Organic-PLUS - grant agreement No [774340]

Pathways to phase-out contentious inputs from organic agriculture in Europe

Deliverable 2.10:

Policy briefing and phase-out reflections on contentious inputs from organic (and conventional) agricultural production

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The following request for revision comment was addressed: "*As recommended during the review meeting, please include a table displaying the scenarios and actions (including the years where the phasing out is anticipated to take effect) for phasing out the contentious inputs".* This was done by adding Section 5.3 in version 3. In addition, further final editing for spelling, readability, adding some missing references, removing figures and text not strictly required or already published in other deliverables was conducted by the editor *Dr Francis Rayns, Coventry University* (not involved as author in this WP).

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Content

1 Can we use agroecology to push organic farming further and remove contentious inputs?

1.1 Where is agroecology now?

Agroecology is defined as a science, social movement and a practice. It has been put forward for mainstreaming in the agricultural research sector for many years (e.g. Wibbelman, Schmutz, et al., 2013) and public policies, FAO, EU and funding bodies are increasingly recognising its significance. Currently agroecology is prominently used by the SCAR (Standing Committee on Agricultural Research (https://scar-europe.org) and a European wide **'Partnership on agroecology living labs and research infrastructures'** as part of 'Horizon', the largest research and innovation funding programme in the world (European Commission, 2022).

Here we discuss how an agroecological approach can be used to phase-out contentious inputs from organic and conventional agriculture. The ideas are further developed from a recent IFSA Symposium. This was the 14th European Farming Systems Conference held by the IFSA (International Farming System Association) held at the University of Évora, Portugal, 10-14 April 2022), where a presentation was given by Stéphane Bellon with input from co-authors Sara Burbi and Ulrich Schmutz.

1.2 The potential of agroecology

Agroecology is promoted as a more sustainable alternative to current input intensive agriculture and a holistic system approach. It is also recognised as a promising approach for climate change adaptation, as many contentious inputs are fossil fuel derived (e.g. mineral oil, plastic etc.) could be phased out by adopting agroecology principles. Similarly peat, often described as a *'young fossil fuel'* that continues to be used in horticulture, has severe consequences for the landscapes from which it is extracted and results in release of carbon stored in peatlands.

Agroecology, in common with many other concepts has also 'suffered' from institutionalisation and appropriation of the concept. Although the term agroecology is also promoted (and legally protected) as an intervention under the legal definition of *'organic, biological or ecological agriculture'* in EU regulation science 1991, in our discussion we use the concept of agroecology to improve organic with system thinking. In other words, we aim for ***organic plus holistic agroecology*** and not ***agroecology below the existing legal organic standards,*** in the EU and worldwide.

Agroecological practices have potential to make farming systems more robust and reduce the need for contentious inputs. Many contentious inputs are used because organic systems have been converted from more intensive conventional systems. While this is an improvement in itself, these systems often have problems locked-in from the previous conventional management. These include large fields, degraded soil fertility, limited hedgerows and agrobiodiversity, intensively planted orchards, relatively high input dairy systems with limited free-range grazing and little agroforestry or mixed farming to utilise the diversity of landscapes.

Figure 1 shows the potential of agroecological practices and their low, medium or high level of integration in today's agriculture. An assessment of the potential of agroecological practices is also shown and, since this is based on 2014 analysis (Wezel et al. 2014), some practices like agroforestry with low integration may now be underestimated; the potential assessment will improve with further knowledge. There is also potential of agroecological practices to enhance resilience (tabulated in Altieri et al. 2015) which might reduce the need for contentious inputs in the first instance.

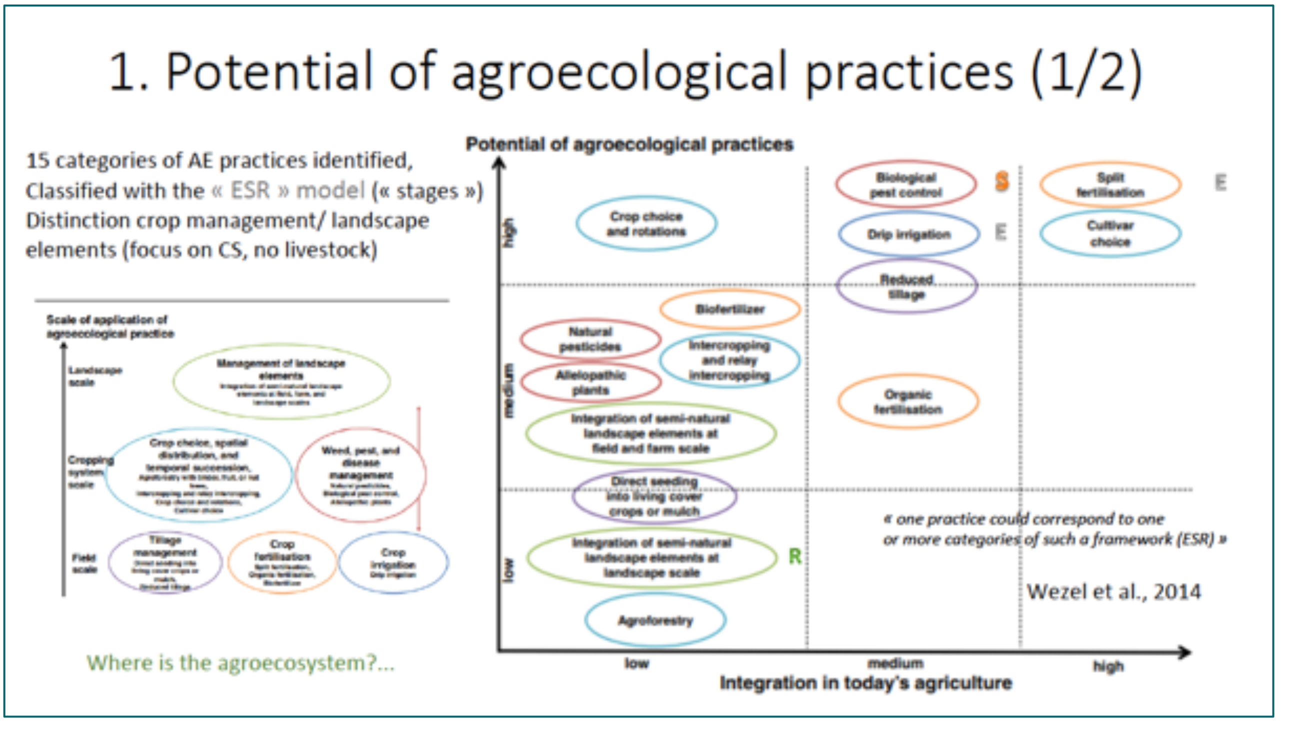

Figure 1: Potential of agroecological practices (AE). Example of a slide used at IFSA presentation, 2022 and based on data from Wezel et al. 2014.

There is further information that agroecological practices can help with climate change mitigation (Leippert et al 2022). Key agroecological practices link well with good climate change mitigation performance (e.g. soil biodiversity parameters like soil organic carbon content, soil biodiversity or soil microbial activity). This is also the case for organic agriculture and agroforestry, due to increased crop diversity, however this is just 'organic' without 'organic plus'. Data show key practices and characteristics (e.g. low-input systems, diversified systems, agroforestry, organic agriculture) also perform well regarding natural/biological plant protection, creating a baseline from which to improve organic with more agroecology. Important to note is, that key characteristics of agroecology such as biodiversity and landscape complexity correlate with higher yields and improved pollination services, and higher diversity also correlates with greater yield stability over time. More agroecology in organic systems without contentious inputs is, therefore not a strategy to reduce organic yields and long-term yield stability, it is rather to lift the potential of organic holistically.

1.3 First conclusions

Agroecology has not only the potential to adapt farming to a changing climate, it can also be beneficial in the phase-out of contentious inputs. Its combination of approaches, provides 'system solutions', and, if pushed further, agroecology can contribute to eliminate the main driver of climate change: fossil fuel use, starting with all contentious inputs that are fossil fuel derived. It can contribute to the *'draw-down'* of historic pollution from greenhouse gases since the beginning of industrial coal and oil use. This is through carbon capture in soils and plants, specifically trees, and through restoring global peatlands once peat use is banned. By phasing out fossil fuel pesticides and fossil fuel derived synthetic fertilisers, agroecology has already achieved a lot, but now, much more radical changes are required to avoid a catastrophic climate breakdown and the extinction of large parts of the planet's biodiversity.

Previous authors (e.g. Wezel et al., 2014 in figure 1) may have underestimated the potential of agroforestry for more radical food and farming system changes. They may also have underestimated how much land becomes available if food waste is addressed and intensive livestock systems are eliminated. More research is needed around changes in diets to flexitarian, vegetarian and to vegan, and how much this impacts the landscape in terms of crop choice. Since two thirds of Europe's arable land is used for animal feed, even small changes in diets can have large effects on transforming landscapes into agroforestry and mixed farming.

In the phase-out of all contentious inputs, agroecology and 'system solutions' built with the main elements sign-posted above are needed to make progress beyond simple input substitution. This is the case for all contentious inputs like copper, mineral oil and the remaining pesticides permitted in organic and agroecological systems.t can also be the case for remaining inputs like peat, plastic and fertilisers manufactured from or with fossil fuels. This is without considering fossil fuels used on organic farms for cultivation, heating, transport and lubrication from the current phase-out discussion.

For livestock, agroforestry and silvo-pasture can eliminate the need for antibiotics, anthelmintics and synthetic vitamins, making it possible to outlaw their routine use and any intensive livestock systems relying on them in 21st century, as morally contentious inputs into agriculture were made illegal in the 19th century. Therefore, not only can we push agroecology a step further, we also must, if we take into account the climate change threat, phase-out of fossil fuels, and other contentious inputs.

2 Why 'organic' has to outperform itself and how system approaches can contribute

2.1 Introduction

"*Organic agriculture has a history of being contentious",* is the opening sentence of a paper published by authors addressing the potential of organic food and farming (OF&F) in the twenty-first century (Reganold and Wachter, 2016), and the Organic-PLUS consortium is part of this dynamic. More specifically, another *Nature* paper *"The contentious nature of soil organic matter"*, also from American authors, contrasts how traditional and emergent views of the nature of soil organic matter affect how we predict and manage soil, air and water (Lehman and Kleber, 2015). It indirectly questions one organic paradigm, "organic matters" as a metaphor and gives a central role to (stable) humus and in soil fertility and land care. It notes that 'organic' also refers to *living organism*, which can be applied at various levels, including at farm scale. This second understanding of 'living organism' is the one the organic movement inspired at the beginning in the 1920s.

In the Organic-PLUS consortium, with its 25 partner organisations, a wide range of issues were addressed, enabling the identification of specific propositions and their dissemination with practice abstracts. Attempts to integrate such results took different forms within the time frame of the project (e.g. joint presentations and stimulation of possible interactions among WP, combined discussion with the Scientific Board as documented in this deliverable in further chapters). Likewise, the Organic-PLUS consortium contributed to (and opened) a policy debate during the TP Organic Innovation Days in December 2021, organised together with the RELACS project and further dissemination at e.g. Biofach and IFOAM world conferences.

However, the expected "holistic approach", consistent with the premises and definition of organic agriculture can still be further developed and is never complete, even if in some cases input substitution alone could also solve a problem.

2.2 Convergences and synergies

While identifying convergences and synergies, we offer some reflections regarding the future of Organic Food & Farming (we calling it OF&F to include organic food processing standards), with a focus on its ability to outperform firstly unclear defined "conventional" agriculture, as Sumberg and Giller (2022) called it in their paper on *"what is 'conventional' agriculture?"*. But, secondly, also OF&F's own reality and challenges. In this sense, the contribution of system approaches is also addressed in terms of system identity, questioning its boundaries with the environment and system properties likely to guide its future (the organic movement has not intervened in defining 'conventional' and when the word is used in this project it simply means all forms of non-organic agriculture versus the organic minimum standards enshrined in law in most countries).

We first discuss OF&F as a potential prototype for sustainable agriculture in general, then we discuss the redesign issue, progressing to define and evaluate the performance of re-design and what this could mean for renewed research and the policy agenda for organic farming.

2.3 Organic as a prototype for sustainable agriculture

The concept of prototype frames to what extent OF&F is a good representation of sustainable agriculture, and also an example of agroecology. At least three interpretations of this concept can be identified, reflecting both internal and external challenges.

First, due to its higher level of constraints and the absence of chemical crutches in production and other processes, specific solutions to arising problems have to be found, and such solutions can be helpful for other forms of agriculture (it might be compared to the application of racing car technology in our everyday cars).

The second interpretation refers to the ability of OF&F to achieve a wide set of performances, e.g. increasing productivity and closing yield gaps can be done at the expense of closing nutrient cycles and achieving a health enhancing food system. Such trade-offs are common in various forms of agriculture, albeit they often focus on the environment (regenerative agriculture) or one of its components (conservation agriculture).

The third perspective refers to OF&F development pathways, since a prototype is never completely achieved or else has to be adapted to site specific conditions. This opens the gate to OF&F dynamics and its diversity, enabling transitions or transformations with development more than growth (usually expressed as expected organic area). In the same vein, prototyping was proposed as an approach to design integrated and ecological arable farming systems (Vereijken, 1997).

Among the global challenges for agriculture, reducing drastically (and finally completely) the use of pesticides in production and their presence in products has become a goal shared by most European countries and is a major issue in public policy due to the increasing awareness of the long-term negative impacts of pesticides on the environment and on human health. The discussion around 'Insect Armageddon' triggered by research findings of more than 75% decline over 27 years in Germany (Hallmann et al., 2017) is an example for this renewed urgency which will arguably influence the European Green Deal and the Biodiversity Strategy with the target of 25% organic land use by 2030.

These challenges entail new paradigms and research fronts (Gascuel-Odoux et al., 2022; Jacquet et al., 2022), while considering that the organic regime of knowledge lies between societal expectations, farmers experiences and scientific evidence.

Simultaneously, an increasing number of challengers appear in the agricultural sector, putting forward their environmental benefits and sometimes following the same direction as organic agriculture, with specific standards or labels. This leads to competition and possibly controversies, although the organic movement has a long history, a wide international recognition and a strong tripartite standard regime of governance that consists of standard-setting, accreditation, and rigorous third-party or group certification (Loconto and Busch, 2010). This can equally be a strength in international trade, and a weakness to connect to the diversity of organic and agroecological movements.

2.3.1 Internal challenges

The organic sector also faces internal challenges. Several interpretations of the EU organic regulation (2018/848) are possible, and can be categorised around two contrasted polarities.

First we begin with the initial statements depicting a vision for the future of organic production within EU regulation.

The **first polarity** is particularly significant: *"Organic production is an overall system of farm management and food production that combines best environmental and climate action practices, a high level of biodiversity, the preservation of natural resources and the application of high animal welfare standards and high production standards in line with the demand of a growing number of consumers for products produced using natural substances and processes. Organic production thus plays a dual societal role, where, on the one hand, it provides for a specific market responding to consumer demand for organic products and, on the other hand, it delivers publicly available goods that contribute to the protection of the environment and animal welfare, as well as to rural development."* This includes explicitly a systemic dimension, while connecting management practices, food production, processes, products, consumers and standards. The dual societal role or organic production also enables framing the range of attached performances.

The **second polarity** starts with the end of the regulation main text, epitomised by a list of eligible inputs in the appendix supporting the implementation of organic production and processing. Such an interpretation partly led to a subsequent debate on observing the "conventionalisation" of the organic sector in Califorina (Buck et al. 1997, Guthman, 2004) while rejecting this finding for Germany (Seidel et al. 2019) and outlining a contribution organic can make to transition pathways for deeper sustainability (Darnhofer, 2014).

Between those two polarities, principles (e.g. soil-based crop cultivation) and production rules serve as an ideal to orientate a diversity of organic practices.

2.3.2 Internal diversity

The internal diversity of organics can also be described with the two previous polarities, as a first vertical axis (socio-technical design), and a second orthogonal axis. This second axis refers to management and governance (Sylvander et al., 2006), as previously identified in economic work. It also discriminates two polarities:

Corporate or individual governance: initiatives are based on a single actor's logic and strategic autonomy (for production, as well as processing and marketing), even on small producers' groups where each member keeps a certain part of autonomy, selling often directly to private customers on a local scale. The producer is usually in a position to face the consumer (or retailer) and justify his/her practices or products. Medium supply chains, dominated by a single "channel captain", can identified in this category. The products are generally less processed.

Sectorial or territorial governance: consists of several enterprises (in the production/processing stage), committed in a collective action (cooperatives and networks as well), with collective management devices ("hybrid forms" including formal contracts), on a supply chain basis or territorial basis. These types of enterprise market processed products, on regional, national or international scale.

These two axes define four quadrants (see Figure 2 and attached organic development models, with some commonalities (e.g. ability to be certified as a group) and possible trajectories to shift from one quadrant to another one. According to the models which are developing in the reality and/ or the public goals, it will be possible to infer different types of public policies. Implications in terms of research and innovation agenda are also addressed in the last section of the text, since the requirements in terms of knowledge and support are also different among development models.

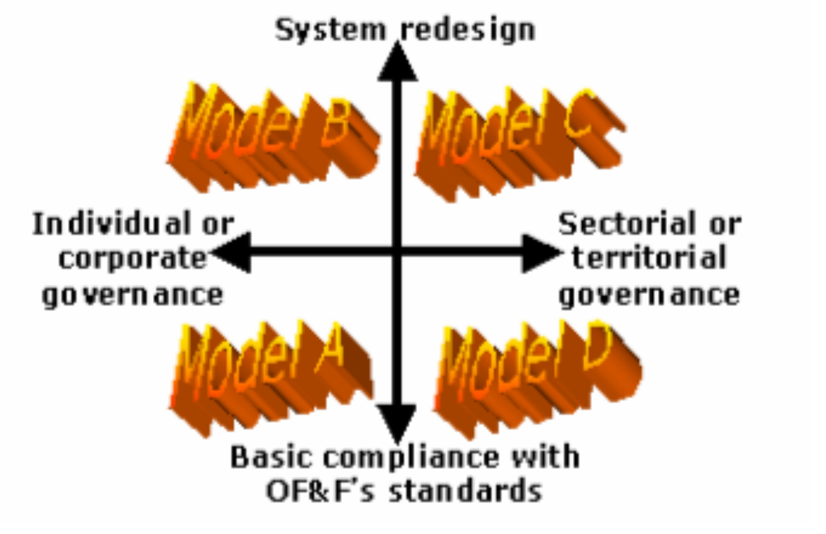

Figure. 2: A graphical representation of the diversity of development models in OF&F (Organic Food & Farming).

Admitting this internal diversity questions the identity of the organic sector and is also challenged by newer movements such as political agroecology. However, growth of the agroecological movement also raises questions about its nature: does it contribute to a radical break with the models inspired by the industrialisation of agriculture, or is it a range of new technical proposals that would allow the current regime to evolve from within (or be fragmented with the emergence of multiple innovative initiatives)?
To answer these questions, another two-dimensional framework was proposed to situate transition approaches (Antier et al., 2021) and enrich a debate on the coexistence or coevolution of models. Agroecological proposals are positioned in a space with two dimensions: on the one hand, the announced amplitude of the proposal or initiative: from specific (centred on a limited number of actors forming a homogeneous collective), to inclusive (integrating all actors in their diversity) and on the other its degree of radicality: from adaptation of practices for greater sustainability to an agroecology based on ecosystem services and including social dimensions. Subsequently, OF&F has to continue such dynamics, in co-evolution with other forms of agriculture, to fulfil the ambitions set in the EU organic regulation and the new challenges included in the EU "Farm to Fork" strategy regarding the scalability of organic farming.

2.4 The system redesign issue

Together with its growing recognition, organic agriculture continues to evolve. This evolution can be addressed with two paradigms – **decomposition** and **identity** – in the perspective of organic development. The first one is based on the possibility of decomposing and recombining resources, including cognitive resources; this is also applicable to complex systems, assuming their “near-decomposability” (Simon, 2002) into sub-systems (farming systems, cropping and livestock systems). The second is based on 'transcendent' resources. This is the case of the 'principles' of organic food and farming, which express a purpose and activate an alternative conception of knowledge to the idea of decomposing problems with universal benchmarks.

Defining the object system implies a specific viewpoint. For instance in apple orchards, a systemic approach to apple scab management was enabled by identifying about twenty strategies contributing at different levels: fungus, tree, orchard and commercial system (Vanloqueren and Baret, 2009). The scab problem can also be addressed through the development of resistant varieties, but other research programmes can be carried out to identify the natural predators of the fungus (antagonistic fungi) and which products enable the tree to defend itself better (induced systemic resistance). In commercial farms, a combination of techniques can be used, starting from the orchard establishment (choice of varieties; depending on the soil, variety and rootstock, planting distances that achieve a compromise between yield, vigour and aeration of the tree) to its management (training system adapted to the plant material, adjustment of fertilisation and irrigation).

Regular prophylaxis also contributes with (i) management of scab inoculum destruction of leaf litter (sweeping, burying, shredding) and complementary protection for codling moth (elimination of sources of infestation, placing of trap-bands in outbreaks). Direct control with pesticides of natural or mineral origin, biological, biotechnical (mating disruption) and microbiological control comes afterwards (Penvern et al., 2010). This technical route, seen as a logical and orderly sequence of interactive technical operations, is attached to a systemic view of the cultivated plot in agronomy. Considering agroecosystems generates other levers in land development: with the creation of refuges (nesting boxes, shelters, etc. for insects, birds, bats, etc.) and with controlled diversity in the vegetal environment (hedges, flower strips) to preserve, promote or restore natural balances while limiting harmful interactions for the orchard. In agroecology, the concept of agroecosystem reshapes the boundaries between the field/farm and its environment. It also conveys another vision of the environment, less compartmentalised, with its own integrity and multiple networks, paying attention to interactions and possible synergies e.g. between soil fertility and pest regulation (Altieri et al. 2015). Likewise, the concept of food system also enlarges the prevalent linear vision of food/value chains.

2.4.1 Transition perspectives

Conversion to organic farming is considered a complex innovation that requires a strategic or system change on the part of the farmer. It is difficult for farmers to experiment with the organic management system on small parts of the farm, although such experiments seem to be very important in the farmers’ decision-making process (Padel, 2001).

The fortune of the “Efficiency – Substitution – Redesign (ESR) model” (Hill, 1985) to analyse transitions as a stepwise and evolutionary process must be tempered (Padel et al., 2020). It should not be considered as linear, temporally determined or exclusive. Initially proposed as steps, later called levels, ESR must be addressed as polarities. Non-linearity can be exemplified with conversion to organics, which “by nature” implies input substitution. After conversion in its formal duration (2-3 years, and hence differing from transitions which entail larger time spans), a farmer can optimise the use of eligible inputs (thus increasing the efficiency and effectiveness or organic practices) without re-designing his system (Lamine and Bellon, 2009). ESR then becomes SE(R). The value of system Redesign (R) refers to the construction of diversified agroecosystems, enhancing ecological principles, where interactions between system components guarantee fertility, productivity and resilience properties.

The ESR polarities may also not exclude each other, as e.g. efficiency and redesign can be implemented in parallel on a farm. Referring to the previous example, a farmer can both develop ecological infrastructures or alternative crop rotations, whose functionalities will be effective after some years, and use biological control agents in the meantime. This is linked both with whole farm planning and with system innovations (Elzen et al., 2012). Moreover, it is sometimes difficult to classify agroecological practices per se into one or another category (E,S or R), for instance regarding cultivar choice (Wezel et al., 2014) and plant breeding, which can also be orientated towards wider "pathosystems" addressing several diseases, such as in vineyards.

The objective of redesigning agriculture (and later the food system) on the basis of principles is the aim of the organic movement and the ESR progression scheme guides the reflection of the actors of the movement on the translation of principles into practice. Thus, for example, the recognition of organic as a global management system has inspired the recent evolution of organic standards requiring a high degree of local autonomy for livestock feed supply. The tension between the diversity and identity of organic agriculture can be resolved by the adaptation of this ESR approach and thus connecting organic food and farming further.

2.5 Definition and evaluation of performances

There is a long tradition of evaluation of performance in scientific literature. The use of indicators to address incommensurability of dimensions, their trade-offs and tipping points is a considerable task. But indicator frameworks remain analytic in their interpretation.

Conversely, expected system properties to develop (self-reliance, resilience, etc.) can be an asset in selecting meaningful indicators to guide processes, practices and subsequent performances. There are further new dimensions to explore e.g. justice, fair price, sovereignty. Equally of interest is the self-referral capability in the organic and agroecology movements and carbon neutrality (Aubert et al., 2019). Finally, there is a new evaluation criterion to imagine; the further ecological transformation of organic food and farming (organics), economy and public policies entail a normative shift, where productivity cannot be the unique performance.

2.6 Towards renewed research and political agendas

By following the economic theory of conventions (Thévenot, 2001) and going beyond the conventionalisation thesis, it is possible to identify an evolution of organics from an interpersonal convention (designed and organised with regards to interpersonal relationships between the actors, farmers, consumers, small-scale food processors) to a market-led and industrial one (organised according to the classical market rules and technical standards).

At least three issues are related with the development of organics: the **opportunities to redesign organic systems** instead of favouring steady states; the **redefinition of the expected performance** for an organic agriculture in keeping with societal expectations, including the provision of public goods; and the balances to **maintain within the diversity of organics to scale it up**. An ongoing challenge is to maintain innovative capacities while preserving organic identity. These tensions can be productive and can lead towards a renewed research and political agenda which reconnects organic with its holistic and radical political roots e.g. for urban agroecology (Schmutz, 2017) or its contribution to healthy diets and the climate crisis (Schmutz, 2022). These are system innovations applied to food and farming system transformation on a much larger scale (Zasada et al. 2019) than the isolated organic pioneer farmers could imagine.

In the next chapter we present condensed project results from the Organic-PLUS project to feed into the discussion provided in the first two chapters of this deliverable.

3 Condensed project results presented to advisory boards

3.1 Overview and WP1 – LEAD

3.1.1 Key scientific findings

This workpackage has limited research activities, however there are 12 important new insights from the last 4 years:

1. Although **severely disrupted by COVID-19**, the project was resilient and risks could be managed. With the extension granted, trials were finished in 2022 and all work initially planned, was delivered. There have also been additional, unplanned activities and cooperation.
2. The project, although designed in 2017 before the EU Green Deal with the 25% organic land use target and Glasgow's 2021 COP26, has fed into the wider political aim of increasing organic, whilst also improving it - a better organic or **"The Organic-PLUS principle":** phasing out fossil-fuel dependency in some inputs, zero pollution and antibiotic/anthelmintic free livestock husbandry with system re-design.
3. Phase-outs, e.g. peat, work only to a **certain degree when voluntary**. They set the scene, involve early adopters and generate innovation among those early adopters. However, at a certain point, legally binding regulation (the ban of certain contentious inputs) is needed to drive this further. Any **ban** should be forward-looking, with enough time for the industry to adopt, make early innovations more mainstream and reduce costs. However, if the contentious input is not eventually banned the "alternative bio-industry" and the investments made do not pay off. Regulatory certainty looking ahead 5 to 10 years is needed.

4. The contentious inputs researched have **different phase-out trajectories**. Some can be phased out immediately e.g. conventional straw, conventional manure and mineral oils as plant protection products.

5. Some phase-outs require **not only input substitution** (e.g. conventional straw replaced by organic straw or agroforestry/woody material) they require system re-design.

6. **System re-design** is needed in intensive organic orchards, intensive organic dairy and pig systems, intensive crop rotations with potatoes and also in intensive organic greenhouses.

7. **Vegan organic** (organic farming without domesticated livestock) is a potential example of a system re-design, changing the role livestock and livestock inputs traditionally had in organic farming. System re-design may however create its own problems and more research with longer timeframes is needed to make re-design a 'multi-functional' success within organic production. This is also necessary for including more agroforestry which has a 15-50+ year planning horizon, depending on the agroforestry type used.

8. ***"More knowledge per hectare"*** is needed. This could be innovative farmers, peer-to-peer learning, DSS (Decision Support Systems), satellite data etc. to manage more complex re-designed systems in an equally professional way. This could work on any scale but is most likely better on a smaller scale, including and empowering small-scale land management.

9. **Working together** with the sister project RELACS and several other EU projects as been hugely beneficial to co-develop new knowledge together.

10. In addition, several members of the consortium have collaborated to apply for new funding and have been **successful** in securing follow-on projects, e.g. FOOdIVERSE a 1m Susfood Core Organic project and further national funding.

11. Further research is needed and this could be in the form of novel Innovation Actions like **7-year phase-out missions**. These should have longer timescales than the present 4 years, with the option of adding new partners each year (as is possible in EU-COST actions) and with many micro-enterprises as partners. These can be farmers or small-scale innovative supply-chain or organic food processing businesses in transition who give 30% funds in cash or 30% in-kind (e.g. as time for small farmers labour or trial site management.

12. A **proposal** for those potential phase-out missions and calls is made in the next section.

3.1.2 Suggestions for future research

Horizon Europe: New Innovation Actions -plus or Phase-out Missions:

They are 7 years (longer then 4 years currently), with COST-type of adding of micro-enterprises (farmers, SME supply chain businesses) every year and at the end a phase-out could be a result. As regards budget, €10 million over 7 years is proposed for each topic, with a total of €80 million:

1. Copper minimisation in perennial crops (esp. Mediterranean)

2. Copper minimisation in annual crops (potatoes, greenhouse crops)

3. Peat phase-out, esp. peat in mushrooms

4. Fossil-fuel plastic mulch phase-out

5. Organic plant-based fertilisers (vegan organic)

6. Antibiotics phase-out and livestock system re-design

7. Anthelmintics phase-out and livestock system re-design

8. Pesticide-free or organically sourced livestock bedding

3.2 WP2 – IMPACT

This workpackage focused on disseminating results from the Organic-PLUS project and ensuring a good dialogue between scientists and a range of stakeholders about contentious inputs in organic agriculture. In addition to dissemination, training and education work, WP2 also undertook novel social-scientific research concerning citizen and farmer views of contentious inputs in organic agriculture. For the purpose of this overview, we focus attention on two original and significant pieces of social scientific research that were conducted in the Organic-PLUS project.

The first consisted of the largest ever representative survey of consumer views of contentious inputs in organic agriculture (15,000 respondents in 7 European countries), the second consisted of more in-depth, qualitative citizen and farmer 'juries', in which groups met over a period of 4-6 weeks to discuss contentious issues in organic agriculture in 3 European countries (the UK, Norway and Italy). Results from the international survey show that consumers believed that it was important to reduce a range of different contentious inputs in organic agriculture.

3.2.1 Results from survey

- **Reducing antibiotics, avoiding plastic packaging** and avoiding the **use of copper** were considered to be the most important topics to address, on average, across the 7 European countries studied.
- **Regular consumers of organic food** rated all contentious inputs as more important than non-regular consumers of organic food.
- Results also showed a **high level of consumer uncertainty about contentious inputs**, especially regarding issues of peat reduction and vegan organic, indicating that broader public engagement and dialogue is needed in relation to these issues.
- Regular consumers of organic food emphasised the **importance of phasing out contentious inputs**, they want **stricter regulations** and are more **willing to pay** for organic products that are produced without the use of contentious inputs.

3.2.2 Results from the citizen and farmer juries

- Gaining knowledge about contentious inputs tended to assert the importance of **addressing these issues in both organic and conventional agriculture**. This could indicate that, if done in a careful and considered way, opening-up some of the contentious details of organic farming to broader public scrutiny could, in the long term, increase the credibility of organic assurance and promote broader sustainable purchasing behaviours.
- Instead of introducing new organic labels to address contentious inputs (e.g. Organic-PLUS or copper-free organic), there was support for **improving the standards of existing organic labels**.
- Improving and expanding organic agriculture entails focusing on the **sustainability of the whole system** beyond the substitution of particular inputs at the farm level. When asked what they thought the problems were around organic agriculture, the participants were focused much more on the whole picture of production rather than on isolated on-farm

inputs. For example, participants were concerned about the **wellbeing of organic farmers**, the use of plastics in food packaging and the **importance of shortening food chains**.

- Participants expressed a deep-seated wish to **improve the economics of organic food**. Participants in the UK stressed the importance of improving the affordability of organic food for consumers and participants from all three countries were united on their concern about the economic precarity of sustainable producers (particularly small-scale) and that any improvements in organic standards which make compliance harder for farmers must also be coupled with measures to **increase farmers' financial stability**.
- **Improving awareness** among consumers was a substantial focus of discussion in all the groups, with participants from every country advocating that greater attention should be given to sustainable agriculture as part of formal education.
- During the sessions a range of **additional contentious issues** in organic farming were raised. In the UK these included: damaging cultivation techniques, animal welfare and a lack of consideration of greenhouse gas emissions. In Italy they included: having inadequate measures to fight against invasive species, a lack of trust in the certification system (especially with regards to the authenticity of imported organic foods) and perceptions that on-farm inspections are often inadequate. In Norway they included: concerns about the rigidity of organic certification and concerns about the yields of organic farms and whether they could provide enough food to feed a growing global population.

3.2.3 Future research needs

- Additional social-science research is needed to **expand the survey** research into other European countries (e.g. Denmark) and to countries outside of Europe. This will enable us to have a better understanding of the perception and relative importance of contentious inputs across a broader geographical area. As the survey was conducted before COVID-19 and the 'war of aggression' in Ukraine, consumer views on contentious inputs may have changed considerably.
- Additional, **in-depth qualitative research** is also needed with a range of stakeholders, members of the public and especially farmers, to gain further insights into contentious inputs, farmer well-being and the barriers to adopting alternatives including system re-design.

3.2.4 Recommendations for stakeholders

- Organic certification bodies should be **open and transparent about the contentious issues** that they face and the measures they are taking to continually raise standards. This will help to improve public debate more generally about sustainable agriculture. This information sharing will have to be conducted in a careful and considered manner, placing contentious inputs in organic agriculture in the broader context of the state of agriculture more generally.
- Efforts to improve standards in organic agriculture should go beyond the farm to consider the importance of the **whole organic food supply chain** and to address issues such as local and seasonal food provisioning, sustainable packaging and **farmer well-being**.

- Policy makers should further recognise organic food and farming as a **key route to sustainability** and **zero-pollution** and adopt appropriate measures to promote and financially support organic farming, **particularly in the United Kingdom**.

3.3 WP3 – PLANT (copper, mineral oil, sulphur)

3.3.1 Key scientific findings

- A comprehensive mapping of copper (Cu) use in organic horticulture in Europe (Katsoulas et al., 2020) was done and published in peer-reviewed journals.
- New **designs for protection systems in potato, olive, tomato, aubergines and citrus** were assessed in the field.
- New tools and options have been researched: decision support systems (**DSS) for potato** and **greenhouse crops,** alternative products and assessment methods.

3.3.2 Future research needs

- Experimental assessments of the medium/long term performances of the newly designed prototype systems.
- Acceptance measures by all key actors: industry adjustments, economic models to foster adoption and regulatory measures.

3.3.3 Recommendations for stakeholders

- Establish demonstration networks with organic (and conventional) farmers and supply chain industry.
- Strengthen communication between all parties.

3.4 WP4 – LIVESTOCK

3.4.1 Key scientific findings

Testing for antimicrobial effects: **Oregano EO** (essential oil) presents the best antimicrobial effect, followed by **Thymus oil** and **Tea tree oil.** Cinnamic aldehyde showed the best results against *S. aureus*, and carvacrol, cinnamic aldehyde, and thymol were the best ones against other bacteria. In addition to test the Minimum Inhibitory Concentration (MIC) of essential oils (EO) and natural identical compounds (NIC), it would be necessary to test the cytotoxicity to adjust the adequate dose to be administered.

Alternatives to conventional straw bedding from woody materials included processing residues and agroforestry products. Using existing technology, the properties of bedding pellets can be improved if processed from lignocellulosic material in a twin-screw extruder and pelletising plant at specific settings.

The **anthelmintic properties** of three different plant extracts (*Malva sylvestris, Chamomilla recutita and Althaea officinalis*) were assessed through in-vitro evaluation. We used *Haemonchus contortus* since it is one of the best-known nematodes affecting grazing livestock and therefore can represent a good model for similar parasites (like the cattle nematode *Ostertagia ostertagi*).

Scutellaria baicallensis contains bioactive compounds with anti-inflammatory and antioxidant properties. The supplementation with 20g SB/animal per day during 4 months in Charolaise cattle did not impair feed intake or digestibility. It did not have a detrimental or a beneficial impact on growth performance. It did not modify plasmatic Vitamin E or impact on the metabolic profile.

Herbs containing bioactive compounds in Holstein-Frisian dairy cows. They received three boluses between calving and 30 days in milk production. Plasmatic samples taken and fertility traits also recorded. The treatment did not impact milk production and composition, nor the plasmatic parameters or fertility traits when cows presented a low or high somatic cell counts in the preceding lactation.

The use of **bark extract** or green tea + grape extract as a substitute for Vitamin E in Ross 308 line chicken broilers. We reached a successful substitution of Vitamin E by using plant extract. We obtained a similar feed conversion of bark extract than Vitamin E. Green tea and grape extract has the best protective effect on the kidneys, and bark extract on the liver. Preliminary results show that there is potential for other advantages for the animals besides the primary function of bedding, but more work is now required to determine the most suitable sources. **Different settings of the extruder**, combined with properties of the raw material, have an influence on the fibre and pellets that are produced. This means there is a large number of tests required to adjust the twin-screw extruder and ring-die-press to specific settings.

The use of **water extracted bark from Norway spruce (*Picea abies*)** against Eimeria spp. in young lambs. Our results showed that the bark extract affected the development of ovine *Eimeria* spp. in the intestines of the lambs. We found that infected lambs treated with bark extract had a lower oocyst count per gram of faeces compared to the untreated control animals. Moreover, we found that animals treated with bark extract had a higher faecal consistency score (softer faeces) than the untreated infected control group during the treatment period (day 0-11), but that the treated lambs had firmer faeces than the untreated control animals after discontinuation of treatment (day 11-22).

The use of **poly-phenols from seaweed (*Saccharina latissimi, Ulva lactuca* and *Ascophyllum nodosum*)** as a substitute for medicinal zinc to avoid diarrhoea in pigs. During testing, it became obvious that it is difficult to perform diagnostics in outdoor conditions because the diarrhoea faeces disappear very easily. Likewise, seaweed showed only a tendency to decrease post-weaning diarrhoea. As demonstrated in the studies conducted, infection pressure is high and varies very much when in the farrowing outdoor pen. Even if the infection is not directly related to diarrhoea (e.g. in the case of lung disease), it can cause poor health, which in turn may be partly responsible for the diarrhoea. A 7-week-old piglet must have a generally high level of health in order to manage the weaning period. In many cases, the piglets looked very fit before weaning but they quickly developed serious health problems.

The high number of potential infection agents means that it is not realistic to expect one specific additive to be the solution to all problems.

The use of *Artemisia absinthium* in weaned piglets to prevent intestinal worms such as *Ascaris suum* and *Oesophagostomum dentatum* infestation which are common in organic pig production. The result did not confirm that the synthetic anthelmintic was more effective than the *Artemisia absinthium*. On the other hand, the result may give rise to considerations regarding the need for deworming, unless the infection pressure is significantly higher. Among other things, there is a lack of knowledge of what is an acceptable infection pressure, whether the number of worm eggs is the best indicator of a strain and what measures the farmer can take to reduce the infection pressure when it comes to outdoor herds. Differences in growth figures cannot be immediately linked to the treatments. Experiences from herds that offer new pens for each farrowing confirm that this provides better health/robustness and better productivity.

To **discriminate Organic vs Conventional bulk milk**. Samples (n = 225) from 24 farms (organic = 12; conventional = 12) located in the same area, mainly rearing Holstein-Friesian cows under similar management conditions, except for organic livestock spending a period of time on pasture, were collected from September 2019 to August 2020. Organic milk had lower protein and casein content, although these differences were not observed for any of the individual amino acids, lower C16:1n9 content, which was not reflected in the total fat content, lower S content, which has no impact on ash content, and greater somatic cells than conventional milk. Moreover, the PCA was not able to discriminate midinfrared (MIR; 5,000-900 cm^{-1}) and vis/near-infrared (Vis/NIR, 400-2,500 nm) spectra from both groups. The PLS-DA revealed an accuracy of the model in the test set of 54.1% and 62.9%, for MIR and Vis/NIR, respectively. The lack of differences between **organic** and **conventional** milk could be related to the similarity of the selected farms in both categories and that organic systems are still very similar to conventional, especially regarding the reduced availability of free-range grazing land in lowland Italy.

3.4.2 Future research needs

- Regarding antiparasitics, we need **in vivo validation studies** on sheep and potentially in cattle in order to translate these extracts into new products available to farmers. Until then, from an animal welfare perspective, it is not acceptable to use products that are not efficacious and that, therefore, cannot fully protect animal health in field conditions.
- To test **different doses of *Scutellaria baicalensis***, and to evaluate the effect on the animals' products.
- To test different **doses of herbs** and evaluate cows with high levels of SCC, fertility problems or under stress conditions in the current lactation.
- To evaluate the effect of the **rumen microbiota** on the degradation of plant feed additives.
- To evaluate the effect of the extracts on the quality of meat products.
- Although **bark extract from *Picea abies*** may be a potentially useful anticoccidium in young lambs, we need more research to see if this effect is due to CT or other biological components in the bark and to see if the effect is permanent and how this influences the performance of the lambs over a longer time frame. If this is to be transferred into

practical use for the farmers, we need to find a simple and secure method for application and a practically, technically, and economically viable method for extract production.

3.4.3 Recommendations for stakeholders

- **Management practices** are really important to keep animals healthy in organic production.
- There are still **few approved herbal products** against livestock diseases.
- Results have to be carefully interpreted to see the **efficacy** of the products.

3.5 WP5 – SOIL

3.5.1 Peat in growing media

As peat substitution, **completely mature compost** can function well for seed germination and growth of seedlings. Such compost may be produced using locally available, selected materials. We have worked with chopped pruning material from olive trees, leaves, grass clippings, horse manure, sheep manure, separated cattle slurry and chopped forest biomass. The effects of applying **beneficial organisms** were tested (MFAL) and deserve further study. It remains unclear how (by which characteristics) a satisfactory compost quality for growing of perennials (e.g. olive saplings, medicinal plants) can be measured efficiently, and this should be researched. For the raising of vegetable transplants, poor growth may be a challenge because of low N availability in some composts.

Woody material and other plant residues may be treated mechanically (ATB) or biologically (CU) to replace peat in growing media; **mechanical treatment, like extrusion**, may produce specific fibre quality for growing media and reduce the time required for decomposition/composting under farm conditions (IRTA). In the UK, **composted chipped wood** has been used for several years as an alternative to peat in both commercially available and on-farm produced growing media. CU have been working with an industry partner, a UK grower who raises all vegetable transplants on farm using composted wood but also significant proportion of **vermiculite** – trials were conducted to reduce or replace the vermiculite, as this is also a contentious input.

Appropriate **application of organic fertilisers** during production of plants in growing media is a challenge, especially for vegetables. For perennials, the growing media may well be completely peat-free (MFAL, EAM), whereas for germination and early growth of vegetables, growing media may be significantly peat-reduced (EAM). Appropriate fertilisation with organic fertilisers of various peat-free and or peat-reduced growing media requires further research.

Growing media rich in nutrients e.g., composts from animal manure, may lead to leaching of excess nutrients especially N and K but also P (IRTA). This calls for research to optimise water and nutrient management, but also for studies to gain **deeper insight into microbiological activity in growing media** and the effects of such activity on plant growth.

3.5.2 Plastic for soil cover

Completely biodegradable, non-fossil derived mulching films may be produced from lactic acid polymers produced from potato starch (CUT; two patents filed). In northern Europe, the films need to be a **dark colour** to avoid weed growth underneath. In southern Europe, the films may well be white to avoid excessive soil temperatures. Degradation is highly dependent on local growing conditions; in southern Europe, films degraded too quickly, but thickness is not the only factor affecting decomposition rate, so further studies are required. In spite of rapid decomposition of the film, it **significantly reduced weed growth in field vegetables** under Mediterranean climate conditions.

The **bio-degradable biopolymers may be mixed** with other organic materials such as extruded wood fibre or biochar to reduce consumption of polymer, in products such as horticultural accessories including tomato plant supports, clips and pots. This research topic is a good example of technology and agronomy coming together and further research needs to proceed in several directions. Non-degradable, fossil-fuel derived plastic products pose a significant problem in horticulture and agriculture, both organic and non-organic.

3.5.3 Fertilisers derived from conventional livestock farming

Animal-derived products from organically managed animals are not generally seen as contentious in the organic movement, only if they are derived from non-organic (conventional) managed animals. Only vegan organic excludes all animal inputs, at least from domesticated animals (biodiversity services from wild animals are seen as acceptable).

With this in mind, several materials have been tested for nutrient availability in field experiments (SEGES, CU, UoH, NORSØK), searching for locally available materials in line with the principles of organic farming (organic materials, self-sufficiency in nutrients; recycling resources; low environmental impact) and vegan organic movements. The tested materials were categorised in three groups:

- **URBAN fertilisers**: anaerobically digested household waste; struvite
- **VEGAN fertilisers**: legume and grass materials, solid, liquid or composted; plant extracts e.g., comfrey, nettles
- **RESIDUAL fertilisers**: fish pond sediments; cuttings from pruned trees; processing residues e.g. tofu whey; marine-derived fertilisers e.g. seaweed, fishbones

The materials were compared with contentious input controls: farmyard manure, poultry manure, horn grit. Overall, most of the materials tested gave **yields comparable with control treatments** when equal amounts of N were applied. However, the N availability is highly variable, hence **further research on the fine tuning of application rates and amounts** is still needed to match crop demand and deserves further study.

Some materials are (regionally) available in significant amounts, but infrastructure and regulations hamper utilisation. New fertilisers are most likely more costly compared with currently applied alternatives, but fertiliser prices are increasing, especially those embedded with high energy or fossil-fuel inputs.

We must be **aware of nutrient imbalances**: alternative fertilisers as well as the current contentious inputs are multi-element fertilisers with a nutrient composition that differs from that of harvested products; this may result in nutrient imbalances. Hence, soil testing is required and new fertilisation strategies with combinations of different fertilisers, or combinations of materials into complete fertilisers, needs to be developed. We should also be aware of pollution with **potentially toxic elements microplastics.** The development of value chains for new fertilisers will become much more challenging if/when industries start to **compete for bio-based raw materials**.

Further research should **combine** «top-down» approaches such as **nutrient budgets** for various productions (RELACS) and «bottom-up» approaches such as **innovative fertilisers** (Organic-PLUS). In RELACS, studies showed that many (arable) organic farms need inputs of P and K, whereas some (horticultural) farms require N fertilisers with low P. In Organic-PLUS, we have seen that several materials can substitute the current contentious fertiliser inputs. If farmed animals numbers are reduced to respond to reductions in meat consumption, efforts to **recycle more nutrients from fork to field** (e.g. by anaerobic digestion of food waste, struvite, processing residues like tofu whey) will link food consumption more directly back to farmers, but this new situation also faces **multiple administrative and societal challenges**. Organic agriculture needs up-to-date and dynamic regulations to support the recycling of nutrients while maintaining high food quality standards. Organic-PLUS has tested aquatic inputs (fish pond sediments), marine-derived fertilisers as residues (fish bones and seaweed), but more research is needed to link **organic aquaculture, sustainable fisheries** and organic food and farming closer together. This is a specific opportunity for Europe as it has many islands and peninsulas and hence an abundance of coastal resources.

3.6 WP6 - MODEL

WP6 employs a number of assessment methods at different levels, namely feasibility and sustainability at the farm level, whereas environmental impact was assessed by using life cycle assessment (LCA) at product level. This has involved:

1) evaluating the feasibility and operational management options for different pathways and methods of using alternative external inputs (for targeted aspects of horticulture, plant and animal production);

2) conducting an environmental assessment and a sustainability assessment for representative farming systems to test and validate the proposed methodologies in comparison with traditional systems and methods.

3.6.1 Feasibility studies.

This has involved finding and describing factors that effect the production in terms of operational feasibility, usability, practicability, etc. compared to the standard methods when a contentious input is phased out or reduced to very low level. The studies are based on information gathered from case farms across different organic sectors and regions in Europe. Recommendations regarding feasibility and key findings are outlined below:

3.6.1.1 Copper (Cu)

In vegetable production, phasing out copper 100% is difficult, but a significant reduction of around 90% can be achieved using a combination of management measures, selection of resistant varieties and the use of potassium bicarbonate as an alternative fungicide.

In grapes for wine, a significant reduction (50% or more) can be achieved. Fungus resistant varieties are available and advanced spray techniques can improve efficiency and avoid losses to the environment.

Potato production with zero copper is feasible in northern European countries. Blight can be a challenge and in some years results in reduced yields. With an optimal strategy and good management, reasonable outcomes can be achieved. Extra labour, decision support systems and machine inputs may be required but standard machinery and techniques can be used.

3.6.1.2 Sulphur (S) in apple production

Phasing out sulphur is feasible but may result in increased occurrence of apple scab. However, there are alternative organic approved fungicides on the market. No significant increase in machine and energy inputs are seen. Yield and sale prices were as for common organic apples although no spraying with S and Cu was used.

3.6.1.3 Fossil fuel derived plastic films

Phasing out the fossil-fuel derived plastic film for weed control (plastic mulch) is feasible when alternative products such as non-fossil bioplastic and paper mulch are used. However, the alternative films are more expensive. On the other hand, the alternative films are degradable and do not need to be collected and disposed of after use, thereby reducing workload.

3.6.1.4 Antibiotics and anthelminthics

A complete phasing out of antibiotics is not feasible in most countries due to animal welfare legislation; a sick animal must be treated. However, the studies have shown that pig production with very low input of antibiotics and anthelminthics is feasible, as the production output can be in line with standard production outputs. Key factors are the late weaning of piglets, quality feed and good overall management. No significant change in machinery, energy and labour input were reported.

3.6.1.5 Conventional manure

Removing conventional manure and only allowing manure from certified organic sources is feasible. However, the feasibility for phasing out conventional manure in organic plant production strongly depends on the availability of alternative fertilisers. Digestates from biogas production, green waste compost and other organic bio-fertilisers are possible. The phasing out will require improved crop rotations with legumes and increased use of green manures. If alternative organic fertilisers are available, yields can be maintained. Changes in crop rotation and the use of green manures may increase labour and machine inputs.

3.6.2 Future research needs

It was necessary to modify the original plan for conducting the feasibility studies. Initially, the intention was to conduct the studies based on documented reference data for the various organic production systems compared to current data from selected case-farms where the proposed solutions without contentious inputs is implemented. However, there were unexpected problems in finding sufficient and relevant reference data. Furthermore, it proved difficult to identify suitable case farms to be included in the feasibility studies for both before and after changes to the use of contentious inputs.

The solution adopted was to look at different cases and register/evaluate the changes both in a quantitative way (if possible) and also in a more qualitative manner. In this way, we have a description of a before and after situation for case farms and specific contentious inputs and alternatives. Following this **qualitative description, the feasibility was modelled**.

Future research should entail a more comprehensive acquisition of reference data before and after contentious input changes with all else being held constant. This would require **direct contact with case farms over an extended period of time**. With longer innovation actions (phase-out missions) and farmer participation with financial consideration in the research design (farmers participate as 'micro-enterprises' in innovation actions and are funded with 70% and remaining 30% could be in-kind input, if a small-scale farmer) such comprehensive use of reference data would be a project internal activity, covered by data protection and anonymised for research outputs.

3.7 Additional results on environmental LCA

Environmental assessment was conducted following a life cycle perspective, specifically using the **Life Cycle Assessment (LCA)** tools recommended by the European Commission and the United Nations Environmental Programme in the frame of the Environment Footprint and Life Cycle Initiatives. This tool was selected due to its holistic vision, including both the whole production chain concept and multi criteria environmental indicators, as well as its quantitative, scientific approach to estimating environmental impacts. However, being aware of the limitations of LCA tools in their ability to assess the comprehensive sustainability of organic production systems, the assessment has been complemented by using the Response Inducing Sustainability Evaluation (RISE) tool and in some cases by adding semi-structured farmer interviews to the RISE assessment. It was the ambition of the Organic-PLUS project to contribute to **improving the LCA methodology for organic systems**. This includes inventories for organic inputs and to make it more suitable for understanding organic production systems holistically, together with the ecosystem services (e.g. biodiversity) they may provide.

3.7.1 Key scientific findings

1) From a holistic environmental perspective, it can be stated that there are **other environmental hotspot aspects, which may have greater importance** than those inputs researched in the Organic-PLUS and RELACS projects. We highlight fossil fuel-based energy consumption such as diesel for cultivation operations, electricity consumption and transport. Additionally, water consumption, in particular, for dry Mediterranean regions could be an

input with negative environmental implications, and hence is a contentious input in certain climates. These issues are equally relevant for organic and non-organic (conventional) agriculture.

2) When alternatives to contentious inputs developed and studied in the Organic-PLUS project were considered, e.g. compost to replace peat in growing media and degradable plastic from potato starch for mulch covering of soil, these products presented a **mixed picture i.e. an improvement for some environmental aspects, but neutral or worse for others**. From the revealed "hotspots", it can be identified where efforts can be put, if the goal is to develop alternatives which score better in LCA.

3) LCA methodology may be useful to assess the environmental effects of agricultural production, but still requires further development to better grasp the particularities of organic production systems. Hence, additional sustainability assessment tools (e.g. RISE) are useful to account for other aspects of organic agriculture at the farm-level.

4) The main critical aspects found within the life cycle inventory (LCI) of organic crop and livestock products include the **lack of manufacturing datasets for inputs** used in organic production systems. There were no available manufacturing datasets for **biological control agents (BCAs), plant-derived essential oils (thymol, carvacrol, neem), mineral oil, pyrethrin, Spinosad and copper oxychloride**. Several proposals to improve datasets for organic production have been presented (Montemayor et al. 2022).

5) We have contributed to the development of characterisation factors for biodiversity indicators in agricultural production following the work initiated by Knudsen et al (2017). These authors developed characterisation factors (CFs) to include biodiversity impacts for organic and conventional agricultural production, based on standardised sampling of plant species richness in organic and conventional farms across six countries in Europe within the temperate broadleaf and mixed forest biome. However, in the context of Organic-PLUS and for agriculture in Europe, one limitation of this model is that it does not have **CFs for the Mediterranean biome**, one of the most agriculturally productive areas in Europe. Therefore, we have developed CFs for the Mediterranean biome using the methods described in Knudsen et al. (2017) and secondary plant richness data from organic grape, olive and arable crop farms in Spain, Italy, France and Greece (Montemayor et al., 2023 submitted).

6) Proposals for further research to improve the environmental assessment of organic production systems were made in these papers. They emphasise that the **current dominating impact categories are not well suited** to discriminate between various farming practices: organic, bio-dynamic, non-organic (e.g. integrated and other forms of conventional).

3.7.2 Further research needs

1) Implementation of **specific organic production datasets** through local databases, which can capture the variability of products and production systems.
2) Improvement of **emissions factors** related to organic residue treatments (i.e. composting, anaerobic digestion, etc.)
3) Accounting for **biological pest control technologies** (all methods of plant protection using natural mechanisms): organic "natural" compounds, new upcoming application technologies, dissemination and effects of "natural enemies", etc.
4) Implementing new models to deal with the issues of **formulation (adjuvants and surfactants, nanoparticles, etc.)** and potential metabolites.
5) Better adjustment of emissions modelling and characterisation factors for **toxicity of inorganic compounds** (metals, sulphur, etc.)
6) Enhancing LCA through **biodiversity and ecosystem services indicator models** to include different agronomic and livestock practices.
7) Development of **more precise soil quality indicators**.
8) Inclusion of **antimicrobial resistance indicators**.
9) Extension of assessment to processing, logistics and use phases.

3.7.3 Recommendations for stakeholders

Comparisons between contentious inputs and novel alternatives show that alternatives may present a clear improvement for some environmental aspects, but a neutral or worse behaviour for others. To assess it holistically a whole chain perspective and multicriteria environmental assessment is crucial. In addition to contentious inputs, there are other environmental hotspots, which need to be improved, including infrastructures such as greenhouses, photovoltaic panels, machinery, fossil fuel based energy consumption, diesel for cultivation operations, electricity consumption, transport and water consumption, in particular for dry Mediterranean climates. LCA tools are useful but they need improvements and research to be adapted to organic food and farming systems. The Organic-PLUS project has made nine research suggestions (Section 3.7.2 above) on how to advance them and further detail is discussed in peer-reviewed papers Montemayor et al. (2022 and 2023).

3.8 Additional results on overall sustainability and RISE assessment

This sustainability report is based on the evaluation of 10 case farms, using the **RISE (Response Inducing Sustainability Evaluation)** assessment tool, designed by Bern University of Applied Science, School of Agricultural, Forest and Food Sciences (BFH-HAFL) in Switzerland. The case farms represent a wide range of organic farms in Europe, experimenting with alternatives to contentious inputs.

Results of the case farm reports were discussed with experts, who have been working with the topical workpackages (WP) of Organic-PLUS: PLANT, LIVESTOCK and SOIL. Work in progress and results from these WP's have given rise to discussions, which are reflected in this report. Specifically, alternatives for conventional manure, copper and antibiotics were identified.

Regardless of the case farm, **biodiversity was not specifically linked to any of the contentious inputs**. The lack of nutrients on some of the case farms was more a conscious choice, than a supply problem. Farms owned by community shares had less pressure on income, while in other cases the premium for selling organic was high enough to compensate for the lower yields, if this was the case due to the removal of contentious inputs. Some farms were in the process of peat replacement, by using composted biogas digestate.

Replacement of copper by substitution with alternative treatments was not found to be the only solution. A **set of preventive measures** was noted, including more resistant varieties, agronomic management (chitting, wider spacing), combinations of natural repellents, but also the acceptance of lower yields to guarantee alignment to the organic principle.

Antibiotic use in organic livestock was identified as being reduced, but not completely eliminated. Organic livestock farmers increase vaccination, preventive measures and alternative treatments, using farmer schools to gain and exchange of experiences. Ultimately, avoidance of animal cruelty by treating sick animals is a legal requirement. It is also thought to be more ethical than culling or selling to conventional farms, where animals would potentially live in poorer or industrial conditions.

4 Notes from the Advisory Board meeting 27 January 2022

The advisory board meetings are also documented in Deliverable *'D1.2 O+ Documentation of boards.pdf'*. Here we condense the notes to use as an input relevant for the reflections in the next section (5.1-5.3). The agenda of the online meeting consisted of advisory board member presentations (4.1), followed by break out groups for the SWOT (Strength, Weaknesses, Opportunities, Threats) analysis and concluding discussions (4.2).

4.1 Presentations from advisory board

Africa (Raymond Auerbach)

- 4 'advanced organic agriculture countries' in Africa
- Kenya and Zambia going backwards
- African Union has agreed to adopt agroecology as a concept and has an organic agriculture initiative
- 6 million farmers do self-claim (self-certify) as organic in Africa
- Southern Africa work with a lot of GIZ support (German international cooperation and development agency)
- South African Organic Network in place
- **Use of peat** is a contentious issue in southern Africa
- African response to Organic-PLUS: "It's hard enough to conform to organic regulations as it is – don't make it even harder!"
- Impressed Europe is tightening up – Africa also currently looking for alternatives to copper, sulphur, etc.

India (Mahesh Chander)

- **Copper** will be an issue in India soon
- Help establishing a project with developing countries so knowledge can be shared
- Organic exports from India have increased by 51% (in 2020-21 c.f. 2019-20)
- Indian cattle are well suited to organic agriculture **– lower producing but disease tolerant – use and need less antibiotics**

Europe - Denmark (Jakob Sehested)

- Significantly **reducing use of conventional slurry** (more through bio-gasification)
- Importance of improving **recycling of nutrients** from industry and society
- Phasing-out **fossil-based plastic**
- Phasing-out **conventional seeds** (OrganicXseeds)
- Phased out **non-EU soya** (to increase circularity of system)
- **Zinc** issues in pigs were discussed, also researched by ICROFS
- ICROFS research includes specialised breeding of cows for organic (SOBcows)

Iran (Reza Ardakani)

- Alternatives for **copper, plant defence, varieties**
- DSS more discussed, **limits of the tools**
- Special regulations of farmer organisations not so much mentioned
- Animal manure must be provided more locally (mixed farming)
- Demonstration network farms for farmers
- Invited Organic-PLUS members to climate smart organic agriculture conference in Korea

North America – Canada (Martine Dorais)

- Very wide projects - 16 million in funding for their organic research consortium
- 66% of Canadians are weekly organic consumers; $8.1 billion/3.3% market share
- New 'Green Agriculture Plan' will include working with farmers to reduce methane and fertiliser emissions, as well as **increasing organic production and consumption**
- **Can't imagine phasing peat out**. In greenhouses in Canada are permitted to grow out of the soil => a lot of peat consumption => work on alternatives very important here
- How to utilise **waste energy** is a key issue (e.g. for greenhouse facilities)
- The Canadian organic market is growing and there is **competition with the USA** in standards e.g. US includes **hydroponic** (growing in water with added fertiliser) as certified organic, Canada does not allow hydroponic, in line with the EU and most parts of the world. Canada however allows organic production in **growing media** (e.g. when soil is frozen), if the media are soil based and biologically active, and it does not ban peat.

4.2 Break out groups

SWOT: Strength Weakness Opportunities Threats

What is strong in Organic-PLUS?

- Lots of WPs, cover lots of areas, cover whole system, seems well integrated.
- **Peat** a good focus within Organic-PLUS area where we can influence policy – influence on standards. When the project was planned it was envisaged that the UK peat story could act as a 'pathfinder' to show how new practices could be effectively introduced by working in close collaboration with the horticultural industry and other stakeholders.
- Phasing out peat might be of **particularly interest in Canada** (as organic production in growing media out of the soil is allowed) – but Canada also has plenty and people don't see it as a priority at the moment. Hard for Spanish producers to find good alternatives to peat at the moment

What is weak in Organic-PLUS?

- Less on **precision agriculture** and how that could be integrated with organic farming.
- Also how to make the most of energy waste is really crucial in Canada (e.g. to heat greenhouses)
- **Labour issues in agriculture are a key aspect**, how does this fit within organic farming?
- e.g. in Canada workers come for 6 months from all over the world, flying in and not treated so well potentially – doesn't fit with organic farming to import labour in this way (rather than using domestic agricultural workers, which to be fair may not be available or equally qualified, with similar work ethic)
- **More work on nutrients needed** – different interpretations across Europe with regard to what is acceptable for organic producers (e.g. with respect to **animal by-products**)

Further opportunities

- For future policy what are the key findings and how can they influence future policy (legislation, organic standards) what can we **learn from other countries**?
- For stakeholder interaction and practice - what should happen to enable?
- For future research topics – what should happen to develop?
- **How can organic help the conventional sector?**
- How can we strengthen our international commonalities in ambition and scientific research to have more of an influence on policy?
- Science will lead and policy will follow – science must show that it is possible for policy to shift.
- **More global organic research collaboration**. How can we collaborate better as an international organic research community?
- There is an opportunity within Organic-PLUS exploring why peat is a less important issue in some countries, e.g. in the UK there has been a long history of **anti-peat campaigns,** initially driven by concerns over habitat loss in the few remaining peat landscapes not mined for industrial peat extraction. This is not the case in many other countries.
- Peat as an input is at very different stages across EU and worldwide, need to work closely with growers – why it is needed to phase it out and what the barriers are, e.g. using discussion groups with growers?
- **Contentious innovations.** How we can/should integrate new tools while respecting Organic principles will be a big question in the coming years – e.g. will be some pressure for **CRISPR, Genetically Modified Organisms (GMOs)** with climate change, pest pressures and the need for new biopesticides.
  - E.g. **MRNA 'treatments'** to improve health of plants and animals already used, but a lot of those who are unhappy with MRNA techniques in vaccines are also part of the organic movement
  - There is also a broader **discussion about new technologies in organic: precision farming, smart agriculture, robots.** Need more research into the broader understanding of technology in organic farming

- The **organic consumer also has to be on board** – a lot of them buy organic for perceptions of naturalness/not technological etc. – if they are not on board there is a limit to where we can go.

Further threats

- For organic farming and further phase-outs (the **total phase-out of fossil fuels** is also not easily achieved in organic)
- For further **system-redesign need more agroecology** and the farming and food system level thinking and governance championed by political agroecology
- **Producer margins** and capability are key in developing the organic standards: how many producers will last if we improve in these ways? Farmers need support as they are under economic pressure, it is not easy to legalise in the standards if it will put additional pressure on farmers, without accompanying support.
- Danger of phasing out peat by regulation rather than co-development. There is a particular **risk** that general rules governing peat use will become more stringent than the organic regulations **- the organic movement should be seen to be a leader rather than a follower.**

5 Conclusions for policy briefings

As part of the 18-month and 36-month reviews, the project executive board held two confidential policy meetings with our sister project RELACS and senior policy officers in Brussels. Internal recommendations were made.

5.1 Further policy and practical engagement

For this final version (version 3) of the deliverable, we have included feedback from the Organic-PLUS proceedings for the Organic World Fair at Biofach, Nuremberg in July 2022. This focussed on the phase-out of copper, the phase-out of peat, a 30% organic action plan in a federal state (the example of Bavaria, the federal state where Nuremberg is located) and also includes the phase-out efforts by private certification bodies using the example of biodynamic certification.

In addition, we held a public conference (see Appendix) with farmers and organic supply chain at the University of Hohenheim, Stuttgart in nearby Baden-Wuerttemberg. Due to attend, was a Member of the European Parliament and Coordinator for the Greens/EFA in the agricultural committee (AGRI), *Martin Häusling, MEP*. The initial plan to host the conference at the European Parliament buildings in Strasbourg was changed as the Biofach fair was moved from February to July in 2022 (due to COVID-19). Unfortunately, *Martin Häusling, MEP* could not attend due to conflicting timetable although his office asked for updates from the research.

By engaging with the European Parliament and agricultural committee, we continued the discussion started during the two confidential review policy meetings. The EU parliament's regulation on organic food and farming is often followed also outside of the EU, i.e. in other parts of Europe and countries worldwide. With this engagement, we aim to fulfil the project's mission:

"To provide high-quality, trans-disciplinary, scientifically informed decision support to help all actors in the organic sector, including, national and regional policy makers, to reach the next level of the organic success story in Europe."

5.2 Key policy messages for the various contentious inputs

This is a condensed version of Section 3 earlier in this text (for further details see Section 3, above). The recommendation for **now** refers to 2023.

5.2.1 Mineral oils

Phasing out mineral oils as pesticides is feasible: They can be phased out by input substitution with plant oils **now (2023).** Plant-oil based alternatives are already commercially available with no or minimal extra costs. Research into system re-design, avoiding the use of any oils based pesticides is ongoing.

5.2.2 Plastic mulch

Phasing out the fossil-fuel derived plastic film mulch for weed control is feasible. They can be phased out by input substitution and further system re-design (e.g. better weeding techniques). The date of such a phase-out is at least **10 years in the future**. Innovation action type research is needed to develop and continuously improve the alternatives.

5.2.3 Copper and sulphur

Minimising **copper** as pesticide further is feasible **now**: for vegetables, a significant reduction of around 90% can be achieved whilst for grapes and perennial crops a significant reduction (50% or more) can be achieved.

Potato production with zero copper is feasible in northern European countries. The current copper allowance of 4 kg/ha/year and 28 kg/ha over **7 years**, can be further minimised. We recommend halving i.e. **2 kg/ha/year and 14 kg/ha over 7 years**. (copper as additional fertiliser may be required in certain soils and conditions, this was not part of the research).

Phasing out **sulphur** as pesticide is feasible (sulphur as additional fertiliser may be required in certain soils and conditions, this was not part of the research).

Both copper and sulphur are micro-nutrients, they are necessary for plant growth. A total phase-out is impossible and equally undesirable. During third-party farm inspections independent soil sampling needs to be added to monitor any potential accumulation whilst ensuring levels which do not minimise plant growth for agricultural use in an organic system.

5.2.4 Antibiotics and anthelmintics in various organic livestock systems

Organic is a certified system that explicitly limits farm antibiotic use and requires farmers to use other methods to prevent and treat diseases. However, a complete phase out antibiotics is **not feasible**. Re-designing animal rearing systems to prioritise animal welfare further, could result long-term in many systems without any antibiotic use.

In organic **pig production**, a very low input of antibiotics and anthelminthics is feasible.

Antibiotic free **milk (dairy cows, buffalo)** production **is feasible** with the appropriate breeds and systems. The demand is increasing and exports to the USA which requires antibiotic free organic milk (USDA-NOP certification) are expanding. In the UK, because of these exports

100% antibiotic free products called PWAB (Produced Without Anti-Biotics) are becoming more familiar to organic farmers and can trigger more local demand too. However, this may mean that cows which have been treated are used for organic meat or are moved to a conventional herd. All this requires **further research** to optimise PWAB without any negative consequences for animal welfare, even if animals are transferred to EU organic or conventional production.

Further antibiotic reduction for **dairy sheep** and **dairy goats** is **feasible**. PWAB produced without antibiotics could also be a market niche in this sector. However, similar issues as described before exist: what happens with treated animals? **Further research** is needed in those systems. Agroforestry and more free-range could help, but so could roofed, dry areas in wet climates to improve animal welfare in organic further.

Organic **poultry production** (eggs and meat) is **already** antibiotic and anthelmintic free.

Organic **aquaculture** was not part of the research. Here issues exist with stocking density and in the production of juveniles; research is need on this too.

5.2.5 Conventional manure and conventional straw

Removing conventional manure and only allowing manure from certified organic sources is feasible **now**.

Removing conventional straw and only allowing bedding material from certified organic or untreated sources (wood and agroforestry products) is technically feasible **now**. However, limited availability and costs can be a **temporary (5-10 years)** issue, but less if more farms convert to organic and organic land use reaches 25%, the availability issue will resolve itself.

5.2.6 Further innovation - 'Phase-out Missions' and system re-design

Further Innovation Action type research is needed to develop and continuously improve the alternatives to contentious inputs. This is already commissioned as call-text and very welcome. Peat and plastic issues are also addressed in Innovation Actions and they are combined with work for the conventional sector as these inputs are equally contentious in this system. Making these innovation actions into missions, with a longer life span (e.g. 7 years) and with the possibility to add new industry/farming partners annually (as in COST actions) would build momentum and create more opportunity for farmers to participate. We have called them **'Phase-out Missions'**. There is also scope for a redesign of some organic systems with deeper understanding of agroecology, as outlined in the beginning of this text.

We call this the **'Organic-PLUS - principle' - making organic better with agroecological system redesign.** As outlined, alternatives like organic straw are available, however not in sufficient quantity and mixed farming is not a legal requirement in the organic EU standard (it is in private standards like Bioland, Demeter). If mixed farming would be mandatory for all organic free-range pig and poultry farms, the availability of straw would not be an issue as it is grown *on-farm*. This would not be possible in mountainous areas where arable farming is difficult, although more agroforestry could help.

Agroforestry is also not legally required in organic, although many pioneering organic farms have adopted this and included further measures from agroecology (see Section 1 and 2 of the report) beyond the legal minimum required for EU organic certification. System re-design would reduce the need of any contentious inputs even further.

5.3 Reflection on pathways to impact and summary display of scenarios

5.3.1 Reflection on pathways to impact at project start

Reflecting on the planned pathways to impact (Figure 3) we developed in a project planning workshop in February 2017, 6 years ago. Today, 2022/23, we find that we have achieved many of the activities e.g. White boxes: Twitter, innovation factsheets, newsletters, YouTube channel, farmer videos, farmer facing articles.

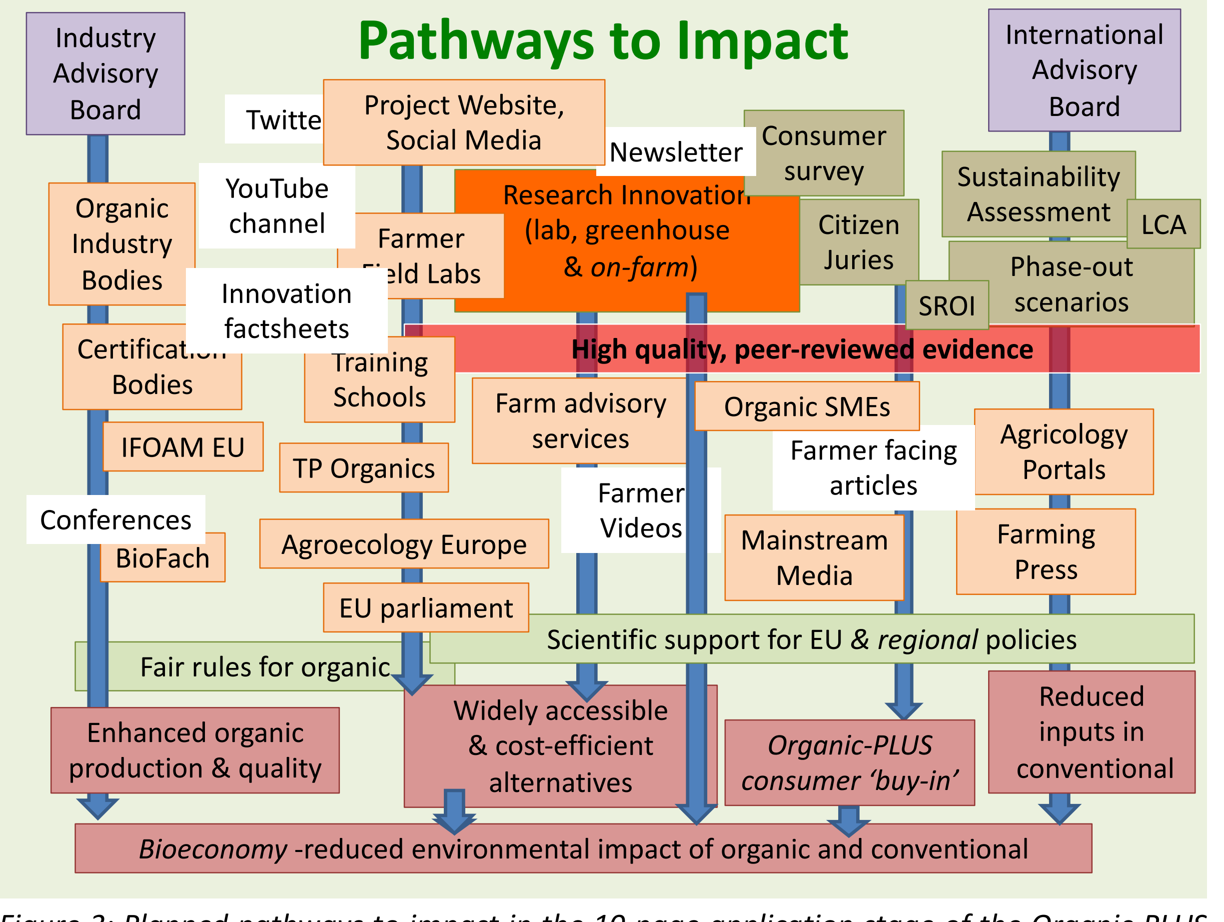

Figure 3: Planned pathways to impact in the 10-page application stage of the Organic-PLUS consortium 14 February 2017.

Research excellence and innovation in labs, greenhouse and on-farm (upper red box) leading to high-quality, peer-reviewed evidence (red box underneath) were also achieved however further papers are still in review, or only in the preparation and submission stage.

We have also included our two advisory boards (purple boxes), however we have combined them and not kept them as two boards as shown in Figure 3. The **international advisory board** was less useful than anticipated, not because the participants did not possess the highest expertise in their field of organic agriculture, rather because contentious inputs are not so high on the research agenda around the world. This finding was still interesting to establish and we nevertheless learned very much from each other. A workshop at the 50 year anniversary of IFOAM in South Korea was organised by one of our advisory board members (Professor Dr Reza Ardakani, Iran). It was not exclusively Organic-PLUS, but a good number of Organic-PLUS participants were there and helped to set the issue of contentious inputs into a much wider context of "Organics for all", the mission of the conference.

Our plan for **industry representation** also changed. Due to the need to have farmers, researchers, marketing experts and advisors on the board, we did not make this a Europe-wide representation, as this would have been impossible on the budget we had. Instead, we opted for an all Danish representation and invited them to the consortium meeting in Denmark. This reflects our judgement that Denmark is the key (or one of the few), leading 'organic' countries in Europe and we can all learn from Denmark's experiences to put organic on a larger scale, without necessarily copying everything the country has done.

In terms of methods (dark green boxes) we used consumer surveys, sustainability assessment, LCA (Life Cycle Assessment) and phase out scenario feasibility modelling with case farms. Instead of 'citizen juries' we used 'hybrid forums' i.e. citizen-farmer competency forums and instead of SROI (Social Return on Investment) we use RISE methodology. In both we considered improvements, more fit for purpose than the original proposal.

The pathways to impact (orange boxes) were all used but not all to the same degree. The primary channels used were TP Organics, IFOAM EU group, Biofach, farmer field labs (Innovative Farmers), one training school, the project website and social media, Agroecology Europe, contact with the EU parliament, mainstream media and the farming press/agricology portal. Used to a lesser extent, and to be expanded upon, are contacts with organic industry bodies, certification bodies, farm advisory services and organic SMEs. The latter are more important in an IA (Innovation Action) which has a higher TRL (Technology Readiness Level), therefore the reduced focus on them is explained (Organic-PLUS and RELACS are a RIA, Research and Innovation Action).

In terms of outcomes (light green boxes), our research can contribute considerably to fair rules for organic, improving and tightening the EU regulation for the next revision and legal removal of contentious inputs then, or even earlier through EGTOP (https://agriculture.ec.europa.eu/farming/organic-farming/co-operation-and-expert-advice/egtop-reports_en) and to set a clear pathway for the phase-outs. Scientific support for the EU and its policy officers was expressed in several meetings and is ongoing, equally through the published material, peer-reviewed papers. The impact on regional policies, e.g. in certain countries such as Türkiye and United Kingdom might be limited. However, this is not the case for the peat phase-out, which became law in the UK during the project lifespan. The full impact may need further time to materialise and as coordinator, Coventry University is committed to track impact for at least the next 5 years. In addition to the above, we worked with IFOAM World (headquartered in Bonn, Germany, not to be confused with IFOAM EU/Europe in Brussels) during the conference in Korea. This means we will continue to advise and lobby for a phase-out of contentious inputs in all organic movements across the world.

From the major impact as mentioned in the call text and also in Figure 2 at the bottom (rust red boxes) we conclude that phase-outs of contentious inputs can enhance organic production or at least has no detrimental effect on yield. The quality of products increases without having copper in the soil. Minimised copper in the soil improves soil life and hence could also have a positive effect on soil carbon storage. Antibiotic reduced or completely free products are of high quality and can achieve a premium over the standard organic price. Equally it is expected that the peat and plastic phase-out will improve consumer trust and 'buy-in' into organics as a leader in sustainability. Both plastic packaging (to a lesser degree plastic film) and peat growing media were found to be contentious in our representative consumer survey across Europe. For the organic sector to be seen leading on phase-outs is important in building trust with consumers.

What we have not yet achieved is widely accessible and cost-effective alternatives; innovation action research and further growth of the organic sector (the 25% organic land use target by 2030 in the EU helps) are needed to achieve this. We may also have failed to reduce inputs from conventional (non-organic) agriculture, however our work on peat and plastic mulch phase-out has received great interest (also in the mainstream media) and both are fully applicable to conventional horticulture, so this could therefore lead to reduced inputs in those systems.

A bio-economy with reduced environmental impacts of organic and conventional is possible, however the term *"reduced impact"* used in the call text can be seen as a 'weak wording' and just reducing impact might not be enough. For many contentious inputs and with system re-design the long-term aim is zero-pollution: no leaching of organic fertilisers, no inputs like antibiotics, anthelmintics or synthetic vitamins, and for vegan organic, no farmed animal inputs. This might be seen as radical by some, but it may also be a realistic proposal to avoid the climate and biodiversity catastrophe.

5.3.2 Summary display of scenarios (with phase-out years)

At the IFOAM 50 year anniversary and ISOFAR conference in Korea, we also discussed the phase-out concept further, including other contentious inputs like mineral oils for the lubrication of farm machinery or diesel, petrol fuels and heating oil or gas from fossil fuels. Equally important is the phase-out of plastic in packaging, one of the top concerns of European consumers.

The summary table (Figure 4) displays the scenarios, including the years where phasing out is anticipated to take effect. The specific action and feasibility are summarised in Section 5.2 and further detail is also found in Schmutz, 2022 and other presentations during the workshop in Korea. The complete conference proceedings text is provided in the references and here: www.isofar.org/Events/2022-ISOFAR-workshops-for-2nd-Organic-Expo-in-Korea-in-Sep-2022. In addition, information with full text and slides is also found in Deliverable *'D1.2 O+ Documentation of boards.pdf'* submitted 31 October 2022. The key finding **specifically for the inputs researched in the Organic-PLUS project** (and informed by the results documented by RELACS) are shown in Figure 4, lines 1-14.

We conclude **all contentious inputs can be phased-out**, the question is only when, and the timelines differ. The phase-out timelines are calibrated for organic agriculture in Europe including the EU, United Kingdom, Switzerland, Norway, and Türkiye.

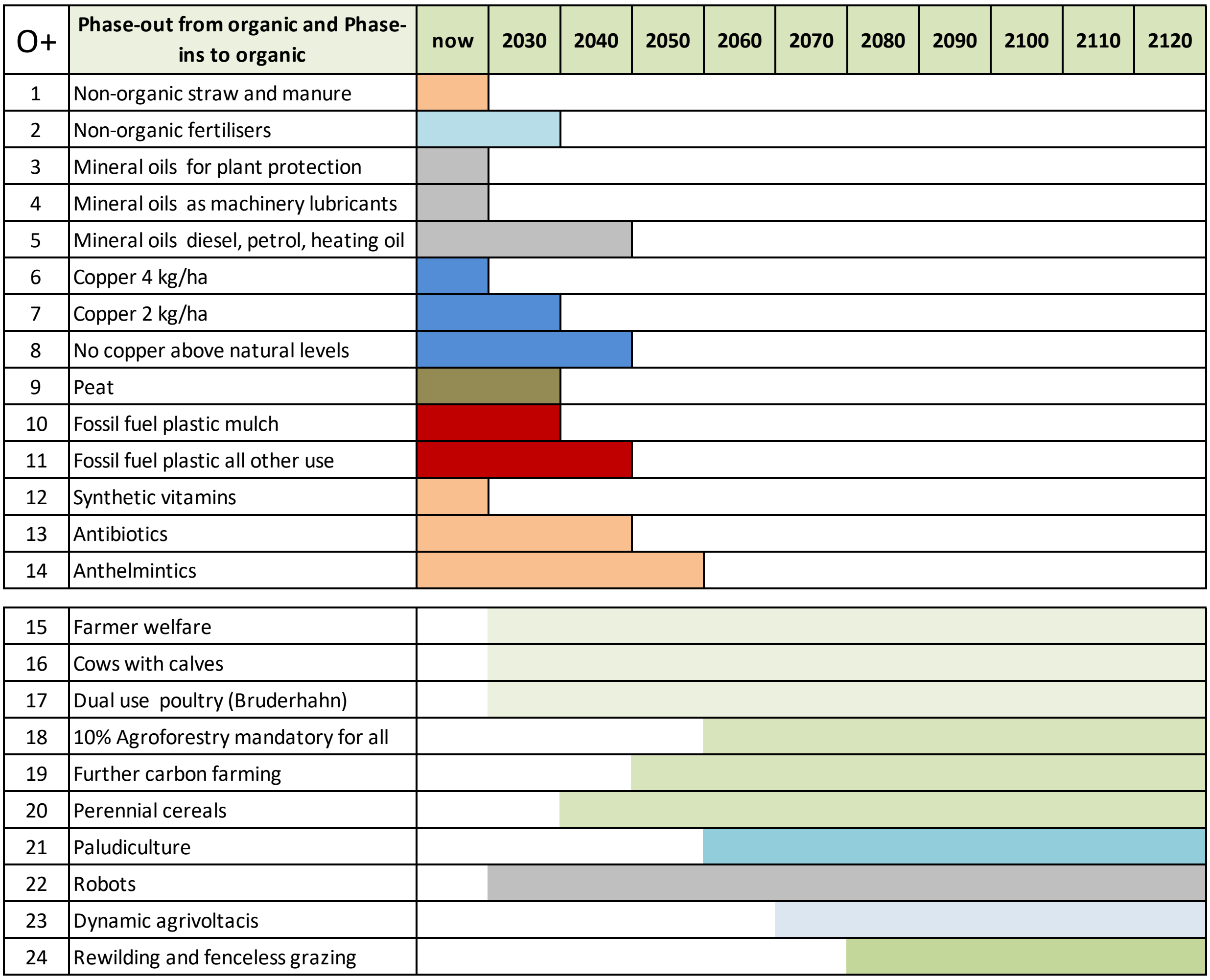

Figure 4: Phase-out scenario proposal with years where the phasing-out is anticipated to be completed for contentious inputs (Proposal 1-14). Also shown are phase-in visions (Line 15-24) visions of other practices. The timeline is now (2023) until 2120 (source: Schmutz, 2022).

For **copper as a fungicide**, the use in all crops can be reduced from 4 kg/ha per year to 2 kg/ha per year after the current 7-year long regulation runs out in 2027. Once 2 kg/ha per year runs another 7 years to 2034 it is possible to reduce copper additions completely. However, copper is a micro-nutrient, and copper fertiliser and fungicides used at rates below 2 kg/ha per year could be acceptable, providing there are evidenced (by soil analysis) copper deficiencies in the soil. A total phase-out of a plant micro-nutrients is impossible and as long as healthy natural soil copper levels are not exceeded, application of below 2 kg/ha after 2034 should be still be acceptable. The copper phase-out is more important in perennial crops (e.g. apple, almond, citrus, hops, olive, roses) as crop rotations are not possible (unlike with potatoes, aubergines, tomatoes and other annual crops).

Mineral oils for plant protection can be phased-out immediately, as plant-oil based alternatives are already commercially available with no or minimal extra costs.

Non-organic straw can be phased out immediately as alternative bedding is available. An increase to 25% organic land use will help with the availability of straw. The same can be concluded for **non-organic manure** which can be phased-out immediately, as alternative fertilisers are available and if organic farms need manure they can always increase their own organic livestock as mixed farming should be encouraged. This policy is an example of indirect support for mixed farming and diverse land use within agroforestry systems. The increase of organic land to 25% (or 30% in some countries) by 2030 will help with any availability and supply chain problems.

Non-organic fertilisers can also be phased-out soon but currently there is limited availability e.g. Vinasse from sugar-beet and leguminous fertilisers like bean powder are not (yet) exclusively from organic farming systems. This still provides a pathway for pesticide contamination from conventional inputs. Here, again, 30% organic by 2030 will help with the overall availability of organic products and by-products from processing. Further research is needed to explore options to secure reliable sources of enough nutrient inputs as required for a growing organic sector. This also includes Humanure and Struvite (a phosphorous fertiliser based on human waste).

Peat as a soil conditioner is already phased-out, remaining phase-outs are needed for **nursery crop production** (plant and tree nurseries), for **blocking growing media** and peat as **casings for mushrooms**. Peat smoke is used in very low quantities to flavour whiskey and fish, but even for these, alternatives are available. Peat restoration and peatlands are among the key drawdown options, and it is useful to re-wet peatland also where organic farming is currently practised. Alternative crops e.g. sphagnum moss, floating sweet grass, hemp agrimony, cranberries, wet rice, can be considered to establish **organic paludiculture** (paludiculture or wet-farming is the practice of farming on wet land, such as rewetted bogs and fens e.g. www.greatfen.org.uk/big-ideas/wet-farming) also in temperate climates where those soils have been drained and given over to agricultural production. Agroforestry can be added around the new ‘paddy fields’ of Northern Europe.

Fossil fuel derived **plastic mulch** can be phased-out by 2030. Alternative biodegradable bio-based plastics are available, although they require further research in more applied innovation actions and locally sourced materials may be more appropriate. Like all other phase-outs, this is also required in conventional horticulture and agriculture.

The use of **antibiotics** requires system re-design in some intensive organic systems in Europe. These are still very ‘conventional’, with high yielding dairy breeds and limited grazing. Those systems, without re-design and re-creating a mixed grazing landscape with agroforestry, will have little chance to remain organic until 2050. In all other organic systems, including 365 days free-range pigs and poultry, antibiotics are not needed and should be reserved for accidental damage in individual animals (as per the organic welfare and care principles). Group treatment of mastitis for the whole dairy, sheep or goat herd will be phased out.

The full phasing out of **anthelmintics** is difficult, as grazing is still too confined in organic. Mixed grazing and the healthy use of pasture is often not possible and here re-design is also required to ‘rewild’ organic grazing patterns and introduce more trees (agroforestry) with beneficial anthelmintic properties and generally reduce the intensity further while equally increasing quality.

Further growth of **vegan organic** is also very welcomed as it gives the remaining domesticated animals more space to re-design and improve grazing to phase-out anthelmintics. **100% vegan organic** is not desirable as it would erase all benefits of high welfare animals and make domesticated animals extinct.

Mandatory **agroforestry** (10% or more) in organic, can help with carbon farming and with better integrated in livestock grazing and mixed farming reducing the need for antibiotics and anthelmintics.

In conclusion, with this vision, organic agriculture can phase-out all the contentious inputs currently identified (however, there may always be others not researched in these projects e.g. vermiculite, steel/concrete, diesel fuel for tractors, certain statutory vaccines). This phase-out will still take at least 10-20 more years to achieve, but it is made easier as it is combined with the growth of organic land to 25% by 2030 in the EU. In addition, further research investment from the Strategic Research and Innovation Agenda (SRIA) for a European Partnership on **Agroecology Living Labs and Research Infrastructures** over the next decade will help ensure that organic is rejuvenated by the social and food system principles of agroecology including the social questions of farmer welfare and fairer community supported supply chains. The phase-out will target inputs head on, which contribute to the **climate crisis (fossil fuel inputs, peat, plastic),** while equally opening up organic to carbon 'drawdown' back to 350 ppm CO_2, by rewetting peatland and making agroforestry mandatory. **Anaerobic digestion** (AD) within organic will also play a major role, potentially using multifunctional green manure/biomass crops in digesters and digestate from organic and food waste inputs as fertiliser and peat alternatives.

With all these phase-outs one might think – **what to phase-in?** (Figure 4, line 15-24)

What to adopt more in organic requires further discussion and research (Schmutz, 2022). Examples are: farmer welfare (mentioned several times as an outcome of consumer research), cows with calves for 1-3 months and dual use poultry *'Bruderhahn'* (animal welfare is a key consumer concern), trees with at least 10% agroforestry mandatory for all organic farms, further carbon farming, perennial cereals, paludiculture (wetland agriculture to capture more carbon), small-scale robots, dynamic agrivoltaics (solar panels above crops, called dynamic as they can be tilting for hail and sun-burn protection) and rewilding and fenceless grazing (with GPS-collars for animals). However, too many trees on farms, small-scale robots, solar panels and GPS-collars for fenceless grazing might in itself become contentious in the future.

6 References

Aguilera, E., Díaz-Gaona, C., García-Laureano, R., Reyes-Palomo, C., Guzmán, G. I., Ortolani, L., Rodríguez- Estévez, V. (2020). Agroecology for adaptation to climate change and resource depletion in the Mediterranean region. A review. Agricultural Systems, 181(August 2019), 102809. https://doi.org/10.1016/j.agsy.2020.102809

Altieri M.A., Nicholls C., Henao A., Lana M. (2015). Agroecology and the design of climate change-resilient farming system. Review article. Agron. Sustain. Dev. 35:869–890 https://doi.org/10.1007/s13593-015-0285-2

Antier, Clémentine, Viguier, Loïc, Messéan, Antoine, & Baret, Philippe V. (2021). Recommendations for overcoming barriers to crop diversification towards sustainable agriculture. Zenodo. https://doi.org/10.5281/zenodo.5824417

Aubert, P.M., Schwoob, M.H., Poux, X. (2019). Agroecology and carbon neutrality in Europe by 2050: what are the issues? Findings from the TYFA modelling exercise. IDDRI, *Study* N°02/19. https://www.iddri.org/en/publications-and-events/study/agroecology-and-carbon-neutrality-europe-2050-what-are-issues

Buck, D., Getz, C., and Guthman, J. (1997). From farm to table: The organic vegetable commodity chain of Northern California. Sociologia ruralis, 37(1), 3-20.

Darnhofer, I. (2014). Contributing to a Transition to Sustainability of Agri-Food Systems: Potentials and Pitfalls for Organic Farming. In: Bellon, S., Penvern, S. (eds) Organic Farming, Prototype for Sustainable Agricultures. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-7927-3_24

Elzen, B., Barbier, M., Cerf, M., Grin, J. (2012). Farming Systems Research into the 21st Century: The New Dynamic. https://doi.org/10.1007/978-94-007-4503-2_19 .

European Commission (2022). A partnership on agroecology living labs and research infrastructures. https://ec.europa.eu/info/research-and-innovation/research-area/agriculture-and-forestry/ecological-approaches-and-organic-farming/partnership-agroecology_en

Gascuel-Odoux, C., Lescourret, F., Dedieu, B. et al. (2022). A research agenda for scaling up agroecology in European countries. Agron. Sustain. Dev. 42, 53 https://doi.org/10.1007/s13593-022-00786-4

Guthman, J. (2004). The Trouble with 'Organic Lite' in California: A rejoinder to the 'Conventionalisation' debate. Sociologia Ruralis, 44: 301-316. https://doi.org/10.1111/j.1467-9523.2004.00277.x

Hallmann CA, Sorg M, Jongejans E, Siepel H, Hofland N, Schwan H, et al. (2017) More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLoS ONE 12(10): e0185809. https://doi.org/10.1371/journal.pone.0185809s .

Hernández-Morcillo, M., Burgess, P., Mirck, J., Pantera, A., Plieninger, T. (2018). Scanning agroforestry-based solutions for climate change mitigation and adaptation in Europe. Environmental Science and Policy, 80(November 2017), 44–52. https://doi.org/10.1016/j.envsci.2017.11.013

Hill, S. 1985. Redesigning the food system for sustainability. *Alternatives* 12:32–36.

Jacquet, F., Jeuffroy, MH., Jouan, J. et al. (2022) Pesticide-free agriculture as a new paradigm for research. Agron. Sustain. Dev. 42, 8. https://doi.org/10.1007/s13593-021-00742-8

Lamine, C. and Bellon, S. (2009) Conversion to Organic Farming: A Multidimensional Research Object at the Crossroads of Agricultural and Social Sciences. A Review. Agronomy for Sustainable Development, 29, 97-112. https://doi.org/10.1051/agro:2008007

Lehmann, J., Kleber, M. (2015). The contentious nature of soil organic matter. Nature 528, 60–68. https://doi.org/10.1038/nature16069

Leippert, F., Darmaun, M., Bernoux, M. and Mpheshea, M. 2020. The potential of agroecology to build climate-resilient livelihoods and food systems. Rome. FAO and Biovision. https://doi.org/10.4060/cb0438en

Loconto, A. and Busch L. (2010) Standards, techno-economic networks, and playing fields: Performing the global market economy, Review of International Political Economy, 17:3, 507-536. https://doi.org/10.1080/09692290903319870

Knudsen, M.T., et al. (2017). Characterization factors for land use impacts on biodiversity in life cycle assessment based on direct measures of plant species richness in European farmland in the 'Temperate Broadleaf and Mixed Forest' biome. Science of the Total Environment 580, 358–366. https://doi.org/10.1016/j.scitotenv.2016.11.172

Montemayor, E., Andrade, E.P., Bonmatí, A., Antón A. (2022). Critical analysis of life cycle inventory datasets for organic crop production systems. Int J Life Cycle Assess 27, 543–563 (2022). https://doi.org/10.1007/s11367-022-02044-x

Montemayor, E., Knudsen, M., Bonmatí, A., Antón, A. (2023). Life cycle assessment characterization factors for land use impacts on biodiversity in organic and conventional farmland in the European Mediterranean biome. Science of the Total Environment, (submitted).

Padel, S. (2001), Conversion to Organic Farming: A Typical Example of the Diffusion of an Innovation? Sociologia Ruralis, 41: 40-61. https://doi.org/10.1111/1467-9523.00169

Padel, S. Levidow, L. Pearce, B. (2020) UK farmers' transition pathways towards agroecological farm redesign: evaluating explanatory models, Agroecology and Sustainable Food Systems, 44:2, 139-163, https://doi.org/10.1080/21683565.2019.1631936

Penvern, S., Bellon, S., Fauriel, J., Sauphanor, B. (2010). Peach orchard protection strategies and aphid communities: Towards an integrated agroecosystem approach. Crop Protection 29. 1148-1156. https://doi.org/10.1016/j.cropro.2010.06.010

Reganold, J., Wachter, J. (2016). Organic agriculture in the twenty-first century. Nature Plants 2, 15221. https://doi.org/10.1038/nplants.2015.221

Schmutz, U. (2017). Urban Agriculture or Urban Agroecology? Urban Agriculture Magazine, 33, 7-7.

Schmutz, U. (2022). How can organic agriculture & agroecology contribute solving the climate crisis in a healthy world? In G. Rahmann (Ed.), Research for Organic Agriculture to tackle future challenges proceedings: ISOFAR International Scientific Workshops (1 ed., Vol. 1, pp. 181-185). International Federation of Organic Agriculture Movements. www.isofar.org/Events/2022-ISOFAR-workshops-for-2nd-Organic-Expo-in-Korea-in-Sep-2022

Seidel, C.; Heckelei, T.; Lakner, S. (2019) Conventionalization of Organic Farms in Germany: An Empirical Investigation Based on a Composite Indicator Approach. Sustainability, 11, 2934. https://doi.org/10.3390/su11102934

Simon, H. (2002). Near decomposability and the speed of evolution. Industrial and Corporate Change. 11. 587-599. https://doi.org/10.1093/icc/11.3.587

Sumberg J. Giller K. (2022) What is 'conventional' agriculture? Global Food Security, 32, 100617. https://doi.org/10.1016/j.gfs.2022.100617 .

Sylvander, B., Bellon, S. and M. Benoît (2006) Facing the organic reality: the diversity of development models and consequences on the public policies. OF and European Rural Development. Joint Organic Congress, Odense (DK), 30-31 2006.

Wezel A., Casagrande M., Celette F., Vian J.-F., Ferrer A., Peigné J., (2014). Agroecological practices for sustainable agriculture. A review. Agron. Sustain. Dev. 34:1–2 https://doi.org/10.1007/s13593-013-0180-7

Vanloqueren, G., Baret, P. (2009) How agricultural research systems shape a technological regime that develops genetic engineering but locks out agroecological innovations, Research Policy, 38, 6, 971-983, https://doi.org/10.1016/j.respol.2009.02.008

Vereijken P. (1997) A methodical way of prototyping integrated and ecological arable farming systems (I/EAFS) in interaction with pilot farms, https://doi.org/10.1016/S0378-519X(97)80029-3.

Wibbelmann, M., Schmutz, U., Wright, J., Udall, D., Rayns, F., Kneafsey, M., Trenchard, L., Bennett, J., Lennartsson Turner, M. (2013). Mainstreaming Agroecology: Implications for Global Food and Farming Systems. Centre for Agroecology and Food Security, Coventry University. www.fao.org/agroecology/database/detail/en/c/455332

Zasada, I., Schmutz, U., Wascher, D., Kneafsey, M., Corsi, S., Mazzocchi, C., Monaco, F., Boyce, P., Doernberg, A., Sali, G., & Piorr, A. (2017). Food beyond the City – Analysing Foodsheds and Self-Sufficiency under different Food System Scenarios in European Metropolitan Regions. *City, Culture and Society*, *16 (2019)*, 25-35. https://doi.org/10.1016/j.ccs.2017.06.002

7 Appendix - Program of final project meeting

Organic-PLUS Consortium Meeting and Annual General Assembly
Nürnberg & Hohenheim, Germany, 27th - 30th July 2022

Venues:

Day 1 - Biofach, Nürnberg
Day 2 - University of Hohenheim, Stuttgart-Hohenheim + field trip
Day 3 - University of Hohenheim, Stuttgart-Hohenheim + field trip
Day 4 – Full day field trip departing from Stuttgart-Hohenheim to Lake Constance region

Preliminary Programme, Final Project Meeting Organic-PLUS
University of Hohenheim, 27th - 30th of July
Conference venue: Manor House of the University of Hohenheim (unless otherwise stated)

Tuesday, 26th July **Arrival Day**	
17:00	**Arrival at UHOH or at Nuremberg** For those arriving at UHOH: 17:00 Guided tour through the Botanical Garden of the University of Hohenheim, maybe with a visit of the Manor House
19:30	**Dinner in Stuttgart - beer garden?** Venue to be determined (The cost will <u>not</u> be covered as part of the consortium meeting so will need to come from your organisation's individual O+ budget or private budget for spouses)

Wednesday, 27th July **Day 1 - Biofach Nuremberg**	
07:30 10.00 10.30- 11.30	**Visit of Biofach, Biofach, Nuremberg** Departure from Hohenheim to Nuremberg. Organic-PLUS hired room "Riga "(in the conference centre) Holger Reising, Ökoboard, Bayerische Landesanstalt für Landwirtschaft *How to reach 30% organic in Bavaria by 2030 – challenges and opportunities?* Dr Christopher Brock, Forschungsring, Germany *Bio-dynamic (Demeter) - Its current state and research in Germany and how it phases out contentious inputs as part of a premium organic concept.* Participants have the possibility to visit Biofach.

14:30- 15.30	**Workshop at Biofach, Nuremberg together with RELACS project and TP Organic** ***'Raising the Bar for Organic: Input substitution or system re-design? A tale of peat and copper'*** **(**Dr Christoph Brock (moderation): Dr Bram Moeskop TP-Organic/RELACS and Dr Bas Drukker RELACS on copper Dr Ulrich Schmutz and Dr Margi Lennartsson Turner, Organic-PLUS on peat Phase-out discussion
16:00	**Departure to Hohenheim**
20:00	**Dinner** Garbe Stuttgart-Hohenheim

Thursday, 28th July **Day 2 - Conference Day 1: Organic-PLUS (open to the public)**	
08:30	**Welcome and Registration - Coffee**
 09:00 09:10 11.00 Coffee Break 11.30	**Public Conference - Opening addresses:** Prof. Dr. Stephan Dabbert, Rector of the University of Hohenheim Prof. Dr. Ulrich Schmutz, Coordinator of Organic-PLUS Dr Sabine Zikeli Organic in Baden-Wuerttemberg Organic-Plus WP headline overview (3 min each WP leader) **Public Conference -** Contentious inputs the perspective of organic businesses and farmers with (tbc): • Biofa (Company producing fertilisers and plant protection products for organic farming) • Theresia Kübler (Farmer, dairy cows) Green party work for Regional Parliament, Farmer succession • Jonas Klein (Farmer, dairy cows & Journalist) • Thomas Makary (farmer and scientist, laying hens, dairy goats, arable farming, direct marketing, cheese diary)
13:00	**End of conference (lunch pick-up)**
13:30	**Departure to field trip** **1. Field trip** Natterer (Bioland) - Organic plantlet nursery Vaihingen/Enz, www.natterer-bioland.de Biohof Hörz, Organic horticultural farm, outskirts of Stuttgart Vegetable production (field and greenhouses) (~80 crops), Farm shop and market stand, box scheme, fruits and other products, Energy concept (Solar power system and delivery vans/ bikes are powered by electricity/battery) www.gemuesehofhoerz.de

Friday, 29th July **Day 3 - Conference Day 2: Organic-PLUS (internal meeting)**	
09:00 9.30 11.30	**Start of internal meeting** **Opening address:** Judith Conroy, Project Manager of Organic-PLUS 1. **AGA**, Annual General Assembly 2. **WP meetings** to discuss any remaining issues in person (can be parallel and followed up with the usual online meeting) (allow for 5 Parallel sessions) 3. **WP leads report back** - loose ends. 4. **Dissemination of on-farm innovation and project legacy** 5. **Publication strategy**, some of this will be after final project end 6. **Finance and reporting**, preparation for 54-month final report Martin Häusling, MEP Member of the European Parliament, Coordinator for the Greens/EFA in the agricultural committee (AGRI) (to be confirmed) Phase-out of contentious inputs from Organic- what can the next EU regulation deliver? **Closing remarks:** Prof. Dr. Ulrich Schmutz, Coordinator
13:00	**End of conference**
13:30	**Departure to field trip** **2. Field trip** 1. Topic: Farm with animal husbandry 2. Topic: Organic Grape Cultivation and Winery
	Dinner at the farm + wine tasting?

Saturday, 30th July **Day 4 - Field trip, Lake Constance region**	
7:30 a.m.	**All day: 3. Field trip to Lake Constance region** 1. **Farm Heggelbach** https://hofgemeinschaft-heggelbach.de/ agro-photovoltaics, pigs, cows, vegetable and arable production, cheese dairy 2. **Farm: Johannes Bentele,** www.wir-bodensee.bio/hofportrais/demeterhof-bentele Apples and hops **Farm: Eva Maria Walle, PlantaWalle** www.plantawalle.org/en/ Medicinal plants, herbs for tea, tea production, consulting on herb and medicinal plant production