unipd.it

12.1. Introduction

De Marchi M.: In the acme of the pandemia (April, 2020), Boaventura De Sousa Santos published the book, *The Cruel Pedagogy of Virus*. It is an account of the role of the virus in opening the eyes of people to the critical conditions of normality. Despite the narration on the unity of humanity and of a virus making people equally at risk, de Sousa Santos highlights how we are living in a world where colonialism and patriarchy are still well alive.

The tragic transparency of the virus demonstrates how there is a 'south of the quarantine', a group of people paying a higher tribute to the pandemic: women, informal and autonomous workers, peddlers, homeless, poor, refugees, immigrants, displaced people, elders, prisoners, disabled persons.

However, the pandemic can be an opportunity for change, and a new future can start now. So, what can we learn from agroecology in the current pandemic context? How can agroecological knowledge provide the basis for a path to technological sovereignty?

12.2. Agroecological Transitions Towards a Sustainable Food System

Altieri M.A.: In the world, industrial agriculture dominates the landscape. Globally, about 80 per cent of the 1.5 billion hectares of arable land are devoted to industrial monocultures, reshaping the landscape, and impacting the biosphere by promoting deforestation and with a yearly injection of about 5 billion pounds of pesticides (Altieri and Nicholls, 2020). Way before the pandemic, agroecologists started warning that industrial agriculture had become too narrow ecologically, highly dependent on off-farm inputs, and extremely vulnerable to insect pests and climate change (Altieri *et al*., 2015). And now, as demonstrated by the Covid-19 pandemic, it is evident that the conventional food system is very prone to a complete shutdown by this unforeseen crisis. Certainly, one thing that the Covid-19 is revealing is how closely linked human, animal, and ecological health are.

When we practice agriculture, we manipulate nature by simplifying ecosystems. This simplification has substantially reduced the biodiversity of agroecosystems overriding ecological principles, which in turn trigger ecological disasters and affect human health. Even though industrial agriculture occupies about 70-80 per cent of the world's arable land, it uses about 5.2 billion pounds of pesticides, consumes 70 per cent of the water, and 80 per cent of the fossil fuels, and emits 30 per cent of the greenhouse gases, but it only produces 30 per cent of the food that we eat. So, it is a myth that the food we eat in the world is produced by industrial agriculture. It is actually mostly produced by smallholder farmers in small plots, using almost no modern agricultural technologies.

The effects of climate disruptions are already visible. For example, in May 2012, in the midwest of the United States, there was the worst drought in fifty years, affecting transgenic soybean and corn production with a yield reduction of about 30 per cent. So the latest technology of genetic engineering was demonstrated to be extremely vulnerable to climate change. In the last ten years, California has suffered prolonged droughts that put out of production about 200 thousand hectares of monocultures, with a loss of about 1.5 five billion dollars. Another example comes from the recent hurricanes that have been affecting the Carribean: in the 2017 hurricane, Maria decimated the monocultures of bananas and other plantations in Puerto Rico, showing the lack of resilience of this kind of monocultural production systems.

Large-scale monocultures have advanced, causing wide deforestation and natural habitat loss, and migration of wild animals which coexist with hundreds of virus species towards human settlements. This, in combination with the way we raise animals for human consumption, thousands of genetically homogeneous animals confined in small spaces, created the conditions for the evolution and spread of new deadly viruses and pathogens. In South America, soybean production now covers about 57 million ha, mostly transgenic, being produced at the expense of natural forests (Oliveira and Hecht, 2017). In these ecosystems, different animals coexist with different viruses, but they normally remain within the forests. When the forest is destroyed, these pathogens spillover into livestock and then into human populations – a common pathway for zoonotic diseases. This is exactly what seemed to have happened with Covid-19 and previous epidemics, like avian flu and swine fever.

What is happening now is that Covid-19 is revealing the socio-ecological fragility of the current industrial globalized food system. The effects of the pandemic on the food supply chains are already being felt in terms of widespread food shortages, price spikes, and diet changes. Because of the pandemic, a lot of people do not have access to fresh food anymore. Many migrant workers have lost their work or they are more exposed to the Covid-19 because they are not guaranteed safe working conditions. Another problem is children's access to school lunches. For example, in Latin America and the Caribbean, over 10 million children rely on school lunches, which is perhaps the only meal that they have during the day. Considering that often schools are closed due to the pandemic, they do not have access to that food anymore (Altieri and Nicholls, 2020). Moreover, small farmers are being highly affected because in many countries, restrictions on travel, trade, and lockdown of entire cities restrict access to markets. This is remarkably problematic, especially in cities where millions of people live, requiring thousand tons of food per day, which mostly comes from areas on average about 1000 km far from cities. The decline of transportation has reduced the possibility to move fresh food for long distances. This has undoubtedly increased levels of food loss and waste, reducing access to fresh food especially for the poor (Purdy, 2020).

So, we are already feeling the effects of the pandemic on the food supply. Therefore, what we need is a huge transition to a more socially, just, and ecologically resilient and localized food system.

Diantini, A.: *What role can agroecology play in building a more sustainable post-Covid-19 agriculture?*

Altieri, M.A.: Well, what we need to do is to move from industrial agriculture, which causes high environmental degradation, depends on fertilizers, pesticides, and petroleum, to a more sustainable and diversified agriculture, based on natural biological interactions and ecological processes that emerge from complex cropping systems. The way to implement and guide this transition is a science called 'agroecology'. Basically, agroecology is a science that is composed on one side by Western sciences, such as ecology, agronomic sciences, and sociology, and on the other, by the knowledge of traditional people who have been farming the land for thousands of years (Francis *et al*., 2003). In Latin America, we are blessed to have traditional agriculture systems that have stood the test of time (more than five thousand years in the Andes) and still exist. Therefore, it is from this dialogue of wisdoms that the principles of agroecology emerge as the potential basis to guide the much-needed agrarian transition. So what we are looking for is an agriculture that is decoupled from fossil fuel dependence, characterized by diversified agroecosystems that replace monocultures, which have high environmental impacts, and reduce diversity. This new agriculture should be resilient to climate change and multifunctional; producing ecological services as well as providing social and economic services to the communities, thereby enabling the foundation of local food systems. Such systems reduce the distance between producers and consumers and ensure the maintenance of the local culture, such as the traditional culinary traditions and sustainable ways of natural resource management.

Thus, agroecology is a science that shows a different way forward, by providing the principles on how to restore and re-design agricultural systems that can withstand future crises, such as pest outbreaks, diseases, pandemics, climate disruptions, and eventual financial meltdowns (Altieri and Nicholls, 2020). Agroecological systems are resistant because they have a high level of diversity and resilience – both emergent properties increasingly recognized for their potential to reduce risk from climate change and other threats (Nicholls, Altieri and Vazquez, 2016).

So, let me explain how I see agroecology as providing the basis for the reconstruction of new agriculture after Covid-19. First of all, it is important to say that a return to normality would be a disaster: it is just this 'normality' that caused the crisis we are facing today. We need to come up with alternatives and actions to restore the environments weakened and impoverished by conventional agriculture and farming, rethinking how to redesign the agroecosystem matrix and the landscapes that surround agricultural systems. We need to promote rural agriculture as well as urban agriculture based on agroecology, and we also need

to promote more ecologically-sound management of pests and diseases without pesticides. This change will certainly lead to healthier conditions for wild and domestic animals and humans too, keeping pathogens in their habitat, as diverse vegetation in the borders of crop fields act as ecological firebreaks. Thus biodiversity, which is worldwide alarmingly declining, is better conserved in mosaics of small farms inserted in complex landscapes. Moreover, the agroecological transition of agriculture will provide nutritional and food security for people since they will eat more fresh fruits and vegetables produced in the proximity. Food will be free of pesticides as a result of a sustainable agroecological system. All this will lead to better livelihoods, local food sovereignty, greater ecological integrity, and in the end, environmental and human health.

To establish an agroecological-based system, one of the first steps is to overcome the pesticide treadmill. Industrial agriculture in the world injects into the biosphere about 2.3 billion kgs of pesticides (Pimentel *et al*., 1980). Some of these pesticides are endocrine disruptors, while many are immunosuppressive (Repetto and Baliga, 1996). This issue represents a potentially serious risk especially in case of a pandemic, such as this we are living in. To go beyond the pesticide treadmill, we have to replace monocultures with safe agriculture systems, such as polycultures and agroforestry. This gives farmers greater autonomy, as they need not depend on inputs from corporations for pesticides or fertilizers, but rather, rely on the ecological interactions within the agroecosystems. For example, if we break the monocultures into polycultures, we create ecological conditions for richer biodiversity of natural predators and parasites, enhancing biological control (Altieri and Nicholls, 2014). A diversified system has also more favorable conditions for pollinators, which are essential in agriculture, especially considering that they are experiencing a critical decline due to the massive use of pesticides in industrial systems (Constanza *et al*., 2014). In California, experiments have been done in vineyards where different species of flowering plants were seeded to promote the presence of beneficial insects. Enhancing plant diversity in agroecosystems is a mechanism to support soil fertility, attract pollinators and predators, reduce the use of external inputs and ensure higher productivity (Altieri and Nicholls, 2014).

Diantini A.: *As you said, for post-Covid-19 agriculture, we also need to restore the environments compromised by conventional agricultural practices. How can agroecology and ecological restoration be combined in this light?*

Altieri M.A.: Another important approach for the reconstruction of post-Covid-19 agriculture is to restore the environment. For this, we need to combine agroecology with ecological restoration to create sustainable and resilient agro-landscapes. In agroecology, what we prefer in terms of landscape pattern, is a complex matrix of farms surrounded by forests linked with ecological corridors. In such environments, ecosystems are rich in biodiversity that perform services for agriculture. The forest also acts as an ecological barrier, preventing wildlife with potential pathogens to move into agricultural systems.

The key point is to increase diversity and complexity. In Asia, some studies highlighted that in rice fields surrounded by complex landscapes, compared to simple conventional agroecosystems, there are more beneficial insects and predators, including specific fish species that consume insect pests. These systems show a reduced incidence of plant diseases and insect pest presence (Koohafkan and Altieri, 2016; Zheng and Deng, 1998).

Moreover, a complex and diverse matrix surrounding cultivated fields also provides food for the people. Many small farmers not only depend on the crops that they produce in the fields, but also depend on the wild fruits and weeds that grow in the borders, plants which in industrial agriculture are usually eliminated with herbicides, destroying an important source of food. There are cases in Mexico where after ecological restoration guided by agroecological principles, farmers created agroecosystems that enabled extra-economic income from the sale of fruits and vegetables harvested from the field borders.

There are other examples of degraded landscapes on which, using different techniques, like windbreaks, terraced agroforestry systems, silverbush, corridors, etc., the environment can be fully restored. A specific example comes from Sierra Mixteca, in the highlands of Mexico. Here the agroecosystem was completely degraded by deforestation and overgrazing, but the small farmers did not want to migrate; so they started an ecological restoration project, reforesting the top of the mountains with autochthonous plants, creating terraces and using traditional water-harvesting techniques. In this way, the community was able to stay in the territory and revitalize the production systems. Another example is from Colombia, where a community that did not have any water because the watershed was deforested, started to work to restore the environment. Now they have enough water for themselves, the animals, and the crops. What they have done is not only to restore the watershed, but have also modified their agriculture, which depended on monocultures of mostly tuber crops. Today that system has changed, becoming a highly diversified agroecosystem resilient to insect pests, diseases, and droughts. So the results are that they restored 75 per cent of the forest cover and now they are producing 90 per cent of what they consume, including fruits, coffee, and vegetables. This new agroecosystem undoubtedly enhanced the community's food security. Additionally, the restoration of the landscape implemented in harmony with nature resulted also in a higher level of social cohesion, as the entire community, including children and women, was involved in the process.

Another important property inherent to complex systems is that they are far more resilient to climate change as demonstrated by studies conducted in Central America and the Caribbean. For example, after Hurricane Mitch in 1998, Eric Holt found that the farmers who had monocultures suffered more mudslides than those who had polycultures. In Cuba, studies show that in many cases, monocultures were completely destroyed by hurricanes, whereas the more diversified systems, such as agroforestry systems and farms surrounded by complex borders, were more protected against the strong winds.

In the end, ecological restoration of agricultural landscapes characterized by diversified agroecosystems represents an essential adaptive strategy. Indeed, the resilience of agricultural systems is deeply linked to their diversity: the more complex and diverse the territory inside and around the farm, the better it is in coping with climate change and pest pressure.

Question: How can the principles of agroecology also support a more ecological animal production system?

Let us consider the large list of deadly pathogens linked to large-scale conventional animal production systems: from 5N1-Asian Avian Influenza (H5N2) to multiple Swine Fluvariants (H1N1, H1N2), a variety of influenzas (Weiss, 2013) and, lastly, at least for the moment, Covid-19. The agroecological perspective can facilitate the development of alternative sustainable and effective livestock production systems, such as the sylvopastoral systems (SPS), which combine the production of forage grasses and leguminous herbs with shrubs and trees for animal feeding and complementary uses. It is like a building with different layers of plants that are going to provide different services. These agro-landscapes promote biodiversity and create complex habitats that support animals, plants, and a richer soil biota. Trees and other plants can provide farmers, cattle, and wild fauna with food. In these systems, since the animals live in very complex environments and eat plants grown organically, antibiotics are rarely used, given that the animals' immune system is high (Altieri and Nicholls, 2020). In such systems, the health of the animals is better, leading to higher milk and meat production and a reduced risk to human health as well. For example, in SPS, milk production is confirmed to be sensibly higher than in conventional systems (Murgueitio *et al*., 2015). SPS grant healthy animal conditions together with increasing the resilience of the agroecosystem.

12.3. Revitalizing Traditional Peasant Agriculture and Urban Agriculture

Diantini, A.: *What is the link between agroecology and traditional peasant farms?*

Altieri, M.A.: Many effective agroecological practices are part of traditional agriculture and farming, thus representing a co-evolution of nature and culture, where farmers developed systems that did not depend on modern technology, such as pesticides and other external inputs (Francis *et al*., 2003). Evidence shows that agroecology can restore the production capacity of small traditional peasants and farmers by increasing biodiversity which usually leads to less pests and improved soil fertility (Altieri, 1999). Studies on several agroecology projects realized in Africa, Asia, and Latin America highlighted that productivity of traditional farming can be significantly increased if they strictly follow the principles of agroecology

(Rosset and Altieri, 2017). Even in Italy, where there are many rural traditions where farmers possess a very intimate knowledge of their agricultural systems (for example, vines intercropped with olives), the adoption of agroecological practices could lead to successful results in terms of production.

Agroecology can optimize traditional agricultural systems, but traditional farms can also be an important resource for agroecology as well. Indeed, about 7 thousand crop species and 2 million local genetic varieties are in the hands of small peasants, representing the genetic basis for the agriculture of the future. Given this rich agrobiodiversity, it is ironic that the diet of most of the people in the world is composed of three major crops: wheat, rice, and corn (UNSCN, 2020). Crop diversity is essential for agricultural climate adaptation. The Green Revolution has simplified this variety, moving from a traditional diverse and rich agricultural production to an ecologically poor and homogenized agroecosystem and leading to major consequences for the provision of ecosystem services, as well as crop sustainability, and food sovereignty (Jackson, Pascual, and Hodgkin, 2007). Therefore, traditional peasants and farmers have an essential role in maintaining a high crop species diversity in the agroecosystems, which is one of the pillars of agroecology.

Despite the fact that small farmers only control 25-30 per cent of the world's arable land, use 30 per cent of the water and 20 per cent of the fossil fuels, they produce 50-70 per cent of the food that we eat (ETC, 2017). So every time we eat, we need to thank a small farmer, not big corporations, because those industrial agricultural systems do not produce the food that we eat.

There are many examples of traditional farming in different parts of the world. One case, from Chile, for example, is related to half-a-hectare farm. Here a family of two adults and three children divided their land into six plots in a rotational system. Production levels reached about 1.12 tons of vegetables per year, with more than 2,500 eggs, which a family of five would not even eat in one year. So they can produce what they need for themselves, except salt, pasta, and rice. The surplus is sold, bringing income to help economically sustain the family. They do not have to use pesticides or fertilizer, so the cost of production is low and they also have extra time, since they didn't need to invest time in the application of external inputs. Another example comes from Cuba, where up to 72 per cent of the small farmers adopted agroecological practices (Rosset *et al*., 2011). An illustrative case in Cuba is that of a family which obtained the land from the government and originally was used to growing tobacco and corn in the conventional way. But after training in agroecology, they transformed their farm into a very diverse system where you have a combination of vegetable crops and agroforestry systems with pastures for animals, producing eggs, milk, meat, fruit, vegetables, wood, and water. Many Cuban small farmers adopting agroecology produce food per hectare, sufficient to feed about fifteen to twenty people per year, showing an energy efficiency of around 10:1 (Funes and Vasquez, 2016). This means that for every kilocalorie invested in the management of the farm, they

obtain ten back. This is highly efficient, considering that industrial agriculture has an efficiency of 1.5:1.

Pappalardo S.: *We live on an urbanised planet, as most of the people live in cities. Can the agroecological principles also be applied to urban agriculture?*

If we consider that 60 per cent of the world's population and 56 per cent of the world's poor live in urbanised areas (de Bon, Parrot, and Moustier, 2009), it turns out that today, more than ever, we need to promote localized food systems within the cities to overcome the difficulties posed by the current pandemic in terms of food access. In effect, in many cities, there is a lot of abandoned land that could be put into production. In 2005, the UNDP (United Nations Development Programme) did a study and found out that 30 per cent of the food consumed in the world's major cities came from urban agriculture, and the global urban production ranges between 20-180 million tons per year. One of the benefits of urban agriculture is that it ensures access to fresh vegetables and fruits, improving local food security and nutrition, particularly in not well-served communities.

The same agroecological principles adopted in rural areas can effectively work also in urban areas, designing biodiversified home, school and community gardens with increased soil fertility, crop protection, and production with very few external inputs (Altieri and Nichols. 2020).

One example of urban agriculture that has been very successful comes from Cuba. In the 1990s, after the collapse of the Soviet Union, Cuba, which was highly dependent on pesticides, fertilizers, and fossil fuels, had no more access to these external resources. Practically, there was no way to bring food from rural areas to urban areas because there was no fuel for trucks and cars. Therefore, urban agriculture started flourishing on the island to the point that 50 per cent of the vegetables that are consumed in the major cities come from urban agriculture. The agroecological production in urban areas is very high, reaching an average 15-20 kg/m^2/year (Funes and Vazquez, 2016). In Cuba, one square meter of an agroecological well-designed urban garden can yield ten cabbages every ninety days, thirty-six heads of lettuce every sixty days and a hundred onions every 120 days. If we consider that each person eats 72 kg of vegetables per year, in one year a 10 m^2 garden produces 200 kg of food, potentially satisfying 55 per cent of the annual vegetable needs of a family of five (Clouse, 2014). More than 26 thousand urban gardens in Cuba are producing about 25 thousand tons of food per year, generating jobs particularly for elderly people, women and young people. Today, in times of pandemic, generating jobs is critical. For example, the unemployment rate in Colombia is currently 42 per cent among young people. There is no job in the cities, so a solution would be for the government to promote rural enterprises run by young people.

Overall, the potential of urban agriculture is enormous and its development is not just possible but strategic to enhance access to locally produced food.

12.4. Combining Local Knowledge and Technologies of Geographical Information in Agroecology

Diantini A.: This Covid-19 pandemic showed us there is a strong link between human beings, domestic and wild animals, and plants within the ecosystems. This is the basis of ecology, which can be summarized as the relationship between living beings and the environment. In this light, we can consider what Charles Darwin said about the struggle for existence. If you think about this pandemic, it is due to a virus which is simply a particle that is ten times smaller than a million parts of a metre, made of RNA, and covered by proteins. Viruses have been here on the Earth for billions of years. They initially started to fight against bacteria, then against plants, then against animals; finally, around 2-3 hundred thousand years, against humans. We surely are a young species compared to viruses and maybe we are not in an advantageous position against them. But in this struggle we have a plus, which is that we can think, we can plan, we can learn from the past and build a more sustainable future, for example, through agroecology. Among the pillars of this discipline, some important steps are, for example, shifting from monocultures to polycultures and combining agroecology and ecological landscape restoration. As explained above, agroecology is already used in traditional agriculture in many parts of the world.

My question comes from the fieldwork I did in the oil extraction context in the Amazon forest. I spent some time in indigenous communities and I was very surprised on going into their forest gardens, which in their local language are called *chakras*. There they cultivate, for example, around or even more than twenty species of plants, creating complex ecosystems. This is a pure example of agroecology. But talking with them, some told me they want to deforest their areas to implement their 'big projects', like monocultures since this seems to be the only alternative to oil activities in the area. Have you ever experienced this kind of situation, that maybe can be called 'globalization of industrial agriculture', also spreading inside indigenous populations?

Pappalardo S.: Agriculture is practised in many different countries of the world. This pandemic undressed the structural issues related to the global development and production models, questioning the way we manage environmental resources. I have to say that here, in Italy, from an institutional point of view, we are a little bit behind the concepts and practices of agroecology. Sometimes even in some academic environments, it is a kind of taboo, although there are some experiences in farming networks that are growing and making more sustainable agriculture possible. I'm interested in the opportunity to strengthen these networks and also increase their knowledge about agroecology.

I would like to try to make some reflection about innovation and new technologies in agriculture. You summarized it very well. There is a traditional

knowledge coming from experiences of many centuries or sometimes also millennia of local people using natural resources in harmony. They haven't gone through the environmental suicide committed by Western societies. So what about technology in agriculture? I am especially interested in the application of geographic information systems and the use of drones in agricultural systems. In many parts of the world, in the collective memory of the farmers, the application of such technology is receiving attention but it is far from being widespread. Anyway, at least in Italy, whenever this technology is used in agriculture, the main target is always to increase crop production. Overall, I don't know if there is a kind of cultural gap or perhaps a condition that seems that traditional knowledge and new technologies do not fit together. Maybe it is more of a digital gap, which means there is a lack of access to technology, which is basically a problem of democratization of technology. So what do you think about this problem in agriculture?

Altieri M.A.: On the first question, I think it is important to say that indigenous people, traditional farmers, and peasants are connected to the world, and many of them receive information to change their systems because the dominant discourse is that they need to link into the global economy. Well, it is not our role as scientists to go there and tell them what to do; these are complex decisions that they have to make on themselves. As researchers, our role can be to facilitate the decision-making process. We can become facilitators of a process so that they become aware of the implications of adopting a particular technology, as Freire's pedagogy teaches. Will they become dependent on external sources of knowledge and inputs? So, as agroecologists, one effective way for spreading ideas and practices is to identify communities where farmers are successfully using agroecology and enable an exchange of information with farmers from other communities. This works very well because as soon as farmers see other farms that are operating in a much more ecological and sustainable way, with less cost, and higher production, they tend to abandon their monocultures and associated conventional agriculture practices. Another way is to use a methodology featuring participatory and interactive techniques to facilitate awareness of the consequences of adopting a technology. For example, one activity consists of giving farmers different colors to the resources they need for their agriculture projects: in green, the resources of the farmers, in red, what comes from the industry, in blue, what comes from the government. So if farmers want to adopt monocultures of cassava, they need to identify what resources they need and where will they come from. Improved seeds? Red or blue, as they come from the industry or government. Labour? Green, if it is family labor, if hired, red. Pesticides and fertilizers – red, information about agrochemical use and dosage blue, as this information is usually provided by government extension agents, or red, if provided by pesticide salesmen. This exercise can be very useful for a community, as they can visualize that if their chosen approach to agriculture required more than 50 per cent red and blue cards, they can easily realize that they are losing control over their production process,

and becoming dependent on outside forces. This is when farmers usually propose approaches that enable more 'green-colored' solutions, as they realize they can be more independent and autonomous.

On the second question, well, I think that the issue is that, at least in Latin America, 80 per cent of the small farmers live in marginal areas and they are very poor. So the main problem is access to the technology and also who controls the technology. Many people say that these poor farmers should be using drones and geographic information system, which would be fantastic because it would provide them with key information to increase crop production. But if they don't have access to technology, then how can they do that? The point is democratizing GIS technology. We have to find a way to provide farmers with digital tools and drones that are owned by the community, allowing this technology to be more accessible and user-friendly. But, we have also to consider that if they have access to this technology, what will they use it for? How will the technology provide them with more information to make decisions but without bypassing their own rationale? We rationalize things from our Western perspective, but most peasants do not make decisions based on the same parameters and indicators that we use. For example, in Mexico, most farmers practice the 'milpa', which is a system where maize, common beans, and squash are grown in association (Altieri, Nicholls, and Montalba, 2017). Many economists have done studies of this system and have shown that the milpa, from a neo-liberal economic perspective, doesn't make sense. But the milpa persists and it is used by thousands of farmers because there are other factors – cultural and ecological – at the basis of its use, despite economic studies affirming they are not viable economically. I want to repeat it: democratizing technology is very important. We have to find out a way that these fantastic innovations are accessible to the community. But also, we need to be open to the fact that some communities may want to reject this technology. Why do they have to accept drones? Just because we say that is good for them? They need to make an informed decision, understanding what it means for them; why is it useful for them; what is going to be the impact on their culture and their social relations; who is going to have access to the technology. Because sometimes what happens in communities is that some people have access to the innovations and some don't, thus creating social gaps within the community. For example, fair-trade coffee is a great idea, but it turns out that it is promoting big inequalities in many communities of Latin America. Why? Because only a few farmers have the quality demanded by the market and are part of the network of this so-called 'fair-trade system'; other farmers are left out and do not receive a premium price, creating a social stratification within the communities. So we need to make sure that you are not going to exacerbate inequalities with GIS technology. Another aspect in relation to this issue is that, if you provide technology to a community, you will find that some people learn quickly and get ahead easily, leaving behind those who learn more slowly, and may not even benefit from the technology at all. It is important to utilize the information and the indicators that the farmers use. For example, if we go to a community and we want to measure how good

is the soil, we use analytic methods that measure pH, nitrogen, phosphorus, etc. Conversely, farmers simply taste or smell the soil to assess its quality. Perhaps the chemical parameters measured may not be useful for farmers. We need to figure out a pedagogical way of involving the people in a participatory manner from the beginning to see if they need the technology, how accessible it is, and if they want to use it. At best, we can try to combine both sets of indicators.

12.5. Changing the System

Question: As you said, the current food system is not sustainable and has to be changed together with the global capitalistic system, which rules the economy, including food production. How can we do it?

Altieri, M.A.: Well, first of all, we can try to change the world in two ways, using reformist or transformative strategies. Reformists don't question the capitalist system; thus alternatives are proposed to align with the logic of the market economy. For example, more than 80 per cent of certified organic farming in the world maintains monoculture, using input-substitution approaches. Most of the production is for export, so it does not contribute to national food security, and only wealthy people benefit from the food as only a few people can pay for the high prices of organic food. Why is organic food more expensive than conventional? It is because organic farming is playing the game of the market economy, which it is part of. It simply takes advantage of the windows left in the capitalist system but it does not attempt to change it. Of course, organic agriculture is better for the environment and generates cleaner food. On the contrary, agroecology is transformative, as it wants to change the system by changing the way we produce, distribute, and consume food.

Changing the structure of the dominant food system is very difficult. It is more practical to start by creating autonomous territories with markets that are based more on an economy ruled by solidarity principles between producers and consumers, rather than the principles of the capitalistic market economy. We need to democratize food, so that the vulnerable and poor people may have access to healthy food. For example, in Brasil, there is a network called Rede de Agroecologia Ecovida, which is a cooperative between consumers and producers where they agree on the price that has to be fair for both the farmers and the consumers. These are market rules based on solidarity.

With the Covid-19, there are a lot of interesting experiences that are happening to make the food accessible to people at fair prices. There are many people who have lost their jobs and don't have anything to eat. Therefore, there are communities that are mobilizing to develop new production and food distribution systems, like kitchen soups.

We need to create new networks of food production and consumption that reduce the distance between producers and consumers while ensuring that the food is accessible and healthy to everybody. I think an important lesson from

Covid-19 is that we need to put food production in the hands of small farmers and urban farmers. This is the only way to ensure the supply of fresh food at affordable prices in local markets.

This re-design of the food system, based on short supply chains, will require some profound changes. We need to provide small farmers with access to land, seeds, water, and equitable markets. There is a need for training in agroecology and research on the agroecological systems, which is the role of the university.

Anyway, we cannot put the weight of the change of the food system only on farmers. A big difficulty is that the big corporations are controlling the food system, determining what farmers should grow, for whom and the technologies they are going to use. They also control the supermarkets and what people are going to eat, the quality of the food, and its price. In fact, every time we go to the supermarket, we support the capitalist food-chain, but if, instead, we support local farmers' markets instead of the corporate food-chain, we promote socio-ecological sustainability and resilience in our communities. So those of us who have jobs, have a huge responsibility with our wallets in terms of deciding what we consume. Profound changes are needed, but substituting the industrial monocultures with ecological practices is not enough. We need to dismantle the control of the multinationals on the food system and the neo-liberal policies that maintain this structure. This is not a matter of painting capitalism a bit more green or making it a little bit more sustainable with reformist practices; it requires a complete transformation, a full shift from the market economy to a solidarity economy, from fossil fuel dependence to renewable energy, from big corporations controlling the food system to cooperatives between producers and consumers. Such a new world should be led by allied social, urban, and rural movements.

Covid-19 has exposed the tragedy of animal farming and industrial agriculture that has led to a dramatic loss of biodiversity and caused obesity, malnutrition, food waste, bad conditions for the workers, while undermining the livelihoods of small farmers, who are the ones that produce the food we eat. Now that the global supply chains are in a disarray, it is time to enhance regional food systems in order to feed the people in a more equitable way, with food produced through agroecological production practices. In this light, agroecology is today positioning itself as a key agricultural path for the future.

Question: What are the drivers of the change we need?

Altieri M.A.: Well, one of the drivers is a crisis, something that usually motivates changes. I really hope that this crisis caused by Covid-19 and which is linked to other crises we face (climate change, social inequality, etc.) is going to motivate a transformative change, which goes beyond mere reforms. The problems unfolded by the current pandemic can be a key driver to change industrial agriculture for a transition towards agroecological-based food systems. The second driver is social movements. Social movements have been behind most changes in history. If you do not have social movements, pushing agriculture ahead, no change is

going to happen. We cannot just depend on technological changes in agriculture; innovations must run parallel to social and economic changes.

In many rural areas of Latin America, you find that farmers are doing agroecology, promoting changes at the local level, and showing the way of how we can do things differently. This movement, called the *campesino to campesino* (CAC) movement, is basically a grassroots movement using pedagogical tools that allow for the horizontal exchange of information between farmers. A member of a community that knows about agroecology (a promoter) shares his knowledge with the rest through field days and demonstration activities. If a farmer trains ten to fifteen other farmers, then each one of these farmers can become promoter of the agroecological principles and train other ten or fifteen people. This is how agroecology is scaled up.

In Cuba, for example, right after the collapse, only 216 farmers were managing their farms based on agroecology. By adopting CAC methodology in less than ten years, more than 130 thousand farmers adopted agroecological practices. Another grassroots movement is also the *via campesina,* to which millions of farmers in the world belong. They have their voice heard in international fora and can make alliances with other movements, enriching the political discourse for changing agriculture on a global scale. Clearly, agroecological innovations do not emerge from the universities or research institutes, but from farmers in rural areas. Social movements can spread the agroecological principles towards societies no more embedded in the market economy but in alternative sustainable and equitable food systems.

Another driver is to spread agroecological practices that really work and provide solutions to problems affecting agroecosystems. There is too much social and political discourse about agroecology which is good, but we need effective agroecological practices that really work, that are effective in regulating pests, in providing soil fertility, in increasing productivity.

A fourth driver is the political will, which is the support from local politicians that promote enabling policies to scale up agroecology. For example, there are many communities which elected mayors (many of them women) who are agroecological farmers, who, now, from a position of power at the municipality level, are promoting important agroecological initiatives.

Question: You considered many examples of agroecology based in Latin America. But is it possible to change the system through agroecology also in Western countries?

Altieri M.A.: Many examples of agroecology are coming from Latin America because in this region, agriculture is deeply rooted in traditional farming which has been developed for thousands of years. But I would like to stress that agroecological principles are universal and can be applied in Europe, in the USA, or wherever in the world. It is just that the principles take different technological forms depending on the social, cultural, economic, and political conditions

prevailing in each region. In California, for example, there are large-scale farms of more than 200 hectares of vineyards which use agroecological principles, but their practices are different from those of a Central American peasant

One of the big differences between geographical areas, such as Latin America, Africa, and Asia and the more industrialized regions, is that in developing countries rural populations constitute a high proportion of the total. Here rural social movements are very strong. In Europe and the USA, you almost have no farmers left compared to the urban population and thus needed changes in agriculture must emerge from the urban movements. In this light, consumers in Western countries have to become very active and aware of their weight as a big social movement that can support small farmers, locally-based food systems, and promote much-needed socio-ecological change.

Consumers must understand that local agriculture's role is more than provisioning healthy and accessible food. For example, in Brazil, case studies demonstrate that towns surrounded by sugarcane cultivations are 10 degrees hotter than towns surrounded by small farms with diversified ecosystems because of the albedo effect. Other studies show that towns surrounded by industrial large-scale farms have more crime and violence episodes, compared to towns surrounded by agroecological small farmers, where social relations between farmers and consumers are more intimate, thus reflecting a more developed social network that creates conditions of harmony as opposed to towns surrounded by big farms where inequities are huge.

Another important aspect to spread agroecology in Western countries is the existence of an adequate policy framework supporting the adoption and amplification of agroecological principles in agriculture. There are countries where, i.e. Brazil, there is a national law on agroecology (created due to the pressure of social movements) that boosts agroecological practices and alternative marketing schemes. Another case is Uruguay, where the national plan for agroecology represents a tremendous opportunity to promote the agroecological changes in agriculture. Many of these laws contemplate school lunch programs where 30 per cent of the food for school lunches is required to come from small farmers who practice agroecology. So, imagine that in Italy, you were to create a law that requires that all the food consumed in schools, universities, and hospitals has to come from small farmers to nearby cities, this would catapult the promotion of agroecology, where small-scale farmers are actively supported by the government.

Overall, agroecology has developed as a global movement pushed by farmers, peasants, and activists within their pursuits for food sovereignty, biodiversity protection, and promotion, ecological restoration, and a transition to more socially and sustainable rural societies. The agroecological principles work worldwide; the only limits are the imperatives imposed by the globalizing market economy ruling which produces the food and what we eat, and its cost. We need to understand that breaking this system represents an ecological, economic, and political rupture. The choice to change is in our hands.

De Marchi M.: The Covid pandemic, arriving at the end of six decades of uneven development, highlights the global predatory capitalism embodied in many development discourses consolidating social exclusion, resource extraction, environmental injustice, and accumulation by dispossession. Agroecology, as a place-based approach to healing people and ecosystems, offers a rich texture of reflections and practices, challenging the menu of globalizing universalizing development theories and initiatives to propose a pluriverse of words and worlds.

Freire (1992) reminds us that we can create possible futures: the unprecedented achievable. The future is not inevitable and not even given; the world itself is not given, but it is giving itself in a dialectical and conflictual way. Men and women, not only live, they also exist conditioned, but not determined; they can experience oppression, but also liberation. History, seen as a possibility, opens up spaces for responsibility, in which the dream has a fundamental function in a tension between denunciation of the present and announcement of the future. The future must be done and produced, otherwise, it will not arrive as individuals want it (Freire, 1992, pp. 91-102).

Bibliography

Altieri, M.A. (1999). Applying agroecology to enhance productivity of peasant farming systems in Latin America, *Environment, Development and Sustainability*, 1: 197-217.

Altieri, M.A. and C.I. Nicholls (2014). *Manage Insects in Your Farm: A Guide to Ecological Strategies*, Sustainable Agriculture Research and Education Handbook Series, Sustainable Agriculture Research and Education (SARE), College Park, USA.

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

Altieri, M.A., C.I. Nicholls and R. Montalba (2017). Technological approaches to sustainable agriculture at a crossroads: An agroecological perspective, *Sustainability*, **9**(3): 349.

Altieri, M.A., and C.I. Nicholls (2020). Agroecology and the reconstruction of a post-COVID-19 agriculture, *The Journal of Peasant Studies*, 47: 5, 881-898.

Clouse, C. (2014). *Farming Cuba: Urban Agriculture from the Ground Up*, Princeton Architectural Press, New York, USA.

Constanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S.J. Anderson, I. Kubiszewski, S. Faber and K. Turner (2014). Changes in the Global Value of Ecosystem Services, *Global Environmental Change*, 26: 125-156.

de Bon, H., L. Parrot and P. Moustier (2009). Sustainable Urban Agriculture in Developing Countries: A Review, *Agronomy for Sustainable Development*, 30: 21-32.

de Souza Santo, B. (2020). *La Cruel Pedagogia del Virus*, *Ciudad Autónoma de Buenos Aires*, CLACSO.

ETC (Action Group on Erosion, Technology and Concentration). (2017). *Who will Feed Us? The Peasant Food Web vs. The Industrial Food Chain*; retrieved from: https://www.etcgroup.org/whowillfeedus; accessed on 27 April, 2021.

Francis, C., G. Lieblein, S. Gliessman, T.A. Breland, N. Creamer, R. Harwood, L. Salomonsson, J. Helenius, D. Rickerl, R. Salvador, M. Wiedenhoeft, S. Simmons, P. Allen, M.A. Altieri, C. Flora and R. Poincelot (2003). Agroecology: The ecology of food systems, *Journal of Sustainable Agriculture*, **22**(3): 99-118.

Freire, P. (1992). *Pedagogia da esperança, um rencontro com a pedagogia do oprimido*, *Paz e Terra*, Rio de Janeiro, Br.

Funes, F.A. and L.M. Vazquez (2016). *Avances de la agroecología en Cuba*, *Estación Experimental de Pastos y Forrajes Indio Hatuey*, *Editora*, Matanzas, Cu.

Jackson, L.E., U. Pascual and T. Hodgkin (2007). Utilizing and conserving agrobiodiversity in agricultural landscapes, *Agriculture, Ecosystems & Environment*, 1(21): 196-210.

Koohafkan, P. and M.A. Altieri (2016). *Forgotten Agricultural Heritage: Reconnecting Food Systems and Sustainable Development*, Routledge, London, UK.

Murgueitio, E., M. Flores, Z. Calle, J. Chará, R. Barahona, C. Molina and F. Uribe (2015). Productividaden Sistemas Silvopastoriles Intensivos en América Latina. *In:* F. Montagnini, E. Somarriba, E. Murgueitio, H. Fassola and B. Eibl (Eds.). *Sistemas Agroforestales*, *Funciones Productivas, Socioeconómicas y Ambientales*, CATIE, Cali, Co: 59-101.

Nicholls, C.I., M.A. Altieri and L. Vazquez (2016). Principles for the conversion and redesign of farming systems, *Journal of Ecology and Ecography*, 5: 1-18.

Oliveira, G.L.T. and S.B. Hecht (2017). Soy, globalization, and environmental politics in South America, *Critical Agrarian Studies*, Routledge, New York, USA.

Pimentel, D., D. Andow, R. Dyson Hudson, D. Gallahan, S. Jacobson, M. Irish, S. Kroop, A. Moss, I. Schreiner, M. Shepard, T. Thompson and B. Vinzant (1980). Environmental and Social Costs of Pesticides: A Preliminary Assessment, *Oikos*, 34: 127-140.

Purdy, C. (2020). Covid-19 is about to Reach US Farms in a Major Test for Food Supply Chains; Retrieved from https://qz.com/1829558/covid-19-is-about-to-reach-us-farms/; accessed on 27 April, 2021.

Repetto, R. and S.S. Baliga (1996). Pesticides and immunosuppression: The risks to public health, *Health Policy and Planning*, 12: 97-106.

Rosset, P.M. and M.A. Altieri (2017). *Agroecology: Science and Politics*, Fernwood Publishing, Nova Scotia, USA.

Rosset, P.M., B. Machin-Sosa, A.M. Roque-Jaime and D.M. Avila-Lozano (2011). The Campesino a Campesino Agroecology Movement of ANAP in Cuba, *Journal of Peasant Studies*, **38**(1): 161-191.

UNSCN (United Nations System Standing Committee on Nutrition). (2020). The COVID-19 Pandemic is Disrupting People's Food Environments; Retrieved from https://www.unscn.org/en/news-events/recent-news?idnews=2039; accessed on 27 April, 2021.

Weiss, T. (2013). *The Ecological Hoofprint: The Global Burden of Industrial Livestock*, Zed Books, London, UK.

Zheng, Y. and G. Deng (1998). Benefits analysis and comprehensive evaluation of rice-fish-duck symbiotic model, *Chin. J. Eco-Agric*., 6: 48-51.