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SBI/SBSTA Koronivia Joint Work on Agriculture:

2(e) livestock management and, 2 (f) socio-economic and food security dimensions of climate change.

Response from Biovision, FiBL, IFOAM-EU and IFOAM- Organics International

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Introduction

At COP23, Decision –CP/23 invited parties and observers to submit their views on the joint SBSTA-SBI work known as the "Koronivia Joint Work on Agriculture" (KJWA), to inform workshops to be held at UNFCCC COP25 on the topics of: ***2(e) livestock management and, 2 (f) socio-economic and food security dimensions of climate change.***

Inputs on the content of the workshop

Summary

The organizations submitting this contribution, believe that **organic and other agroecological farming practices and principles**, **must be taken into account as very promising strategies to ensure the establishment of sustainable and climate resilient agricultural systems. Combined with shifts in diets and production, agroecological food systems can contribute to reducing GHG emissions and at the same time provide many co-benefits for biodiversity, soil carbon sequestration and adaptation to climate change.**

In the light of the topics of these two workshops and in order to achieve the necessary transformation towards fair and climate resilient food systems, we urge the Koronivia Joint Work on Agriculture to aknowledge the role of agroecology as a path to achieve the Paris Agreement targets and thus to work further on:

- Sharing best practices in the entire food system for meeting the 1,5-degree target, by reducing food waste and modifying consumption patterns towards plant-based proteins.
- Fostering the discussion around the creation of binding regulations that enforce the "polluter pays principle".
- Promoting discussions around startegies for reducing emissions linked to the livestock sector.
- Showcasing practices that decrease the impact of GHG emisisons in the meat and dairy sector by cutting deforestation and nitrogen oversupply and corresponding emissions.
- Sharing best practices to avoid overgrazing though proper management since this practice has a beneficial impact on soil quality and GHG emissions.
- Promoting better storage and processing of manure, which significantly reduce GHG emissions of both nitrous oxide and methane.
- Grounding current and future workstreams related to agriculture and land on the international recognized definition of food security (see page 7), setting criteria that tightly link responses to the climate crisis with the food security dimension.
- Recognising, promoting and supporting agroecology since it provides increased resilience and mitigation co-benefits, in particular through socio-economic aspects.
- Acknowledging that the features of this key socio-economic elements are co-creation and sharing of (traditional) knowledge and fostering local food networks and knowledge webs.
- Promoting access to extension services and knowledge for farmers as well as a supportive instituational context.

Seen the importance of cross sectoral collaboration among food security and climate change, ***we hope you will positively consider the candidacy of Prof. Olivier De Schutter as an expert for the workshop on the socio-economic and food security dimensions of climate change****. Mr. De Schutter would be a valuable speaker considering his previous role as a United Nations Special Rapporteur on the right to food and his current position as a co-chair in the International Panel of Experts on Sustainable Food Systems. He has already confirmed his availability and expressed a great interest in attending the KJWA workshop in October during SB52.*

1. Sustainable livestock management

1.1 Industrial livestock farming is a threat to the world´s climate, human health and natural ecosystems

The industrial meat and dairy sector uses a significant amount of natural resources to satisfy the world's increasing meat demand. These sectors combined emit 7.1 gigatons CO2-eq per annum globally, representing 14,5 percent of human-induced GHG emissions. Feed production and processing and enteric fermentation from ruminants are the two main sources of emissions, with 45 percent (32 Gigatons of carbon dioxide) and 39 percent (2,8 Gigatons) of sector emissions. Manure storage and processing amount to 10 percent of the total, while the remaining 6 percent is due to the processing and transportation of animal products. (Gerber, 2013).

The EU and countries such as the U.S., Canada, Brazil, Argentina, Australia and New Zealand all have both surplus production and high per capita consumption of meat and dairy. Together, they account for 43% of total global emissions from meat and dairy production, even though they are home to just 15% of the world's population *(GRAIN and IATP, 2018)*. These countries are also home to the biggest meat and dairy corporations.

Despite the fact that the world's top five meat and dairy corporations together are responsible for more annual greenhouse gas emissions than oil companies such as ExxonMobil or Shell or BP (GRAIN - IATP, 2018), these companies are not held accountable for their stake in the climate crisis. Indeed, far less effort and transparency in communicating their GHG emission targets and consequently their commitments to mitigate has been requested from these corporations. Nevertheless, it is evident, that any scenario that brings global meat and dairy production and their emissions in line with a 1.5 °C pathway requires significant cuts in emissions by the meat and dairy companies located in the surplus protein centres. Those regions and the respective companies should be held accountable of the absolute emissions linked to the upstream supply chains as well. Livestock use about 70% of global agricultural land, through feed and forage production (Van Zanten, et al., 2018) exerting great pressure on forests and natural ecosystems, but it only provides 18% of the calories consumed globally.

It is therefore necessary to have binding regulations to enforce the "polluter pays principle", phasing out any type of climate damaging incentives (i.e. subsidies that encourage the extension of such intensive form of industrial agriculture and high dependence upon imported feedstocks like soy) (Global Forest Coalition, 2018).

1.2 Turning animal husbandry into a leverage to address the climate crisis

In the light of what has been said, transforming livestock production is critical to maintaining our food systems within planetary boundaries while also achieving consistent production systems. Agroecology and organic farming can lead the way.

The key factor to reduce emissions linked to the livestock sector is to **reduce animal numbers** worldwide and in consequence manure quantities, focusing on those countries performing industrial livestock system to the highest extent.
A central lever to achieve this is on onse side to to **reduce imported feedstocks** and to focus on livestock reared on non-food competing feed, such as grass, byproducts, residues and waste, thus reducing concentrate feed use and production, which also contributes to the nitrogen oversupply and corresponding emissions. On the other side we need a **shift in diet towards more plant-based proteins.**

1.2.1 Focsuing on quality, animal welfare, ecosystems preservation and manure management

Animal husbandry done according to agroecological practices, such as organic agriculture , and with a focus on non food-competing feed, provides sustainable production systems, that are adapted to the local conditions and carrying capacities of ecosystems (Schader et al. 2015, Muller et al. 2017). There are also many specific strategies to reduce GHG emissions in agroecological livestock husbandry. Studies have shown that the methane emission from milk and beef production can be reduced after the adoption of dual-purpose cattle breeds that provide both milk and meat from each animal (Gotz & Buitkamp, 2005). Double-use breeds, commonly used in organic agricultural systems, are normally not kept in conventional buisness because of their lower milk yields. Another strategy is to increase the lifetime and number of lactations of dairy animals, thus reducing the relative emissions per kilogram milk.

Livestock management is indeed an important economic activity that ensures livelihoods worldwide, while having the potential to deliver a number of ecosystem services. For instance, in areas where crop cultivation is physically not possible, mostly in dryland or highlands areas, pastoralism is providing several co-benefits. On one side, it rears livestock on non-competing feed while at the same time providing an essential source of income for the local communities. Several grazed ecosystems naturally accommodate livestock, or even need livestock grazing for the maintenance of key ecosystem functions. However, it is important that grazing is managed sustainably. Studies show that such sustainable cattle grazing where stocking rates are low and within the carrying capacities of the respective areas may improve soil quality and enhance sequestration of carbon and nitrogen (Lemaire, Franzluebbers, & Carvalho, 2014) . Agroecology and organic agriculture can once more serve as an example, because their practices focus on animal welfare and prevents overgrazing due to lower number of heads of livestock, as prescribed in all organic regulations (Kijlstra & Eijck, 2006) (IFOAM, 2016). Avoiding overgrazing though proper management has a beneficial impact on soil quality and GHG emissions, because it keeps carbon in the soil as organic matter, rather than releasing it into the atmosphere as CO2 (Lemaire, Franzluebbers, & Carvalho, 2014).

This practices coupled with better storage and processing of manure can significantly reduce greenhouse gas emissions of both nitrous oxide and methane by 50% (Amon et al., 2006).

Manure composting is often used in agroecology, organic agriculture, and in biodynamic agriculture in particular. This technique alone can reduce nitrous oxide by 50% and methane emissions by 70%, although it does have the potential to increase ammonia emissions and thus may result in 50-120% higher indirect nitrous oxide emissions (IFOAM, FIBL - EU, 2016). Yet, the indirect emissions from the application of manure compost can be much lower than those from normal manure. Given the trade-offs over the entire life- cycle from production to application, manure compost has the potential to reduce emissions from manure management.

1.2.2 Reducing meat consumption is inevitable

A shift in diet from animal-based proteins to plant-based protein, is needed if we want to curb greenhouse-gas emissions. The EAT Lancet report (2019) points out the urge to change our food habits. Strong evidence indicates that the current food production is among the largest drivers of global environmental change by contributing to climate change, biodiversity loss, interference with global nitrogen and phosphorus cycles, and land-system change.

The rapid expansion of livestock production together with the current population growth have led to dedicate almost 80% of the total agricultural land to grow animal feed instead that for direct human consumption (FAO, 2019). The International Institute for Environment and Development (2015) points out that using cropland to produce corn, soybeans and other crops for animal feed rather than to grow food for direct human consumption is “a colossally inefficient” use of resources. This has been recognized also by FAO, which has claimed that “When livestock are raised in intensive systems, they convert carbohydrates and protein that might otherwise be eaten directly by humans and use them to produce a smaller quantity of energy and protein. In these situations, livestock can be said to reduce the “food balance” (Stevenson, 2015). Therefore, reducing the intake of meat and other animal based products would lead to a reduction in dietary GHG emission, which makes a valuable contribution to climate change mitigation.

Even if yield gaps between conventional and organic farming are around 20%, in combination with reduced feed production (e.g. much less forage maize, and much less cereals and soy as concentrate feed) and less animals, this can contribute to a sustainable, more climate friendly production system that delivers enough food. It is pivotal to do so because, organic agriculture and related approaches also build overall resilience in agricultural systems by enhancing soil health and fertility, increasing soil water-holding potential, and increasing the diversity of soil microflora and fauna, keeping in mind that these soil qualities will be critical in dealing with the varied impacts of drought and and other weather extremes due to climate change.

Finally, a sustainable food system cannot be achieved without considering the estimated 1.3 billion tons of food wastage for human occurring each year (Gustavsson et al., 2011). Substantially reducing the amount of food loss and wasted across the food supply chain, combined with reducing the animal numbers of livestock production and organic agriculture, provide a promising scenario for a more sustainable agricultural production, food supply and consumption (Muller et al. 2017).

To end with some more concrete suggestion for the livestock sector, we emphasize that working on reducing nitrogen imports from outside adequately defined local regions would be a promising approach (e.g. by regulations, taxes on external nitrogen imports, etc). This would reduce nitrogen surpluses with corresponding nitrous oxide emissions and biodiversity impacts, it would result in reduced livestock numbers with correspondingly reduced manure quantities and stocking densities and a generally reduced intensity, with positive animal health and welfare effects, it would incentivise optimised recycling of the nutrients in the remaining manure, as well as optimised use of locally available feed sources (grass, residues, processing waste, etc.).

1.2.3 Co-benefits of tackling and reducing industrial livestock systems

- **Addressing the main drivers of biodiversity loss**: wether the livestock production results in positive or negative impacts on biodiversity depends mainly on the intensity of production. The industrial livestock sector exerts a havy pressure on finite resources such as land, forests and water. Beef is, together with soy (as livestock feed), the top agricultural commodity driving deforestation worldwide, not only causing the release of billions of tonnes of carbon dioxide into the atmosphere and but also driving thousands of species of life to extinction each year. Intensive livestock systems also strongly depend on external feed inputs with correspondingly huge nutrient inflows and related damages to the ecosystems in the production areas. Additionally also genetic diversity is eroded when only few livestock breeds are maintained because of their higher productivity. Promoting agroecological livestock systems will allow to upscale preservation of biodiversity. Finally, organic farming does not allow synthetic pesticides that also run off into water bodies with a polluting effect and toxicity for water animals.

- **Addressing nitrogen surplus**: manure storage and processing represent 10 percent of the livestock sector emission. The key factor in reducing these emissions lies in how the manure is handled because the amount of methane emitted dependends on the anaerobic conditions and temperature in the manure management systems. Also the amount of nitrogen lost (partly ultimately resulting in nitrous oxide emissions, i.e. GHG emissions as well) is strongly influenced by housing and manure management conditions. Promoting better storage and processing of manure can significantly reduce greenhouse gas emissions of both nitrous oxide and methane by 50% (Amon et al., 2006). As animal production intensifies, more production occurs further away from feedstock production, making it harder to close nitrogen cycles. Overabundance of nitrogen and subsequent eutrophication threatens water supplies and biodiversity, pollutes the air (ammonia), and contributes to atmospheric warming by fuelling nitrous oxide emissions. Studies show that much higher rates of nitrate leaching occur in conventional farming systems than organic, and that the former are associated with higher levels of pollution.

- **Better soils**: Another factor is the greater amount of soil organic carbon in organic agricultural systems, which results in a correspondingly higher soil quality and fertility. This results in higher nitrogen holding capacity in the topsoil of organic farmland and reduces surface runoff, thereby reducing soil erosion and preventing flooding of agricultural fields (Zeiger and Fohrer, 2009, Lorenz and Lal, 2016). This in turn helps increase yields and helps plants adapt to negative climate change impacts, such as water-related extreme weather events (Muller et al., 2011).

- **Addressing the insurgence of new resistant microorganisms**: the overuse of antibiotics in intensive livestock farming is considered to be one of the biggest emerging threats to human health, spreading resistance to vital drugs and harming millions of lives (Van Boeckel, et al., 2019) (UN, 2017). In the United States, antibiotic use in food animals is estimated to account for ~80% of the nation's annual antimicrobial consumption. (US Food and Drug Administration , 2016). The routine and indiscriminate use of antibiotics in intensive livestock systems, to prevent infections and speed up the animal growth, which ultimately end up with the release of these compounds in the natural environment, creates possibilities for resistant pathogens and new resistant elements to emerge, with unpredictable – but already devastating- impacts on human and animal health. Organic livestock production, which prohibits the use of antibiotics for growth promotion or prophylactic purposes, provides a compelling example of alternative, successful and profitable operations, demonstrating the ability of livestock farms to operate without substantial antibiotic use and providing a model for how agriculture can contribute to a solution (Misiewicz & Shade, 2016).

2. Socioeconomic impact of food security and climate change

2.1 The food and climate nexus.

The severe effects of climate change on agriculture – including crops, livestock, fisheries, aquaculture and forestry – are widely recognized to be already affecting the global food production (Ray, et al., 2019) (FAO, 2016). Agriculture is shown to be highly vulnerable to climate change and absorbs around 26 percent of the total damage of climate-related natural disasters in the developing world (FAO, 2018).

Changes in temperature and precipitation associated with continued emissions of greenhouse gases are bringing changes in land suitability and crop yields. In semiarid areas, droughts can dramatically reduce crop yields and livestock numbers and productivity, exposing land in Sub-Saharan Africa and parts of South Asia to the highest degree of instability in food production. According to FAO (2018), "*in developing countries, up to 83 percent of all damage and loss caused by drought, which climate change is expected to intensify, is absorbed by agriculture*". In fact, climate change has already affected maize and wheat yields, which have decreased by 5% in the last 30 years, and forecast to further decrease of 10-25 percent by 2050. These additional risks on agricultural production directly affect food security and nutrition of the people who directly depend on agriculture for their food and livelihoods.

Over the past years, the connection between climate change and food security has been highly recognized also at international level. The Paris Agreement, the 2030 Agenda for Sustainable Development (particularly SDG2 and SDG13), the Sendai Framework for Disaster Risk Reduction, the IPCC 5th Report (including the IPCC 1.5 Special Report), and the outcome of the United Nation Conference of Sustainable Development (Rio+20) concerning food security, nutrition and sustainable agriculture, emphasize the challenges imposed by the current climate crisis and its evident link to increased disaster risk, which constitute a major threat to the food system.

2.1.2 Building synergies between climate and the food security policy processes is pivotal

The adoption of The Koronivia Joint Work on Agriculture (KJWA) by COP 23 in 2017 marked an important turning point for the status of agriculture in the international climate negotiations, expliciting the needs to take into "*consideration the vulnerabilities of agriculture of climate change and approaches to addressing food security*".

The international recognized definition of food security adopted during the World Food Summit (1996) proclaims that "*Food security exist when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*". This definition points out the four pillars of food security: physical availability of food, economic and physical access to food, food utilization influenced by sanitary and nutritional quality of food and stability of the above three dimensions of food security. The crucial issue behind the definition goes beyond production itself, to rather look at the socioeconomic means at the disposal of the population that must be sufficient to ensure that everyone worldwide has adequate access to food, in the right quantity and quality, all the time. To ensure the stability of the three dimensions explicitly included in this definition, it is essential to take into account the sustainability of the food production systems and their impacts on the natural resources on which food production depends.

Ensuring food security and resilience for farmers while creating and strengthening mitigation co-benefits and low-emission pathways should be the main goal of mitigation and adaptation strategies in agriculture. Acknowledging the important role sustainable livestock production as described above (no food-competing feed, no feed imports, adequate stocking rates, optimised manure management and nutrient cycling, locally adapted breeds, etc.) can play in this in many regions is an important part of this. Governments should consider it a priority when defining greater ambition to reduce emissions in the agricultural sector in the framework of their new Nationally Determined Contributions (NDCs). Mitigation strategies should not pose a threat to food and nutrition security, especially for poor rural populations in developing countries.

In this context, it is important to phase out incentives to false solutions such as monoculture tree plantations, concentrate-feed based large-scale industrialised pig and poultry production or the deployment of bioenergy, including bioenergy with carbon capture and storage (BECCS), as these activities have significant negative impacts on food security and biodiversity, without delivering any climate mitigation or adaptation benefits. (Dooley, K et al., 2018)

There is a need for collective effort and collective results from a systemic perspective to food systems, which requires urgent and integrated, cross-sectoral action guided by multi-stakeholder dialogues, participation and partnership toward co-creating a common agenda for action and advocacy.

- The Committee on World Food Security (CFS) should play a more active and prominent role in raising awareness on the importance of food security and nutrition in the context of the International Climate Change Agenda.
- The UNFCCC KJWA or its follow up process could be a good platform in the future to ensure stronger links and integration between CFS and the UNFCCC process. In addition, relevant decisions taken by the CFS should be taken into consideration by the UNFCCC.

2.3 Agroecology can foster climate resilience on socio-economic dimensions.

The impacts of climatic change will diffuse through the entire food system, from production to consumption and from the individual farmer to society. **Building a climate resilient food system thus not only entails the adaptation of current agricultural practices but also the redesign of the supporting system such as social fabrics and economic models that they are embedded in.** This further requires understanding of contextual elements such as market structures, consumer and producer behavior, availability of technology and others that all are interlinked in the socio-economic dimension (Van der Ploeg, 2019).

Firstly, to address such complexity "integrated approaches will help consolidate multiple goals within broader efforts to manage land" (Meridian Institute, 2011)[1]. Unlike other approaches that put a strong focus on technological solutions, **agroecology has enshrined such an integrated approach through its principles that also include key socio-economic aspects.** Accordingly adaptation benefits of the agroecology approach result also from various interactions between these prinicples. In particular greater diversity and heterogenity of socio-economic components of Agroecology at livelihood scale lead to gains from synergies. Thereby both productivity and resilience gains are realized (Sinclair et al., 2019). Agroecology also builds on synergies between social and economic and environmental dimensions by reducing negative externalities (e.g. minimizing waste and reducing negative effects on health), and supporting positive externalities such as environmental health and resilience.

Secondly, we argue that fostered social aspects within the agriculture sector render livelihoods of stakeholders more resilient against direct and indirect climate shocks. In this context, relevant aspects amongst others are: empowerment and self-determination of stakeholders, social safety nets by communities, or uphold of social principles like equity, inclusion and fairness. Under a rather economic viewpoint, independence from inputs provision, access to functioning markets, financial safeguards and reserves, and sustainable economic models can foster climate resilience of farmers and other stakeholders while avoiding emissions via efficient production and recycling practices.

The following table provides an overview, although not exhaustive, of the socio-economic aspects that are addressed by selected agroecology elements and elaborate on how they could foster climate resilience in food systems or mitigate emissions:

Table 1: Overview of effects and climate related potential of selected Agroecology elements

	Features of Agroecology Element	Adaptation or Resilience Benefits	Mitigation Benefits
Co-creation of Knowledge	- Knowledge generation is context-specific and tailored to local needs. - Traditional and scientific knowledge is combined. - Innovative knowledge is generated through collaboration of actors with different expertise. - Fostered peer to peer learning allows better access to knowledge.	- Various actors acquire a shared understanding about climate risks and the respective needs to adapt. - Adaptation knowledge via peers is effectively uptaken. - Locally adapted knowledge leads to effective and practicable solution. - Awareness-raising about adaptive strategies across generations is fostered and maintained.	- Knowledge about mitigation potential of production forms can lead to reduced emissions. - Examples: residue burning, livestock or soil mana-gement, reuse of manure, avoidance or efficient use of synthetic fertilizer

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[1] Meridian Institute. 2011. "Agriculture and Climate Change Policy Brief: Main Issues for the UNFCCC and Beyond."

Human / Social Values	- Autonomy and adaptive capacities of individuals and communities is ensured. - Dignity, equity, inclusion and justice in livelihoods is fostered. - Empowered women and youth life skills and opportunities(e.g. skills, knowledge, work opportunities, good health).	- Strengthened climate adaptive capacity through community based strategies, networks and resource management. - Respect of social values and norms can foster solidarity in climate crisis situations. - Empowerment of woman and youth can foster their socio-economic resilience and could abate social disintegration in crisis.	- Empowerment, more autonomy or an enabling social environment leads to (technical) innovations or behavior change that could entail emission reductions.
Culture / Traditions	- Enhanced production and consumption of healthy food is fostered. - Diversified nutrition is supported. - Culinary and culturally diets and production forms are adopted.	- Demand for diversified nutrition could foster resilience given the diversification of production required for this. - Healthy people could better adapt to socio-economic changes from climate impacts.	- Healthy foods produced without chemical inputs result in decrease of CO2 emission related to fertilizer manufaturing - Consumption of locally produced food reduces emission from food transportation and storage.
Diversity / Resilience	- Enhanced diversification in produce, types of business models or resource management approaches can enhance climate resiliece	- Enhanced variety of income sources, sales markets, products or types of processing could stabilize financial robustness and thus resilience in crisis. - Crop and animal diversity as well as temporal and spatial heterogeneity protect against losses from climatic events.	- Changes from emission intensive towards ecological production practices can abate emissions. - Examples: stop of field residue burning, synthetic fertilizer replacement, livestock management.
Efficiency/ Recycling /Synergies	- Time savings e.g. from efficient production practices and procedures - financial savings e.g. through reduced external inputs. - Effective (re-)use protects local natural resources. - Reduction of energy intense inputs. - Reduction of food waste. - partnerships, cooperation and responsible governance, involving different actors at multiple scales is empahzised.	- Reduced production costs allow for financial buffer in climate crisis. - Reduced dependency on external resources might increase resilience to natural or economic shocks. - Focussing on synergies adaptation and mitigation benefits can be realized (e.g. solar powered waterpumps, biogas as substitute for fire wood) - Agro-Silvo-Pastoral approaches use synergies and can foster resilience (e.g. shadow and fodder for livestock from fruit trees)	- Reduced emissions from more efficient and effective (re-) use of resources. - Avoided emissions e.g. from less food wasted.
Circular Economy /Good Governance	- Producers and consumers are connected more closely. - The development of local economies is fostered. - Socially fair production is facilitated and local needs of producers and consumers are considered. - Responsible and effective governance to support the transition to sustainable food and agricultural systems	- Participatory guarantee systems, local producer's markets, community based production and retail can foster social safeguards for individuals against shocks. - Short food chains can increase income of producer and provide fair prices for consumers, thus allow for financial savings for more critical times. - Local employment and support by communities might buffer negative economic co-effects of climate impacts (e.g. price volatility). - Public procurement programmes, market regulations for branding of produce, subsidies or incentives for ecosystem services can speed up the transition to resilient food systems - Provision of incentives for the long-term investments that are necessary to protect soil, biodiversity and ecosystem services.	- Avoided emissions from shorter value chains for production or retail of produce - Legislation, policies and programmes can target emission sources and attain emission reduction from the sector (e.g. livestock or energy use) by supporting agroecology systems.

Thirdly, selected **scientific evidence and a broad range of case study examples underpin a positive socio-economic effect of agroecologic approaches**, which then in turn are critical to buffer climate change impacts (Annolfo et. al. 2017, Van der Ploeg 2019, Dumont 2016). A recent study by FAO (2020) highlights how agroecology can increase climate resilience:

- by strengthening ecological dimensions such as (bio-) diversity and healthy soils;
- through **fostering social-economic dimensions, in particular integration and sharing of traditional knowledge as well as integrating spatial and temporal heterogeneity**.

Two country-specific case studies in this study shed further light on how agroecology scores significantly better in various socio-economic indicators[2]. Resilience is strengthened through:

- **integration and sharing of traditional knowledge**
- **connectedness and the ability to self-organize in social cooperation/networks;**
- **reflective and shared learning**

Finally **Agroecology's potential to build resilience depends on its holistic, transformative and systemic nature, which goes beyond a set of practices.** It also includes a social movement, for producers' empowerment and a multidisciplinary scientific paradigm. This holistic approach is key for its potential to strengthen resilience and also generate mitigation co-benefits. To lower barriers to the scaling-up of agroecology and organic practices, such as its knowledge intensity, complexity and context specificity, **farmers needs to be supported through improved access to extension services and knowledge as well as a conducive instituational context so that they can be empowered to fully becoming part of the climate solution and ensure stable and resilient production.**

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[2] According to FAO's SHARP tool these indicators are key for measuring resilience of agroecosystems.

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