Drones and Geographical Information Technologies in Agroecology and Organic Farming

Contributions to Technological Sovereignty

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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

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Part III: Landscapes and Ecosystem Services, Technologies for Agroecological Transitions

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1

Agroecology and Sustainable Food Systems: Inquiring Technological Approaches

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1.1. Introduction

The awareness of impacts of conventional industrial farming and the exceeding of multiple-planet boundaries (Campbell *et al.*, 2017; Montgomery, 2007; Sánchez-Bayoa and Wyckhuys, 2019) has been paired, in the last 30 years, by the faith in technology as a central pillar of innovation for agricultural transition to sustainability.

In this conventional thinking, agroecology is normally not associated with the use of new technologies and is an almost exclusive domain of precision agriculture. Traditions and links with the past are typical Western urban images of agroecology compared with conventional agriculture, based on mechanization and evolving technology use.

In the introductory chapter of this book, we start with reflection on the agroecological transition to map the multiplicity of labels for sustainability in agriculture, combined with the exploration of different interpretations of

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sustainability and the link with technologies and innovation. The approach adopted is the 'technology for all' as a dynamic combination of available tools adapted to specific locations and cultures of myriads of agroecological small farms, going beyond the universalizing closed menu of technological supply for standardizing conventional large farms. The keyword is exploring the 'basket of options' suitable for the multiplicity of small farmers, herders, fisher-folk, peasants, indigenous people, and urban dwellers interested in growing directly their food, suitable for youth and elders, for women and men in cooperation among humans and non-humans.

1.2. Agroecological Transitions

Agroecology's origins, developments, and trends can be summarized by some key concepts following some fundamental contributions: analysis of agroecosystems looking for interaction between place, time, flows, decisions (Conway,1987); a new paradigm of research and development for world agriculture (Altieri, 1989); resource management science for poor farmers in marginal environments (Altieri, 2002); ecology of the food system (Francis *et al*., 2003); science focusing on multi-scalarities and interdisciplinarity (Dalgaard *et al*., 2003); combination of science, movement, practice (Wezel *et al*., 2009), and a transdisciplinary, participatory, action-oriented approach (Mendez *et al*., 2016).

Agroecology is not just a speculative exploratory science but is committed to change through the design of sustainable agroecosystems (Gliessman, 2007; Malezieux, 2012; Wezel *et al*., 2014; Wezel *et al*., 2020). Gliessman (2007, 2014, 2016) summarizes five possible levels of agroecological transition from conventional industrial farming to farming for just food systems.

The first level requires increase in the efficiency of industrial/conventional practices in order to reduce the use and consumption of expensive, scarce or environmentally-damaging inputs. This basic level of efficiency is well represented by precision agriculture or the different declinations of sustainable or smart agriculture, but it is far from a real transition.

The proliferation of multiple labels to describe innovation pluralism of sustainable agriculture often conceals a weak sustainability approach harbored in the paradigms of yield, granted by modernized industrial farming, optimizing chemical and biotechnological energy inputs by the new technological-controlled supply (HLPE, 2019; Klerkxa and Rose, 2020).

The so-called precision agriculture continues to rely on mechanization, fossil fuels, and chemicals, but uses them more efficiently so that instead of spraying an entire field, the chemical inputs are released only in the rows: the idea is to avoid excessive or not useful treatments and to concentrate the operation only when and where necessary. In effect, precision farming was developed as an approach apt to mitigating the environmental impacts of intensive farming implemented in large surfaces with external material and energy inputs (Zhang *et al*., 2002; Gebbers and Adamchuk, 2010). GPS, satellite images, GIS, and drones help conventional farming in localizing in detail where to supply water, pesticides, and fertilizers. Prescription maps define the right place and moment for interventions of machinery fleets (Wolf and Buttel, 1996; Falkenberg, 2015; European Parliament, 2016; European Parliament, 2017; Altieri *et al*., 2017; HLPE, 2019; Klerkxa and Rose, 2020). The yield goal remains the key objective, integrating a more efficient use of resources toward economic-environmental sustainability. Precision farming allows extractive agriculture to enter the sustainability era. Sustainable intensification, climate smart agriculture, nutrition-sensitive agriculture, sustainable Food value chain and other various Agriculture 4.0 declinations are often considered, in the mainstreaming discourses of agricultural policies and practices, the abundant innovative offer of salvation tools for the planet and prosperity. The basic idea is to use industrial practices more efficiently in order to minimize the environmental impacts – this is not a change of model, but a way to protect the yield-universalizing paradigm with belts of 'more efficient', 'less impactful', and 'sustainable'.

There is a level two, where the keyword is 'substitution', that is, replacement of industrial/conventional inputs and practices with sustainable alternatives. It is what organic, biological or ecological agriculture does according to the regulations, for example, of the European Union or the United States. These regulations define all the inputs allowed to guarantee products without traces of industrial/conventional phyto-sanitary products. But agricultural activity can be implemented in fields without trees or living fences. The risk, as Miguel Angel Altieri recalls, is the consolidation of a capitalist market for organic production with a new concentration of distribution and sale of 'ecological inputs' (Altieri, 2002; Guthman, 2004; Altieri, 2017).

In many cases, the change of the conventional production model to organic agriculture is maintained inside the industrial paradigm of the yield, simply with a change of the external input supply from chemical to organic, or better, to all products admitted by regulations.

Industrial organic farming relies on fossil fuel; for example, increase in tilling and soil labouring as an alternative to chemical weed control, and on the dependence of external inputs. Cycles are not closed on the farms and the approach is still inside the typical capitalist markets maintaining two limitations. On one side, the farm is dependent on the market fluctuations of external biological inputs; on the other, the organic food production is conditioned by a price system regulated by a market of commodities not recognizing the right to food and right to decent work of farmers (Guthman, 2004; Altieri, 2017). Industrial organic production maintains the stratification of small and big farms with many of the social and environmental injustices of conventional farming: the paradigm of yield and the basic objectives of producing commodities for the market are not questioned. Industrial organic production can cohabit with mechanization, technology, and a conventional farming machinery landscape without asking for a higher level of transition. Small and transformative organic farming opened a reflection on the convergence between the organic world, and agroecology (Migliorini and

Wezel, 2017), and on the transition to organic Agriculture 3.0 (Rahman *et al*., 2017). Compared to agroecology, organic farming is still more technical and normative, and highly regulated by certification schemes; the logic of changes are driven by an alternative scientific and philosophical northern and Western view; the approach is still in the food chain with a vision on food health and food security; production systems rely on low external input substitution regulated by allowed and forbidden substances; and despite the relevance in the change of northern conventional agriculture, organic farming needs a redesign inspired by agroecology (Rahman *et al*., 2017; Migliorini and Wezel, 2017; Altieri, 2017).

Only level three is the bifurcation point for a true agroecological transition: this level requires the re-design of agroecosystems to adopt functions based on ecological processes. This agroecological transition begins on the farm and in the landscape, but needs to be scaled up to be effective. In level three, agroecology meets landscape ecology and requires ecological infrastructure; thus the differentiation and complexification of the ecosystem happen not just in the field, even if it starts from the field and the farm (Gliessman, 2007; Malezieux, 2012; Wezel *et al*., 2014; Perfecto *et al*., 2009). The machinery landscape of conventional agriculture or industrial organic farming must introduce hedges, trees and forests, wetlands, and soil covered by leaves or dead vegetation. Agroecology stresses policies and equity; the creativity frames agroecological principles with the prominence of southern intercultural view and local indigenous knowledge; the agroecosystem is the point of reference for the management of relations among species, and material, and energy flows; food sovereignty and food networks inspire the approach; additionally, maybe agroecology could need formalization (Rahman *et al*., 2017; Migliorini and Wezel, 2017). In many parts of the world, the agroecosystems, based on agroecology, are still supplying a plurality of services, and level three of the agroecological transition is already active and ready to jump to the next two levels.

With the transition to level four, a more direct connection is re-established between those who grow food and those who consume it. This level is fundamental, both to consolidate the existing agroecological farms resisting the universalizing paradigm of yields and to welcome the new agroecological farms walking the transition paths in order to leave behind the conventional/industrial agricultural approach (Gliessman, 2007, 2014, 2016; HLPE, 2019; Wezel *et al*., 2020). The new food networks, connecting farmers and citizens, are based on direct relations and new tools of PGS (participatory guarantee systems). The trust among those who grow food and who consume it is not granted by a third-party certification body (as in conventional agriculture and organic farming) but by direct contact and accessible direct network of reciprocal commitments (Home *et al*., 2017; FAO, 2018d; Montefrio and Johnson, 2019).

Foundations created at the scale of agroecosystems and landscape (level three) and new connections between food, farmers, and citizens (level four) can culminate in level five, building a new sustainable global food system, which strengthens the resilience of ecosystems over a basis of equity, participation, and justice (Gliessman, 2016; Wezel *et al*., 2018; Anderson *et al*., 2019; Côte *et al*., 2019). Level five asks for a strong commitment by governments in adopting agroecological and food sovereignty policies (Jansen, 2015; Pimbert, 2018), and concretely acting for the scaling up of agroecology (Bellon and Ollivier, 2018).

Considering the multi-scale approach (farm, landscape, region, and world) and the three main dimension of agroecology (research, farmer practices, and social change), it is possible to define the combination of scale/actors involved at different levels of agroecological transition (Gliessman, 2007, 2014, 2016; HLPE, 2019; Wezel *et al*., 2020). Levels one and two (efficiency and substitution) are implemented mainly at the farm level with a direct commitment of farmers and researchers and a minimal contribution of social actors limited to a final decision at the moment of buying food. Level three (re-design) creates the connections among farms and landscapes with the research sector supporting tools for evaluating social and ecological interactions; farmers are key actors of this change and citizens can support farmers' commitments. At level four, the interactions among growers and eaters require the adoption of a food network approach with a primary engagement of citizens and farmers and the contribution of applied interdisciplinary research monitoring effective changes. At this level, agroecology operates on multiple scales: local, regional, and national. A global equitable food system, level five, requires a strong commitment of citizens in pressing decision-makers for agroecology scaling up and the maintenance of appropriate institutions. In this context, farmers adopting agroecology should offer an inspiring example for the change of the agricultural system and research could act as a supportive platform for monitoring the effectiveness of this transition process.

Beyond the responsibility of research, farmers, and citizens, the scaling up of agroecology requires the engagement of institutions, both at local and global levels; reflections are undergoing, so the debate; and the need is to spread exemplary policy practices developed at the national, regional or municipal scale.

1.3. Sustainability and Sustainable Food Systems

The Mexican agroecologist and ethnobotanist, Efraim Hernandez Xolocotzi, analyzing the complexity of indigenous agroecosystem, recognized how sustainability was based in a solid co-evolution of social and environmental dimensions, resulting in the interactions of ecological, technological, and socio-economic place-based components (Hernandez Xolocotzi, 1977; Díaz León and Cruz León, 1998). Modern farming systems abandoned the connection with the ecological roots, allowing market-driven socio-economic components to become the paradigm of management in food systems. In this perspective, sustainability should recognize and rebuild the ecological services of agroecosystems, managing energy and material flows, starting from the natural nitrogen fixation and the co-operation with soil mycorrhizae (Gliessman, 2007, 2014). It does not mean avoidance of any input arriving from outside the system, but use of material and energy flow from natural or contiguous ecosystems; for example, integrating the management of urban organic waste in urban farming. Renewable energy sources should substitute non-renewable energy, without forgetting energy and material efficiency. Sustainability in the agroecosystem requires management and co-existence with different species, desired and unwanted species, and avoiding the control paradigm in the integrated management of soil fertility and vegetation health by maintaining the higher level of biological and ecological services naturally available in the agroecosystem (Altieri, 2012; Malezieux, 2012; Gliessman, 2014).

Agroecology looks at the agroecosystem by focusing on the principles of ecology, the cultural texture, the socio-economic dynamics, and the uniqueness of the place. Agroecology has a multi-scale look, not only at the localized agroecosystems but also at the problems of food production, the way of doing agriculture in different contexts, the environmental management and resource enhancement, and the cultural knowledge as a whole to design better systems: from farm to global food system (Francis *et al*., 2003).

Awareness of food can be a starting point to reflect on the relationship between people and agroecosystems, considering that territories are open systems where the influence of society is not given only by the ecological components, but also by the decisions, the ability to develop co-operative and conflictive behaviours among people driven by desires and visions. So, what we have in mind is larger than what we have on the table (Francis *et al*., 2003).

Human action shapes ecosystems in a direction that can be sustainable or lead to potential degradation. The current globalized system is not fully aware of knowledge about food and ecosystems due to the separation of the place of consumption from the place of production. The global society of the biosphere is creating uncertainty and instability among the people of ecosystems, generating ecological refugees, enlarging the space of collection of food, the substitution among different food chains, and the control of food commodities (Gadgil, 1994). Spaces on concern and collection of resources being far from the spaces of living require the development of a multi-scale awareness, maybe for people living in cities; thinking about food may create a connection with the ecosystem dimension (Gadgil, 1994). This separation leads to a lack of awareness about the implication of food consumed. Food choices are based more on price, global market availability, consuming well-advertised products, and forgetting all the connections between food and health. The latter cannot be reduced to consumer health; there are many concealed dimensions – health of farmers and food processing workers, the ecosystem health and society as a whole, environmental quality, and social impacts. Rebuilding this becomes a fundamental aspect, considering we have a global system producing various types of quality and lower quality food and not granting the right to foods, especially to people who more need it (Francis *et al*., 2003; De Schutter, 2011; FAO, 2015).

The vision of conventional farming based on increasing yield and food quantity separating food chain from externalities (soil erosion, water, and air pollution, biodiversity loss, etc.) should let the floor to the agroecological approach, where there is no separation between society and nature, where people are part of the ecosystem. Then, if people are part of the ecosystem, the logic is based on co-existence, not on separation and extraction (Francis *et al*., 2003; Declaration of the International Forum for Agroecology, Nyéléni, 2015; FAO, 2016a; FAO, 2016a). Food awareness goes beyond productivity to take into account the issue of complexity and justice: humans live in a complex open system, interacting with many ecosystems and species, with nature and societies, and should develop food-efficient systems, taking into account accessibility and sovereignty. In this context, the central theme is the consumer who co-operates in closing the circle, in promoting efficiency and justice inside the food network, and in co-operating in a participatory dialogue involving all the different parties – the researchers, the producers, who transform the food, who trade it, and who consume it. The agroecological cycle closes only if there is a responsible consumer: the 'consumer-actor' makes choices and influences them at various levels. It is necessary that agroecology knows how to inform and involve consumers, sharing information on what is happening in food production, in rural landscapes, in terms of production methods and proposals. So only with more information on how food is produced, processed, and circulated, it is possible to increase the awareness in consumer choices and on the overall choices of the different actors in the world food system (Francis *et al*., 2003; HLPE, 2014; HLPE, 2017a; HLPE, 2017b).

The world sustainable food system is based on many small agroecosystems, which are capable of adapting to local and cultural contexts. In it, the food needs do not prevail on producing commodities for the global market, but food production is concerned with the desires and priorities of the populations, who therefore respond to social needs at different scales. The focus is on the food networks and not the food chains, complex food networks connecting farms and tables and caring for how food is produced, exchanged, distributed, and how it reaches the different tables with networks not only dependent on large-scale distribution chains (Gliessman, 2014; FAO, 2015).

Despite different ways of managing data and statistics (Ricciardi *et al*., 2018; HLPE, 2019), traditional agroecosystems managed by small farmers provide about two-thirds of the world's food. On the other side, many large conventional industrial farms produce commodities with other purposes: livestock feeding and energy supply. So, the priority is the international market and the prices when food is no longer a right, but a commodity. A sustainable world food system equitably distributes food, reduces waste, ensures the important role of agricultural land to grant justice, accessibility, and sovereignty (Patel, 2009; Gliessman, 2014; Grey and Patel, 2014; Figueroa-Helland *et al*., 2018).

Urban agriculture of the future will not be an agriculture 'fishing' in the world market but it will be based on social and proximity farming in order to close the cycle inside the city and create new urban agroecosystems (Gliessman, 2014; Altieri and Nichols, 2019; Almeida and Bizao, 2017; Rentig, 2017).

1.4. Technology for All: Innovation Narratives and Agroecology

Agroecology is a way of managing ecosystems that combine human and non-human needs with higher intensity of knowledge. Traditional agricultural systems are not static (Altieri, 2012): 9,000 years of agriculture in Mexico (Díaz León and Cruz León, 1998) or several thousand years of Amazon polyculture (Brugger *et al*., 2016; Maezumi *et al*., 2018; Neves and Heckemberger, 2019) have required knowledge and ability to care for complex territories (agroecosystems) granting the reproduction of human societies and the evolution of ecosystems.

Long-lasting sustainable agroecosystems show six characteristics (Altieri *et al*., 2012): permanence of productivity; risk reduction and resiliency; integration of economic viability, social equity, and cultural diversity; conservation and enhancement of natural resources, biodiversity, and ecosystem services; wise management of natural cycles and reducing dependency on non-renewable resources; and prevention of environmental land degradation. As Declaration of the International Forum for Agroecology (2015) summarizes: agroecology 'cultivates' biodiversity, respects Mother Earth, and is economically viable; and farmers should be socially rewarded not only for the production of food, but for all thee environmental services they create and maintain.

Agroecosystems, combining farming systems with complex livelihood structures, are rooted in the self-reliance of communities and the ownership of multiple sovereignties – spatial, food, technological, energy blended with sophisticated agroecological knowledge systems (Tomich *et al*., 2011; Altieri, 2012; Paracchini *et al*., 2020).

Agroecology, as a new paradigm changing the unsustainable ways of doing agriculture, can inspire the development of appropriate technologies which are able to grasp the productive potential of the agroecosystem, guaranteeing sustainable subsistence for all (Altieri, 1989). Many discourses on sustainable farming overestimate the role of technology, forgetting the articulated and multifaceted sustainability of existing agroecological systems, when analyzed merely from the yields' lens.

The 2019 HLPE's report, planned to explore the role of agroecology in sustainable food systems, resulted in a final document registering the struggle in the international food policy arena to frame agroecology into a continuous spectrum with 'other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition' (Anderson and Maughan, 2021).

The risk of the agroecology captured by the innovation imperative, as highlighted by the Nyeleni Declaration, requires distinguishing on one side, the different concepts of innovation, and on the other, the key difference of agroecology from 'other innovative approaches' of the wide 'silos' of Agriculture 4.0. The world is fascinated by the agroecology label depicted by actors with completely different visions: international companies interested in marketing products and institutions that perhaps use an agroecological cloak, with a reach cloakroom of synonyms, to use 'junk agroecology' to circulate the older yield paradigm (Alonso-Fradejas *et al*., 2020).

Anderson and Maughan (2021) offer an overview of the 'innovation imperative' comparing two polarities: the dominant supportive approach adopted in sustainable agricultures versus the critical vision to innovation related to agroecology. The authors focus on three sub-frames of the main innovation structure: the measurement sub-frame, the technology sub-frame, and the rights sub-frame. 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 measurable following scientific-technical standards and where local knowledge is negligible. In this 'measurement sub-frame' the innovation approach of agroecology affirms the key role of site-specific local knowledge based on a different plurality in the way of knowing and measuring; place-based evaluation of innovation should be adopted and sustainability expresses the holistic multi-dimensional approach (López-Ridaura *et al*., 2002; Ripoll-Bosch *et al*., 2012; Valdez-Vazqueza *et al*., 2017; de Oliveira Côrtesa *et al*., 2019). About the technological sub-frame (Anderson and Maughan, 2021), agroecology sees a profound connection between social and technological innovation and the multi-scale 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 innovations. New technologies are neither neutral nor good by definition, since they can create negative impacts. In this light, the adoption of a precautionary approach is the key attitude to deal with new technologies (Raghavan *et al*., 2016; Gkisakis *et al*., 2017; Gkisakis and Damianakis, 2020; Niggli *et al*., 2016; Bellon Maurel and Huyghe, 2017; Daly *et al*., 2019). Conversely, the different declinations of Farming 4.0 trust in the identification of innovation with new technologies driven by specialized agencies with the conventional top-down market approach of technology transfer. The narrative is based on some classical rhetoric figure of the green revolution: 'feeding the world', youth priorities, social change, and benefits for farmers. The prominence is on the quantity of novelty against the prudence of the precautionary approach (Anderson and Maughan, 2021).

In the right sub-frame (Anderson and Maughan, 2021), the two polarities see, from the side of industrial sustainable farming, the regimes of intellectual properties protecting innovation, the consumer right to choose the suitable technology, and, in other words, the farmers are entitled to any choice of agricultural products and innovation schemes – this right system should grant the priority right to innovate. A critical view to this approach is based on human rights as a priority framework; so rights should not be granted just to a few private or public institutions specializing in technology production and transfer, but all people are innovators, and the human rights framework protects the 'agency of people in all spheres of life' (Anderson and Maughan, 2021). The right of 'most affected' in the agroecosystems and in the food network should be prioritized. Agroecology, being a knowledge-intensive approach, advocates knowledge sharing, co-creation of knowledge, and intellectual commons. Agroecological knowledge is not fragmented and cannot be sold separately in the market of business intelligence: it is knowledge in the public domain, common good, and heritage of humanity at different scales. Production opportunities must not be taken away from a place to be placed in an international market, but local actors have to benefit first and foremost – 'thousand years of knowledge of the ecosystems through trial and errors up to agriculture' (Díaz León and Cruz León, 1998): isn't this innovation?

1.5. Geographical Information Tools and Knowledge: A Basket of Options

This book is organized into three parts and 14 chapters. It discusses the role of geographical technologies information and knowledge in strengthening the potential of agroecology.

The first part analyzes how technologies of geographic information offer tools to farmers and citizens in the quest for rights of nature and food sovereignty.

Chapter 2, by Massimo De Marchi and Alberto Diantini, offers an outlook on the relations among geographical information, science, and agroecology to disclose the 'power of maps' in agro-ecological transformative scaling up. Geography and cartography have a long and consolidated epistemological and empirical experience about the key role of maps, starting from the pre-digital era, in changing the world through the empowerment of weak and marginalized actors in cities and rural contexts. The chapters explore some key elements of 'mapping for change': from 'material' participatory cartography to immaterial participatory GIS and Volunteered Geography. Despite the low interactions, mostly informal, in the last decades among the science of geographical information and agroecology, there are many areas of common interests and mutual interaction and co-operation.

Alice Morandi, in Chapter 3, deals with the role of livestock in the quest for sustainable agricultural development. Livestock challenges the sustainability in agricultural development for the constellation of impacts, not only on the environment, but also on food security and sovereignty. The chapter explores how livestock can contribute to the Sustainable Development Goals of Agenda 2030 and on the other, how the livestock sector deals with the SDGs' strategic framework. The spatial decision support systems (SDSS), which are GIS tools to support spatial-explicit decision making, can support the livestock sector in simulating, and then implementing, multiple sustainability paths. The chapter presents Gleam-i (global livestock environmental assessment model), a webGIS tool elaborated by the FAO to develop policy assessments of livestock decisions. Gleam-i is applied in a case study of climate change mitigation in the Colombian poultry supply chains, showing the possibility to prevent impacts and to increase food security and food sovereignty. The Gleam-i is a promising open-source tool available on the web to a wide public. We hope the chapter creates interest among policymakers, civil society organizations, and the livestock sector to test alternative policies for climate justice and food sovereignty.

The second part of the book deals with technologies at farm levels; the three chapters provide practical experiences about a positive application of technologies in agroecology: the role of positioning systems, the diffusion of hyperspectral imagery, and the proximal sensing of drones. The chapters of this session have a common thread: the first part of each is more devoted to the description and presentation of the technology and the second part presents the applications in agroecology.

The chapter prepared by Angela Gatti and Alessio Zanoli focuses on the revolution in position precision provided by the availability of GNSS (global navigation satellite systems). The availability of GNSS technology in the consumer market has familiarized citizens with the user segment of the system relying upon more components: the space and the ground control segments. Recursive triangulations among satellites, earth stations, professional or consumer devices allow the refinement of position between metric or centimetric precision. About the use of GSS application in farming, in the last couple of decades, we witnessed a sort of metonymic discourse capturing the precision of position by precision farming, creating a sort of exclusive ownership of this technology. The social globalized imaginary is adsorbed by self-driving tractors spying the right quantity of chemical input controlled by a GNSS. However, imaginary should go beyond the discursive boundaries of Agriculture 4.0. The authors show many applications in agroecology and organic farming: from soil sampling to harvest and biomass monitoring, and the interesting application in livestock management. The chapter closes with a review of the emerging issue of low-cost GNSS, based on cheaply available devices (smartphone and u-blox) revolutionizing the accessibility of this technology and moving toward the democratization of GNSS tools for food sovereignty and agroecological transition.

András Jung and Michael Vohland prepared Chapter 5, which is devoted to hyperspectral remote sensing and field spectroscopy. Compared to normal multispectral satellite images (*see* Chapter 10), with a limited number of spectral bands, hyperspectral sensors collect huge data cubes supplying new generations of imageries with hundreds of spectral bands. These large amounts of spectral data require important processes (and machine resources) for data analysis, but can supply important information on soil constituents or vegetation with fine details of species, and the possibility to distinguish particular phenological or pathological conditions. The authors integrate the presentation of hyperspectral imageries with field spectroscopy and summarize some possible applications in agroecology and organic farming. Hyperspectral imageries and field spectroscopy are a promising technology, even if expensive in terms of equipment and data processing. They can represent an interesting case of reflection in scaling up agroecology and in the transition of public agricultural services in facilitating and sharing advanced technologies for small agroecology farming systems.

Drones for Good is the topic of Chapter 6, written by Salvatore Eugenio Pappalardo and Diego Andrade. UAS (unmanned aerial systems) or UAV (unmanned aerial vehicles) probably represents the icon of GeoICT applied in agroecosystems for a long time trapped in conventional industrial precision farming. The paradigm of Drones for Good and the use of drones not only outside the military domain but also outside the industrialist approach, open many opportunities in agroecological transition and community empowerment. The authors explore possible paths between agroecology and unmanned systems and present different technologies, starting from cameras worn by birds, kites, and balloons: these 'grandparents' of modern drones can disclose a lot of new opportunities. After describing the different UAV platforms (fixed wings and multi-rotors) and sensors, the authors review distinct approaches and methodologies of using UAV in agroecology. Based on their experiences in different contexts (in Ecuador and Italy), Pappalardo and Andrade share interesting case studies of UAV applications for agrobiodiversity conservation and community-based agroecosystems, from farms to landscapes, showing the role of UAV technologies in implementing the multi-scale paradigm of agroecology.

The third part of the book deals with technologies for agroecological transition at the landscape scale, integrating food sovereignty and ecosystem services.

GIS and webGIS are the topics of Chapter 7, opening the third part of the book. Luca Battistella, Federico Gianoli, Marco Minghini and Gregory Duveiller offer an outlook on the different types, trends, and constitutive characterization of web mapping: the collaborative approach in data supplying, validation, and sharing. After a comparison of two business models (proprietary versus open source), the authors describe the geospatial web components, making possible the transition of GIS technology from the desktop to the web. The evolution of web mapping and webGIS shows a large variety of services and tools with different levels of complexity and usability, increasing the inclusion of different categories of social actors, experiencing platforms without coding and handling intuitive tools, like story maps. The implementation, in many jurisdictions, of the right for environmental information, has been supported by the development of SDI (spatial data infrastructures) based on geoportals and geocatalogs, spreading the availability of open data. An example of SDI is the BIOPAMA Regional Reference Information System for Biodiversity and Protected Areas Management. The webGIS in agroecology has a strong potential at different scales of the food system. Despite the limited number of cases, there is a growing increase of applications, especially in the connections among farmers and citizens in making visible food networks, and agroecological approaches in caring for food sovereignty and rights of nature.

Antony Moore and Marion Johnson accompany us to know the experiences of agroecology in Aotearoa, New Zealand, inside the project He Ahuwhenua Taketake (indigenous agroecology). Three case studies of Maori and Moriori farms, based on collective land ownership (trusts) are presented. GIS is used to support a geodesign process, integrating local knowledge with technical-scientific contributions for indigenous agroecological management. The chapter describes the process of data collection and management (from survey to geodatabase) to produce overview maps and facilitating dialogue among indigenous people and institutions. Maori (mainland New Zealand) and Moriori (Chatham Islands) farmers perceive their agroecological practices in the holistic perspective of the '*ki uta ki tai*': from the mountains to the sea. Native plants are central for *mahinga kai* (food) and *rongoa* (traditional medicine) for humans and animals, in a network of relationships among different beings, the *Papatūanuku* (Mother Earth) and *Ranginui* (Father Sky). Participatory approaches and spatial multi-criteria analysis are some tools used in geodesign of place-based agroecology practices. GIS supported the preparation of maps in agroecological planning of Henga and Te Kaio farms, to define zoning and areas for locations of *rongoa* for people and livestock, to integrate tourism activities into agroecosystems, exploring the integration among farming systems and livelihood systems. The Aotearoa He Ahuwhenua Taketake project, involving Maori and Moriori link farms, see in agroecology a first step of a long path for the integration of indigenous rights and food sovereignty facilitated by the use of participatory mapping with GIS and geodesign.

Agroecology and smart cities are analyzed in Chapter 9 prepared by Francesca Peroni, John Choptiany and Samuel Ledermann. The authors start with a critical review of globalized universalizing narrative of a smart city, using the generative question on whether smart cities are creating a real inclusive environment for citizens. On the other side, literature and practices on smart cities do not deal with food production and the right to food in the cities, and at the same time, there is a growing research area focusing on UA (urban agriculture). So, the chapter intends to open innovative paths integrating the debate on smart cities, urban agriculture, and ICT through the lens of agroecology. There are different ways of growing food in cities; however, in a debate on smart cities, it is important to avoid any capture of technological dimension subsuming the paradigm of precision farming and Agriculture 4.0. Urban agriculture is a key challenge of agroecological transition and sustainable food systems, asking for a redefinition of the spaces of urban food production and social inclusion. IC technologies can facilitate the spread of agroecological approaches in urban agriculture. The authors present some promising applications (partially in test phases), which may facilitate dialogue, co-creation, and sharing of knowledge among people interested in growing food by adopting agroecological approaches. Urban agroecology can represent a meeting point to overcome the reductive approach of smart cities, to improve the ability of urban ecosystems in providing multiple ecosystem services, and at the same time promoting food sovereignty and inclusion in urban planning and management.

Daniele Codato, Guido Ceccherini and Hugh D. Eva deal with free and open satellite imageries for land rights and climate justice in Chapter 10. The global importance of agroforestry systems of the Amazon region is widely recognized as a casket of biodiversity and cultural diversity of indigenous nations, and its role in the provision of ecosystem services, and to increase the resilience to climate change. The chapter offers an outlook on remote sensing principles and operations, presenting the different typologies of satellite sensors and platforms. The outlook integrates information on the availability of free satellite imageries on the web and on the tools and platforms available to access and process satellite imageries. Some remote sensing techniques are presented with a summary of band combinations and indexes useful for forestry and agriculture. The authors prepared a sort of 'travel guide' to easily navigate the new commons of free geographical information coming from satellite imageries available with a weekly (Sentinel-2) or fortnightly (Landsat 8) update. Despite its global importance, the Amazon territories are under pressure, driven by land-use changes that destroy (agro) forestry ecosystems and violate indigenous land rights. Neo-colonial policies, based on the extraction of commodities (fossil fuel, mineral resources, wood, agricultural products), are devastating this cultural forest, which for millennia was managed by indigenous people who elaborated the agroecological and polycultural systems combined with nomadism, hunting, fishing, and gathering. The final part of the chapter focuses on the use of remote sensing data in analyzing the hardly accessible area of Amazon rain-forest to implement human rights, environmental and climate justice of indigenous people and peasants.

Chapter 11 deals with the role of agrobiodiversity in connecting farms and landscapes. Ingrid Quintero, Yesica Xiomara Daza-Cruz and Tomás Enrique León-Sicard present the MAS (Main Agroecological Structure). The index, developed by León-Sicard, integrates agroecology and landscape ecology, exploring bioecological and socio-cultural dimensions. MAS is based on 10 criteria and 27 indicators measuring and mapping the internal farm agrobiodiversity, the connections with landscapes, and the agroecological practices implemented by farmers. MAS is an evaluation tool, useful to compare farms using different approaches (conventional and agroecological) or to design the agroecological transition, monitoring the change of MAS in a defined period. The methodology to evaluate MAS combines different types of spatial and non-spatial information and tools: satellite or aerial images, interview with farmers, fieldwork for floristic analysis, participatory mapping, and GIS, field survey, and use of drones to collect qualitative and quantitative variables. The use of participatory and desktop GIS provides the calculation of some indicators of MAS. In this procedure, the cartography is useful in the visualization of the internal condition of the farm and the connections with the surrounding ecosystems and agroecosystems. The MAS evaluation facilitates the dialogue among the different dimensions of agroecology, especially between academic research and farm practices in implementing agroecological transition and scaling up of agroecology, starting from a landscape and farm network approach.

The last chapter of the book collects the debate (co-ordinated by Massimo De Marchi) of the conference held at the University of Padova, on 22 September, 2020, in the context of the annual kick-off seminar of the International Joint

Master Degree on Sustainable Territorial Development, Climate Change Diversity Cooperation (STeDe-CCD). In the challenge of finding territorial alternatives to development in the context of climate change, agroecological transition, and food sovereignty represent the key elements to navigate the uncertainty of the pandemic era. Miguel Angel Altieri highlights the role of agroecology either in the rural and urban context, to overcome the social and environmental impacts of conventional farming through the integrated and multi-scale approach among social and natural systems based on rights of farms and citizens connected in sustainable and sovereign food networks. Salvatore Eugenio Pappalardo and Alberto Diantini intervened as discussants to focus on the role of the technological appropriation of the new commons of geographical information and technology in an emancipatory process which is ongoing in many parts of the world, from the Amazon rain-forest supporting the struggle of indigenous groups for safe territories to urban peripheries and conventional farming areas of the global north.

The technologies presented in this book should be handled in the framework of the Nyeleni Declaration of the International Forum of Agroecology (2015), to support livelihood systems in agroecology and the empowerment of the most affected actors in the world food systems: women and youth, herders and pastoralists, fisher-folk, peasant and small-scale farmers, indigenous people, workers, landless, urban communities, and conscious consumers.

This book starts a dialogue between agroecology multi-scale approach from farm to landscape level, and the potential of geographical information and technologies in promoting alliances between farmers and citizens connecting food webs, both in proximity to urban farming and in the quest for land rights in remote areas in the spirit of 2030 SDG.

Dialogue should continue, focusing on the four entry points for agroecological transition (Wezel *et al*., 2020): responsible governance involving multi-level and multi-actor commitments facilitated by the combination of agroecology and geography experience; circular and solidarity economy being inclusive, technologies and innovation deconstructing the linear accumulation by dispossession; diversity, with all combinations among cultural rights and rights of nature, including the connections among humans and non-humans; the co-creation and sharing of knowledge: the everyday life of farmers and citizens is creative and challenges the unique flow of the disempowering innovation.

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