Harvesting the fruits of transdisciplinary knowledge integration

The *EGON* project on commons-based organic fruit breeding

Evaluations on transdisciplinary research suggest that co-creation should place greater emphasis on the first steps of co-design. This report provides insights and reflections on a sustainable fruit breeding project initiated by practitioners.

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GAIA 32/2 (2023): 257 – 263

Abstract
The research project *EGON* explored a new organizational approach in the fruit sector that builds upon common ownership and collective management: commons-based organic fruit breeding. As agricultural and breeding actors initiated the writing of the research proposal, they became involved on equal footing in the joint problem framing and design of the research project from the very start. In this *Design Report*, we explore contextual factors in the co-design and co-production phase and their influence on the research process, as well as scientific and societal effects. Based on interviews with scientific and practitioner partners in the consortium, we find that early and continuous professional networking with practitioners is essential for fruitful transdisciplinary research processes. Also, joint activities like common excursions, seminars, and joint conference presentations have been valuable to develop mutual understanding, curiosity, and trust. What turned out to be crucial for the commons-based approach of the project were adequate funding opportunities for practitioners in systematic and scientifically supported breeding processes.

Keywords
agriculture, co-design, commons, co-production, plant breeding, sustainability, transdisciplinary research

Agricultural and food systems are challenged on many fronts through, for example, the excessive use of chemicals leading to negative environmental and health impacts and the declining agrobiodiversity (e. g., Rasmussen et al. 2018). Additionally, social and economic injustices, as well as power imbalances, pressurize the sector (e. g., IPES-Food and ETC Group 2021). The fruit sector with its perennial agricultural systems, the high demand for fruit, and the long and complicated breeding processes provide a particularly interesting field for transdisciplinary studies. However, only a few projects have addressed this field in recent years.

At the breeding stage, the sector struggles with at least four sustainability problems (Wolter et al. 2018). First, fruit breeding cycles take about 15 to 20 years. Every fruit tree, and thus the planting of a specific variety, is a long-term and high-risk investment due to an average apple tree's lifetime of 12 to 20 years and the uncertainties of success involved. Unlike vegetables or grain, branding and varietal awareness play a major role at the consumer level, especially for apples and pears. Second, breeding goals in conventional apple breeding – defined as breeding by scientists off-farm, primarily relying on evolutionary theory and genetic research – do not sufficiently consider robustness (i. e., the susceptibility of cultivars against adverse environmental conditions and diseases). Thus, rather intensive plant protection becomes a necessity, especially in organic fruit orchards. In particular organic apple production, where chemical-synthetic pesticides are banned, suffers from this lack of robust cultivars[1]. Third, >

1 Cultivars are plants or parts of plants that have been developed and maintained by agricultural or horticultural practices (cultivation).

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https://doi.org/10.14512/gaia.32.2.9
Received August 19, 2022; revised version accepted June 6, 2023 (double-blind peer review).

SUB-PROJECT 1: applied perspective
- carrying out and documenting the practical apple and pear breeding processes
- experimentation with different crossings at different locations
- cultivation and observation of resulting seedlings

SUB-PROJECT 2: genetic perspective
- genetic analysis of heirloom and underutilized apple cultivars
- identifying pedigree relations of apple varieties
- assessing the role of genetic diversity in breeding

SUB-PROJECT 3: socio-economic perspective
- conceptualizing the approach of commons-based organic fruit breeding
- discussing its potentials and challenges for market integration

FIGURE 1: Sub-projects and core research tasks in the *EGON* research project.

several economically important apple varieties bred in the last decades are genetically interrelated. Their narrow genetic basis leads to inbreeding and "genetic erosion" (Migicovsky et al. 2021), inhibiting the vitality of current and prospective apple varieties. Fourth, newly developed varieties are increasingly privatized as club goods with strictly limited access to varieties.

The research project *EGON*

The project *EGON (Development of organically bred fruit varieties in commons-based initiatives,* January 2017 to July 2020)[2] addressed these challenges by conceptualizing the approach of commons-based organic fruit breeding (Wolter and Sievers-Glotzbach 2019). This approach is mainly characterized by 1. adopting collective responsibility by fruit breeders and farmers for agrobiodiversity through utilizing the genetic diversity of heirloom and underutilized cultivars, 2. its participatory character involving breeders and farmers sharing their knowledge and resources, 3. the implementation of collective and polycentric management practices at diverse breeding locations across Germany, and 4. the collective ownership of important resources including seeds, seedlings, farming and breeding knowledge, and resulting varieties. We hypothesized that a commons-based organic breeding approach is more beneficial for the development and introduction of fruit varieties suitable for organic fruit growing than conventional breeding approaches.

Consortium partners were scientists from the University of Oldenburg, namely the *Economics of the Commons,* the *Ecological Economics,* and the *Plant Biodiversity and Evolution*-Groups, and fruit breeders and farmers from Öko-Obstbau Norddeutschland Versuchs- und Beratungsring e.V. and apfel:gut e.V. In addition, the research team integrated a range of different stakeholders such as fruit farmers or marketeers. On an organizational level, the project was divided into three sub-projects with specific research agendas (figure 1), embedded in joint overarching research questions (Wolter et al. 2018):

- How can organic regional fruit farming be secured, innovative breeding concepts be developed and established, and the access to fruit cultivars be kept open?
- What are the differences between the conducted participatory organic fruit breeding approach and other breeding approaches?
- What ecological, societal, and economic impacts does the conducted participatory organic fruit breeding approach have under different conditions?
- What are the implications of genetic diversity regarding the used cultivars in the breeding process?

Although all sub-projects were separated along disciplinary, as well as science-practice lines, results were regularly integrated and discussed with the overall research team. Starting with a kick-off workshop, meetings took place every two months throughout the whole project. Stakeholders, such as fruit farmers, pomologists, and breeders took part in several personal meetings, depending on the respectively discussed topics. Several of those meetings were combined with joint excursions to breeding areas in Northern Germany and Belgium.

Throughout this regular exchange, the project aimed at a constant integration of knowledge in the different sub-projects. Scientists from sub-project 3 carried out focus groups and interviews with the apfel:gut community, which includes breeders, farmers, and private pomologists, to get insights for the conceptualization of commons-based organic fruit breeding. Subsequently, apfel:gut members were able to directly integrate those insights into the public communication of their pioneer breeding approach and its societal value. Similarly, insights from the genetic analyses carried out in sub-project 2 were concurrently integrated in apfel:gut's practical breeding processes (see the section on co-production).

Beyond the consortium partners, knowledge integration took place with several relevant stakeholders. In sub-project 2, scientists cooperated with other fruit geneticists across Europe and from the US, but also with practitioners to get tissue samples for genetic analyses. In sub-project 3, a Delphi study was carried out with representative actors from fruit cultivation, breeding, marketing, and research to identify market challenges for commons-

2 *https://uol.de/egon*

based organic fruit breeding. In the final stage of the project, a closing conference was jointly organized by the consortium in 2019, where research results were presented and discussed with national and international stakeholders. Overall, these stakeholders have not actively been involved in the whole co-creation process, but merely participated in specific events or tasks, were informed about the research results, or acted as feedback and discussion partners. Figure 2 gives an overview of the relevant stakeholder groups.

Knowledge integration took place in the form of system, target, and transformative knowledge which has been assessed in a case study in Karrasch et al. (2022). It encompassed knowledge about dynamics and problems of fruit breeding and cultivation (system knowledge); about goals, interests, and norms of the actors, such as breeders, farmers, and marketeers (target knowledge); and about how change can be managed and achieved through, for example, breeding new varieties or establishing new business models (transformative knowledge).

In the next section, we reflect on the process dynamics to better show how the transdisciplinary research process was co-designed, how knowledge was co-produced, and how it was disseminated between actors. In the assessment of the project's effects, a specific focus lies on the interconnections between societal effects and contextual conditions, such as the funding structure, the expertise of involved actors, and the recognition between actors (cf., Lam et al. 2021). Our reflections build on interviews with natural scientists and the consortium practitioners, as well as our own experiences as social-science partners. We then identify success factors as well as obstacles that influenced the project results and its outcomes. This allows us to draw conclusions and develop recommendations in the final section.

Reflecting on the co-creation process

For structuring the reflection of the co-creation process, we applied the framework by Mauser et al. (2013).[3] Figure 3 (p. 260) gives an overview of the process stages and key success factors for the *EGON* project.

Co-design: Initiation of the project idea by practitioners

Co-design describes the first phase of transdisciplinary knowledge co-creation, ideally beginning with the joint framing of the societal problem by researchers and non-academic partners, followed by the joint research definition and its implementation into a manageable research project (Mauser et al. 2013, Moser 2016). Following a comparatively broad call for proposals by the agriculture and science ministries of the German federal state Niedersachsen (Lower Saxony) in 2016, breeding experts (practitioners) first approached social scientists with the idea of initiating a transdisciplinary project. Hence, in writing the project proposal a strong focus was put on understanding and solving real-world problems in organic apple cultivation and breeding. The consortium team together translated these practical challenges into the boundary object of "commons-based organic fruit breeding" and developed a joint problem framing that equally accounts for the different interests of natural and social scientists and practitioners.

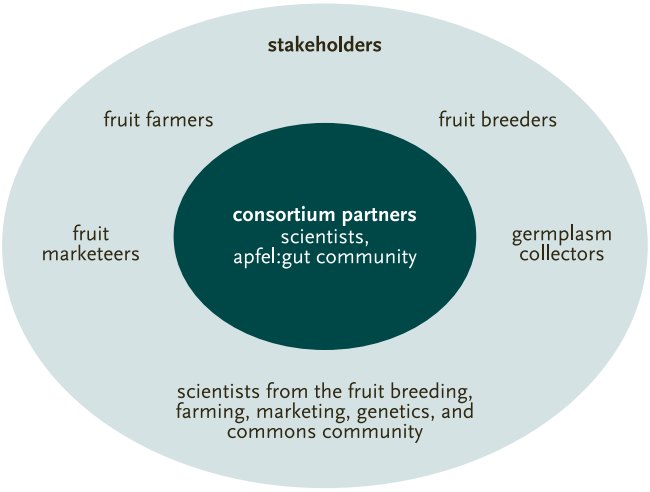

FIGURE 2: Stakeholder groups in the *EGON* project.

Social-communicative knowledge integration was key to collaboratively developing the problem framing. Terms and concepts for the thematic context of the project were discussed with the aim to reach a consensus on the problem definitions, the terms, and the methods used. For example, natural scientists and practitioners had very different normative standpoints on the use of DNA-based technology that had to be discussed to come to a commonly shared understanding for the project. Concerning the project organization, the consortium practitioners conducted a separate sub-project and received partial funding, further demonstrating their formal recognition as equally important partners.

Co-production: Mutual learning across all knowledge types

In the co-production phase, the integration of disciplinary scientific knowledge takes place and societal relevance must be ensured (Mauser et al. 2013). The joint overarching research questions were split up into disciplinary sub-questions. All disciplinary results have been concurrently discussed in the transdisciplinary setting, continuously evaluating and ensuring relevance of the findings.

The integration of these diverse sets of knowledge generated mutual learning. For example, findings from the genetic analyses on pedigree relations of apple varieties (sub-project 2) were combined with practitioner observations of the selection results in the apple breeding process carried out on-farm (sub-project 1). In this way, scientifically sound results and practitioners' insights were fostered by integrating scientific knowledge on the geno- >

3 The three-phased concept of the transdisciplinary research process by Mauser et al. (2013) complements the model advanced by Bergmann et al. (2005), Jahn et al. (2012), and Lang et al. (2012).

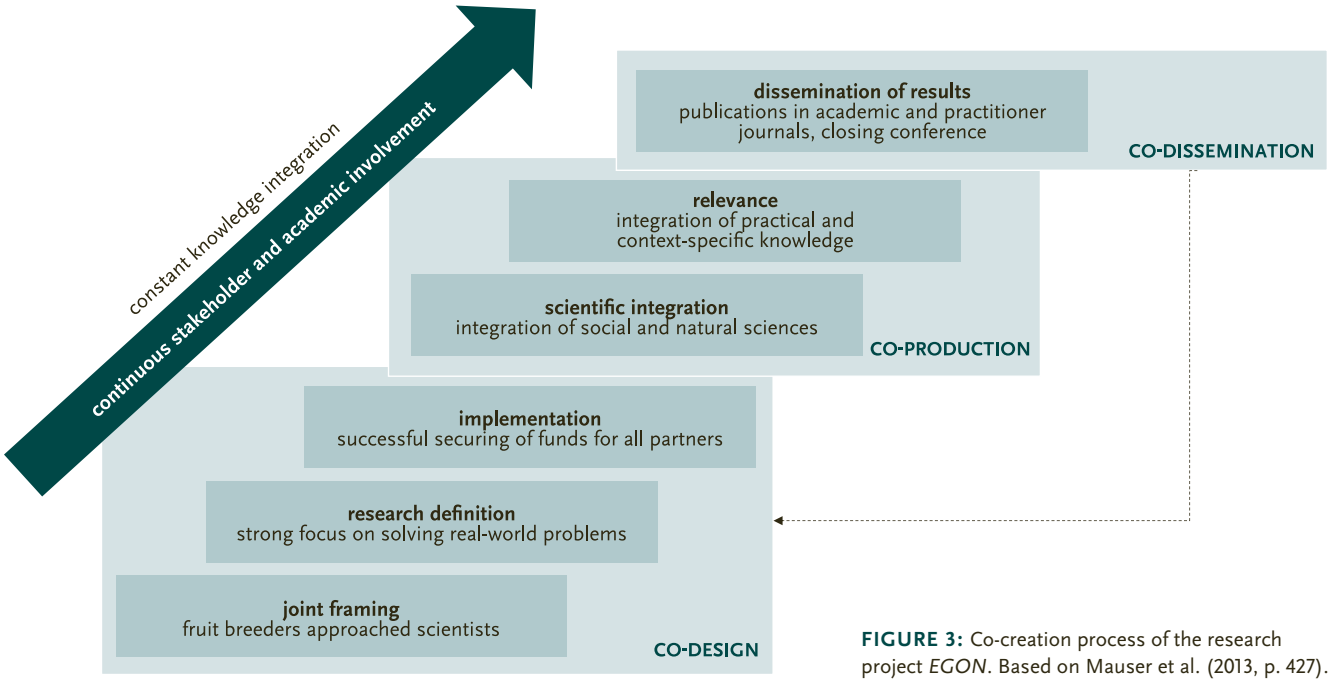

FIGURE 3: Co-creation process of the research project *EGON*. Based on Mauser et al. (2013, p. 427).

type, namely potential traits of cultivars based on genetic data, and practitioners' insights on the phenotype, such as observable traits of cultivars and reactions to environmental conditions. In this context, "we as scientists particularly have to break down our comments so that they are understandable" (interview #2 with natural scientist conducted after project completion). This simultaneously enabled the development of mutual acceptance of sometimes conflicting perspectives. For example, while the apfel:gut breeders were confident that their breeding strategy would avoid inbreeding tendencies, results from the genetic research showed that their crossing combinations provided a higher level of inbreeding than expected. On the other hand, while social scientists aimed to explain the commons-based breeding approach of apfel:gut with established institutional-economic concepts of commons theory for governing natural resources, empirical results revealed that aspects beyond traditional conceptions, specifically Knowledge Commons[4] and Global Commons[5], are equally relevant (Wolter and Sievers-Glotzbach 2019). Hence, the social scientists integrated the new concept of "Hybrid Commons"[6] into the respective scientific discourse. One very concrete result of jointly discussing the sustainability effects of commons-based breeding was the decision by the members of apfel:gut to waive variety protection and register its first newly bred variety as an openly accessible amateur variety. The consortium practitioners reflect: "Commons as a term was quite academic at the beginning, but eventually brought a certain paradigm shift, especially in how we deal with property rights" (interview #1).

Co-dissemination: Making knowledge jointly accessible

Knowledge was disseminated both into academic and practitioner discourses. Research partners published their findings in academic journals that targeted their (disciplinary) research communities. Especially the published results of the genetic analyses (sub-project 2; Howard et al. 2021) received a high resonance in the relevant international scientific community that studies fruit breeding and pedigree relations. Summaries of relevant insights and novel solutions have also been published in practitioner journals and in a practitioners' paper (Forschungsverbund EGON 2020). Moreover, the whole project team produced a conference paper and presented it at the scientific and practice-oriented *Ecofruit* conference (Wolter et al. 2018). Overall, the research team has ensured the project findings are accessible and comprehensible for different stakeholders in both scientific and non-scientific target groups. However, the channels and products of knowledge dissemination hardly reached 1. fruit growers and tree nurseries as further relevant actors along the fruit value chain, and 2. plant breeders apart from apple breeders, particularly conventional ones outside the frame of organic farming. Despite the overall assessment of the project as a "transdisciplinary success" (interview #2), this deficit remains and might be addressed in

4 Knowledge Commons are defined as the "the institutionalized community governance of the sharing and [...] creation, of information, science, knowledge, data, and other types of intellectual and cultural resources" (Frischmann et al. 2014, p. 3).

5 Global Commons refer to global collective action in international and global resource domains (Stern 2011).

6 "Hybrid Commons" are commons arrangements that cannot be entirely grasped with a single conception of commons. For instance, fruit breeding commons bridge Traditional Commons, Knowledge Commons, and Global Commons conceptualizations (Wolter and Sievers-Glotzbach 2019).

the future by seeking for a greater involvement of different stakeholders – thereby developing and implementing stronger co-dissemination strategies.

Through the publishing process, the main challenge was the identification of suitable dissemination options and the coordination of joint publications. As described for the co-production phase, mutual learning processes needed time, coordination efforts, and involvement of the project partners. In particular the first joint publication (Wolter et al. 2018) served as a vehicle to uncover conflicts and differences in expectations and assumptions of the project partners.

As a special form of knowledge dissemination, the social and natural scientists held a joint university seminar for master students of sustainability economics and management, and bachelor students of biology in the summer terms of 2018 and 2019. In this novel teaching cooperation, the students carried out interdisciplinary practical projects in the context of vegetable and fruit breeding, farming, and marketing. Consortium practitioners participated via lectures and excursions. The seminar was honored with an award for excellence in teaching in 2019. A natural scientist described this joint seminar as an eye-opening "aha-experience" (interview #2) to see the value of integrating diverse perspectives. He now integrates socio-economic elements in his own specialist courses for biologists.

Identifying obstacles and key success factors

Initiation by consortium practitioners

The idea and initiative for writing the research proposal originated with practitioners who wanted to contrast the typical process where scientists draft research proposals, then merely consult and involve societal actors at later stages (Karrasch et al. 2022). Therefore, the consortium practitioners had a strong motivation throughout the entire process: "Seeing the value of such a project is more important for the practitioners than for the intrinsically motivated scientists" (interview #2). This initiation by consortium practitioners can be regarded as the strongest form of transdisciplinary co-design, where societal actors actively search for cooperation with scientific partners to jointly develop solutions. It also led to joint leadership, and a common framing of the project focused equally on scientific and practical considerations. This guaranteed a clear focus on the societally relevant problems and a solution-orientation in formulating research goals and questions, consequently framing a transformative-knowledge-driven integration process from the project start.

Funding structure

However, given the formal funding conditions, consortium practitioners were categorized as affiliate partners and thus only received partial funding for sub-project 1. Even though commercial benefits from the project results were out of reach, they were granted a disproportionally smaller budget than the scientific research partners. Considering that funding structures and conditions should be designed in ways that support the engagement of practitioners (Defila and Di Giulio 2020, Schmidt et al. 2018), the given conditions of a research and development project caused a few restrictions.

Additionally, the overall funding structure as a three-year project did not match the overarching goal of developing a robust and tasty fruit variety along the entire breeding process: "On your areas, the first seedlings that we selected jointly three years ago are bearing fruits now. This is the time when we could have compared the results from the different breeding locations" (interview #1). In transdisciplinary projects that address sustainability issues with a larger timeframe, it would thus make sense to give direct opportunities for further funding or longer research periods.

Only a culture of openness, curiosity, mutual trust, and the will of the project partners to really develop a shared understanding can forge a collaborative organization and ensure fruitful communication to and with scientific and societal audiences.

Second order effects

Regarding the societal effects of the project to address the practical sustainability problems of fruit farming, second order effects similar to those described in Schäfer et al. (2021) were observed. First, the practical seedling testing and monitoring process from the crossings continued in orchards across Northern Germany, including the project partner's properties and in trial fields at the university. One follow-up project (*zoeno,* 2021 to 2024)[7] established by the practitioners and funded by the City of Hamburg, allows apfel:gut to continue with their breeding work. Second, the concept of commons-based organic breeding, as developed during this project, was adopted by researchers from sub-project 2 and kale farmers, involving the Botanical Garden of the University of Oldenburg, in another follow-up project proposal. Third, the practitioners were able to introduce their first novel apple variety *Wanja* into the market as an openly accessible amateur variety – thereby further institutionalizing the commons approach.

High level of practical knowledge and its equal recognition in the research process

In the co-production phase, the consortium practitioners provid- >

7 See *Verbundprojekt: Partizipative ökologische Obstzüchtung in Norddeutschland mit Schwerpunkt im Gebiet des Alten Landes*, www.apfel-gut.org/projekte.cfm.

ed thorough knowledge about the effects of different practices on breeding results, such as crossing combinations of apple varieties or experiential knowledge on tending to seedlings. Since the project addressed a specific niche in the broader food system context, they possessed eminent expert knowledge that was important for the success of the whole project. Further, the consortium partners describe their work as "applied breeding research", which the scientists recognized as equally important as the academic research for the project's success.

Initiating joint publications

It is still unusual for scientists to publish together with small-scale non-academic actors. However, as described above, the first joint publication of the consortium partners served to communicate the goals and the approach of the project to both academic and non-academic audiences. In the transdisciplinary literature, joint publications are often valued as important vehicles to achieve internal consensus on the important cornerstones of the research project (cf., Moser 2016). In this case, it aided the process to put goals, assumptions, methods, and insights on paper, and to further mutual ownership and commitment of the project partners.

Consortium practitioner involvement and joint activities

The involvement of the apfel:gut community in the co-production phase was key for acknowledging and integrating diverse perspectives into the data collection process and subsequent discussions (Lang et al. 2012, Schmidt et al. 2018). Overall, this collaboration culture (Lux et al. 2019) created outstanding opportunities for knowledge integration. Activities such as joint excursions, joint seminars, or visiting and presenting at conferences together across scientific disciplines and the applied practitioner perspective advanced mutual understanding.

Recommendations for research planning and design

The *EGON* project represents a special case of transdisciplinary research regarding its starting conditions. Practitioners with a high level of professional expertise, extensive networks, strong motivation, and significant creative power approached the scientists when a suitable funding program was announced. This window of opportunity was seized by the consortium partners to develop the project proposal with fruitful results regarding the breeding processes and the establishment of a commons-based breeding model. As a general conclusion, it can create similar windows of opportunity. For both scientists and practitioners, early and continuous networking is essential for making the collaborative development of research proposals possible. This professional networking is key for transdisciplinary research processes and must also be supported by adequate funding structures, networking events, or small-scale screening projects to identify common topics.

Reflection on the research process leads to a particular recognition of the soft factors of transdisciplinary research: Only a culture of openness, curiosity, mutual trust, and the will of the project partners to really develop a shared understanding can forge a collaborative organization and ensure fruitful communication to and with scientific and societal audiences. Funding bodies are well advised to institutionally support these factors by, for example, giving equal recognition to co-design, co-production, and co-dissemination through adequate funding structures for practitioners. Additionally, co-creation in sustainability research can be fostered especially in the first steps of the co-design phase (i. e., the joint problem framing and writing of the research proposal), which is not only where the seeds are laid for creating sustainable and resilient farming systems, but also for shaping truly trusting transdisciplinary research processes.

Acknowledgement: We would like to thank our partners in the research project *EGON* for fruitful discussions and the interview partners for sharing their valuable insights. We would like to thank three anonymous reviewers for their helpful comments.
Funding: Financial support by the state government of Lower Saxony under grants of the Ministry of Science and Culture (no. 3250) is gratefully acknowledged.
Competing interests: The authors declare no competing interests.
Author contribution: *SSG:* conceptualization, transdisciplinary design and reflection, conducting and analysis of interviews, writing – original draft and review/editing; *HW:* conceptualization, transdisciplinary design and reflection, analysis of interviews, writing – original draft and review/editing; *BS:* conceptualization, transdisciplinary design and reflection, review/editing.

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