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RESEARCH ARTICLE

Diverse Seeds – Shared Practices: Conceptualizing Seed Commons

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Commons approaches in the seed sector are multi-faceted: They span from traditional seed systems, i.e. seed sharing networks, to recent anti-enclosure movements that resist intellectual property rights on varieties, like organic breeding initiatives. This paper derives a conceptualization of 'Seed Commons' at the local and regional level, based on a comprehensive transdisciplinary research process that integrates diverse types of knowledge, both from practitioners (German and Philippine seed initiatives, companies and NGOs), and the scientific community. As a result, we identify four core criteria that characterize diverse Seed Commons arrangements at local and regional scales: (1) collective responsibility, (2) protection from private enclosure, (3) collective, polycentric management, and (4) sharing of formal and practical knowledge. Discussing these Seed Commons criteria in the context of different Commons approaches, we find that Seed Commons transcend the distinction between traditional (natural resource) Commons and New Commons approaches, by integrating biophysical, informational and cultural elements in their collective governance. Reaching beyond resource characteristics, the Seed Commons criteria reflect practices of Commoning, which aim to fulfill social functions such as farmer empowerment and food sovereignty.

Keywords: Seed Commons; conceptualization; transdisciplinary; breeding; review; commoning

1. Introduction

New Commons, including Knowledge Commons, Cultural Commons, and Global Commons have become an increasingly important research topic in Commons studies. As they reach beyond the sector of natural common-pool resources, theoretical advancements of analytical frameworks have been developed, such as proposed by Frischmann, Madison & Strandburg (2014) for Knowledge Commons or by Stern (2011) for Global Commons. In practice, several (New) Commons categories can become equally relevant for designing effective community governance of certain goods, containing material, informational and cultural elements. Commons arrangements in seed systems are an example for such forms of 'Hybrid Commons' (Wolter & Sievers-Glotzbach 2019) that cannot be grasped with single commons conceptions.

Commons in the seed sector are multifaceted: They span from traditional seed systems (such as seed exchange networks or community seed banks) to recent anti-enclosure movements (such as open source seeds and organic breeding initiatives) that resist intellectual property rights on varieties. Despite several meta-studies on certain types of commons-based seed practices and initiatives, a comprehensive conceptual classification of the diversity of local and regional commons initiatives in the field of seeds and varieties is lacking. Such a conceptual investigation of commons approaches in this field can help to generate insights into the entanglement of New Commons (specifically, Global and Knowledge Commons) characteristics with traditional commons elements. Additionally, seed initiatives often aim to achieve social functions on the regional and local level such as community building and democratic participation, which are emphasized in recent conceptions of Commoning (Euler 2018; Müller 2012; Vivero-Pol 2017). Understanding governance

challenges originating from their hybrid nature is a topic of high societal relevance, as commons in the fields of seeds and varieties are being discussed as approaches to enhance food sovereignty, farmer empowerment and sustainable agriculture (e.g., Girard & Frison 2018; Kloppenburg 2014; Pautasso et al. 2013).

The objective of this paper is to derive a conceptualization of 'Seed Commons' at the local and regional level. We aim to (i) identify central features of Seed Commons arrangements, which are compatible with both scientific debates and societal practices, and (ii) show the multiple layers of commons approaches and their interactions relevant in Seed Commons. To achieve these objectives, we apply a transdisciplinary research process that integrates diverse types of knowledge, both from practical actors (German and Philippine seed initiatives, companies and NGOs), and the scientific community. Determining Seed Commons criteria in a transdisciplinary approach helps to bridge the gap between practitioners and scholarly communities, which has been identified as an ongoing challenge in commons research (van Laerhoven, Schoon, and Villamayor-Tomas 2020), and specifically helps to incorporate the meanings, experiential knowledge, and normative perspectives of Commoners (see Vivero-Pol et al. 2018). This methodology is essential when aiming to link resource and practice-oriented approaches of Commons (ibid.). It further aids in understanding sustainability potentials and practical challenges of Seed Commons initiatives.

The paper is structured as follows. After outlining the underlying transdisciplinary research procedure (chapter 2), we discuss the key terms seeds and varieties (chapter 3.1) and present a literature overview of relevant meta-/case studies on commons-based seed initiatives (chapter 3.2). We then approach Seed Commons from an empirical perspective by providing in-depth case studies of two commons-based seed organizations. We focus on the German breeding initiative Kultursaat e.V. and the Philippine farmer network MASIPAG (chapter 4). Integrating the insights from the definition of central terms, the literature overview and the in-depth case studies, we develop a conceptualization of Seed Commons based on essentially four criteria (chapter 5). We then critically discuss these criteria in the context of different commons approaches (chapter 6). Finally, we reflect on the transdisciplinary research process and conclude with the relevance of insights from Seed Commons for the Commons discourse (chapter 7).

2. The transdisciplinary process for conceptualizing Seed Commons

The conceptual work of this paper is part of the transdisciplinary research project *RightSeeds*,[1] which explores commons-based seed systems and their transformative potential for realizing food security, food sovereignty and enhancing agrobiodiversity in plant cultivation. *RightSeeds* follows an understanding of transdisciplinarity as a problem- and solution-oriented endeavor, in which new knowledge is generated through the collaboration of scientists from different disciplines with practitioners (Jahn 2008; Lang et al. 2012). The perspectives and disciplinary knowledge from ecology, economics, political science and ethics, as well as farming, breeding and other practical knowledge from European and Philippine practical partners are integrated. In Germany and Austria, these include 16 organizations and initiatives in the fields of organic plant breeding, seed production and marketing, variety conservation, food retailing and NGOs. In the Philippines, MASIPAG is the practical partner of the project, a network of 35.000 rice grower families, plant breeders, scientists and NGOs. **Figure 1** presents the main steps of the transdisciplinary research process and the methods used for integration of practical and scientific knowledge. In defining relevant key terms and identifying core criteria of Seed Commons, we proceeded as follows.

Defining central terms: A discussion of central terms across disciplines and between science and praxis is essential to develop common ground and avoid misunderstanding in transdisciplinary work. For conceptualizing Seed Commons and explicating its scope, a clear definition of related terms is needed. Accordingly, we identified relevant core terms and examined these against the background of their historical development, their use in different scientific disciplines and political discourses (Kliem & Tschersich 2018). We then discussed the terms seeds and varieties at a moderated project workshop[2] with practical stakeholders and at an international scientific workshop,[3] focusing on aspects with a high degree of controversy and normative content. The resulting definitions are presented in chapter 3.1.

Identifying Seed Commons criteria: To develop Seed Commons as an integrative theoretical framework, we developed a first proposal of Seed Commons criteria based on a literature overview (presented in

[1] RightSeeds is the acronym for the collaborative research project 'Right Seeds? – Commons-based rights on seeds and varieties as a driver for a social-ecological transformation of plant cultivation' (https://www.rightseeds.de/).

[2] *RightSeeds* project workshop "Seeds and Varieties as Common Goods" in Göttingen, 16–17 March 2017.

[3] International Workshop "Conceptualizing the New Commons – the examples of Knowledge Commons & Seed and Variety Commons", in cooperation with the IASC, Oldenburg, 6–8 June 2018.

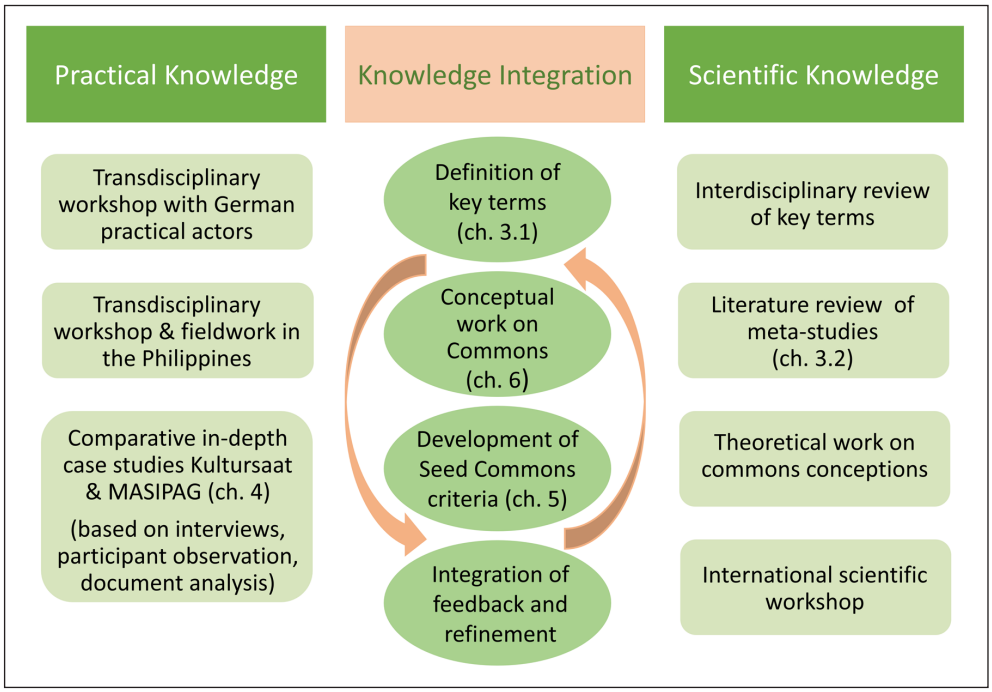

Figure 1: Schematic representation of the iterative, transdisciplinary research process.

chapter 3.2), existing Commons approaches (see chapter 6), and a first analysis of the organizational structures and institutions of the *RightSeeds* practical partners. We discussed and adapted these criteria at the above-mentioned transdisciplinary project workshop, and further refined them at the international scientific workshop. Continuing the iterative research process, we evaluated the criteria in light of the insights from a one-week workshop in the Philippines[4] that allowed for an in-depth exchange between commons-based seed initiatives in Germany and the Philippine organization MASIPAG, specifically on their organizational structures and breeding approaches. Finally, we reconsidered and refined the Seed Commons criteria based on the collected empirical material on the Philippine farmer-led network MASIPAG and the German organic breeding organization Kultursaat e.V. (see chapter 4).

A transdisciplinary research process can produce certain biases, such as through the choice of practical partners. Therefore, we show how the practical partner organizations of *RightSeeds* cover the existing approaches in the field of Seed Commons, and base our derivation of Seed Commons criteria both on the in-depth empirical study of the two organizations Kultursaat e.V. and MASIPAG and the existing literature.

3. Towards Seed Commons

To build an ontological and empirical foundation for conceptualizing Seed Commons, we first define seeds and varieties as the main goods to be governed. The nature, scope and normative content of the two goods are described, reflected upon, and implications for a Seed Commons conceptualization are drawn. Second, we give a literature overview of Seed Commons, identifying the main types of commons in plant breeding, seed production and seed usage.

3.1. Defining Core Terms: Seeds and Varieties[5]

From a biological perspective, **seeds** are defined as seed and fruits that serve as the regenerative organs of a certain species or variety (Freudig 2006). Legally, production, processing and trade of seeds are regulated on the EU level in 12 directives and respective implementations on the national level.[6] Seeds describe material planting resources. This fact is noteworthy, because a complex interrelation exists between the material seed (the reproductive entity of a plant) and its role as the carrier of genetic information applicable

[4] *RightSeeds* workshop between the German and Philippine practical partners in Santa Rosa, Nueva Ecija, Luzon (Philippines), 4–10 February 2019.

[5] This section summarizes and updates the discussion of the two terms from the working paper developed for the *RightSeeds* project (Kliem and Tschersich 2018).

[6] For example, these directives are implemented in the SaatG and the ErhaltungV on the German level.

to the variety (immaterial component) (Halewood 2013). Seeds as material planting resources can be used and modified in several ways. First, they can be planted to grow crops. Second, farmers can collect seeds during harvest and re-sow them in the next planting season (seed saving). Third, seeds can be used to breed new varieties. Seeds can be acquired or disseminated through exchange, gifting and (monetary) trade.

A **variety,** according to the Dictionary of Biology, is a population of cultivated plants that can be clearly distinguished from other populations of the same species based on morphological, physiological, cytological, biochemical and other features (Freudig 2006). These characteristics must be homogenous within the population and must be stable over several generations. Plants of one variety share (almost) the same genetic information, which additionally makes each variety an immaterial resource.

In many countries, including the member states of the EU, new varieties must be filed in a register of plant varieties before they can be used commercially. Variety registration laws emerged with the rise of commercial plant breeding and the modernization of agriculture that required more uniform varieties (Chable et al. 2012). Any new variety must (1) be clearly identifiable by morphological or physiological characteristics and be distinguishable by one or more important characteristics from any other variety, (2) be sufficiently homogenous, and (3) remain stable in its essential characteristics after repeated reproduction or propagation (DUS criteria) (art. 4.1, EC/2002/53 & EC/2002/55). This understanding of 'modern varieties' is also the basis for the grant of intellectual property rights or variety protection in all member states of the International Union for the Protection of New Varieties of Plants (UPOV, art. 6).

The strict criteria of distinctiveness, uniformity and stability (DUS) have been considered problematic for organic breeding and with regard to farmers' rights (Chable et al. 2012; Christinck & Tvedt 2015). Especially the strict interpretation and handling of the uniformity criterion poses difficulties for organic breeders since it limits the possibility for genetically diverse varieties, which is a prerequisite for plants' adaptability to changing environmental and climatic conditions (ibid.). Especially for low input farming (no application of pesticides and mineral fertilizers), a broad selection of genetically diverse varieties is needed for independent variety choice under diverse environmental conditions and as input for breeding varieties that are resistant to pests and diseases (Chable et al. 2012; Döring et al. 2012; Winge 2015).

Moreover, the DUS criteria tend to exclude other types of breeds developed by farmers, including landraces, historic varieties, populations and variety mixtures, which are recognized for their historical value, their essential role in the conservation of cultivated plant diversity and for food sovereignty (Serpolay et al. 2011; Villa et al. 2005). Landraces in particular are often well-adapted to local circumstances or resistant to diseases or pests (ibid.). Moreover, they still play an important role today with regard to yield stability, especially in marginal environments and traditional and subsistence farming systems (Ficiciyan et al. 2018). However, landraces suffer the threat of being replaced by modern varieties, which has already caused widespread genetic erosion (Wattnem 2016; van de Wouw et al. 2009).

The discussion above highlights the connotation of the term 'varieties' with intellectual property rights and its generally limiting legal criteria. Farmers' varieties and heterogeneous material play an essential part in Commons approaches in breeding, seed production and exchange, besides 'new' varieties that are needed by actors operating within the formal seed system. Therefore, the term *varieties* would not be appropriate in conceptualizing Commons approaches in the seed sector. Instead, we use the term 'seeds' to describe the material seed, the genetic information as well as immaterial aspects generally encompassed in the idea of varieties.

3.2. Literature overview on Seed Commons

To derive preliminary criteria for Seed Commons, place the in-depth case studies in the broader literature, and further substantiate the empirical foundation for this research, the literature on commons-based and informal seed systems is analyzed.[7] The intention of this section is not to provide an exhaustive literature review, but rather to provide an overview of the state of the scientific debate on this topic and the types of

[7] For the literature overview, we proceeded in the following way: First, we searched for 'seed commons' or combinations of 'commons' with 'seeds' and 'breeding' on Scopus and Google Scholar. Since this research provided only a limited number of relevant papers, we proceeded by collecting topics and keywords within the discourse of commons-based seed systems, in literature from previous research, and workshops. We grouped the keywords in five preliminary categories for the further search: 'Peasant seeds, conservation & farmers' rights', 'local seed exchange systems'; 'organic farming and breeding', 'crop genetic resource commons' and 'Open Source Seed Systems'. We searched for review papers with different combinations of the respective keywords in SCOPUS from 1990. Keywords with the most results were marked as an indicator of the most important topics in the field. Central review papers and further relevant papers for the respective thematic areas were identified. These papers were examined for key papers in the respective field and potential additional topics. Using the snow-ball system, further relevant papers were identified. All identified papers and citations were scanned for further topics not covered by the preliminary categories.

commons-based seed initiatives that exist and have been assessed. We will identify the main types of Seed Commons, briefly explain what they entail, and point to central papers in the field.

Seed Commons is not yet a common term or concept established in the literature. Nevertheless, the term has gained popularity in recent years. It is associated with a critique of the increasing **commodification and enclosure of seeds and plant genetic resources** for food and agriculture (Aoki 1998; Brandl & Schleissing 2016; Chiarolla 2008; Gelinsky 2012; Howard 2015; Safrin 2004; Timmermann & Robaey 2016), **open source seed systems** (Aoki 2009; Kloppenburg 2014; Kotschi & Horneburg 2018; Montenegro de Wit 2019; Wirz, Kunz & Hurter 2017) or **creative commons licenses** (Deibel 2013; Reyes-García et al. 2018) to protect varieties or landraces and associated knowledge from enclosure, and the global seed commons established by the **multilateral system of the international seed treaty** (Dedeurwaerdere 2012, 2013; Frison 2016; Girard & Frison 2018; Halewood 2013; Halewood et al. 2018; Halewood, López Noriega & Louafi 2013). The term is connected to ex-situ conservation in (international and national) **gene banks**, including those hosted by the Consultative Group on International Agricultural Research (CGIAR), which store genetic resources and seeds under low-temperature conditions, and aim to collect, characterize, document and distribute them (Galluzzi et al. 2016; Tyagi & Agrawal 2015; Westengen et al. 2018). Moreover, the governance of knowledge associated with landraces or genetic material as a Commons is discussed (Calvet-Mir et al. 2018; Frison 2018; Girard 2018; Reyes-García et al. 2018).

Additionally, on the local and regional level, initiatives such as seed sharing and seed saving networks or participatory breeding initiatives are similarly integrating aspects of Commons in their work. While not being explicitly conceptualized as Commons, these initiatives have been at the center of scientific analysis.

(Local) Seed Exchange Networks, most commonly discussed in relation to **informal, traditional or local seed** have received significant attention in the literature (Coomes et al. 2015; Pautasso et al. 2013; Thomas et al. 2011). This includes elaborations on the contribution of these seed networks and informal seed systems to agrobiodiversity, the conservation of plant genetic diversity and resilience (Coomes et al. 2015; Pautasso et al. 2013; Thomas et al. 2011). Moreover, the role of collective action and exchanges in local seed systems (Badstue et al. 2006), food security and food/seed sovereignty (Altieri, Funes-Monzote & Petersen 2012; Kloppenburg 1988; Peschard 2014; de Schutter 2009), and the need for integrated approaches between formal and informal seed systems is assessed (Almekinders and Louwaars 1999; Almekinders, Louwaars & de Bruijn 1994).

Often part of farmers' (informal) seed systems, **Community Seed Banks** are "local, mostly informal institutions whose core function is that of collectively maintaining seeds for local use" (Vernooy et al. 2014: 637) through selection, conservation, exchange and improvement of seeds. Community Seed Banks have diverse scopes, sizes, governance and management models, infrastructure and technical aspects, and fulfil diverse functions such as access to seeds and varieties, conservation, seed and food sovereignty (see Vernooy et al. 2014 for a review of the literature and respective initiatives).

Participatory Plant Breeding (Almekinders, Thiele & Danial 2007; Dawson, Murphy & Jones 2008) is generally understood as collaborations in plant breeding of multiple actors, in particular by scientists and users (Weltzien et al. 2000). There are diverse concepts and versions of participatory plant breeding and related terms, such as Collaborative Plant Breeding (Dawson et al. 2011; Soleri, Smith & Cleveland 2000) and Participatory Crop Improvement (Witcombe et al. 1996), with different institutional contexts, goals and approaches to participation (see Sperling et al. 2001). Most relevant for this paper are farmer-led participatory, often decentralized plant breeding approaches, which are tailored towards the needs of farmers and adapted to local environments (Dawson et al. 2008; McGuire, Manicad & Sperling 1999).

Participatory Plant Breeding is often connected to and discussed in relation to **Organic Breeding and breeding for organic agricultural conditions** (Chable et al. 2014; Dawson et al. 2011, 2008; Desclaux et al. 2012; Desclaux & Nolot 2014). Organic breeding refers to breeding for an organic agriculture that takes place under organic conditions and respects the integrity of the plant (IFOAM 2014). The literature explores principles and values employed in organic breeding, the relevance of organic breeding for organic agriculture under pest and disease stresses and low input conditions, its contributions to agrobiodiversity and resilience, and challenges for organic breeding such as restrictive seed legislations (Braunschweig et al. 2014; Horneburg 2016; Lammerts van Bueren 2010; Lammerts van Bueren et al. 2011; Louwaars 2017; Wilbois et al. 2012).

Initiatives, organizations and networks such as farmer-associations and NGOs have emerged, pursuing explicit objectives of conserving landraces and other plant genetic resources, developing new, adapted (organic) varieties and striving towards food and seed sovereignty by combining aspects of community seed banks, seed-sharing, in-situ conservation and breeding (see Pautasso et al. 2013; Thomas et al. 2011). Osman

and Chable (2009) have provided an inventory of 68 existing initiatives that are involved in breeding and seed multiplication of landraces in 17 European countries. They group these initiatives into the following categories: (1) 'Seed Savers', (2) 'Initiatives to promote in-situ conservation of landraces by farmers', (3) 'Producers of regional varieties'; (4) 'Seed Producers', (5) 'Farmer Breeders', (6) 'Biodynamic breeders of landraces, and old varieties' and (7) 'Supporting institutions' (Osman & Chable 2009; see also Pautasso et al. 2013; Thomas et al. 2011).

The literature overview shows that the term Seed Commons is not yet clearly conceptualized and tends to be used mainly with reference to the global level or open source seed systems. Yet, there is already a significant literature base on the diversity of local and regional initiatives associated with commons approaches in seed production, conservation and plant breeding. A conceptualization is therefore helpful to bring together these diverse strands of discussion.

4. In-depth study of two Seed Commons: Kultursaat e.V. and MASIPAG

The seed initiatives that were involved in this transdisciplinary study cover the main types of commons-based approaches identified by the literature overview presented above. They include organizations which combine aspects of seed sharing and saving with community seed banks from the Global North and the Global South (i.e. Arche Noah in Austria, MASIPAG in the Philippines), seed producers (i.e. Bingenheimer Saatgut AG in Germany), decentral, biodynamic (organic) breeding (Kultursaat e.V. and Saat:gut e.V. in Germany) and farmer-led participatory breeding (MASIPAG). Moreover, members of Agrecol, the German Open-Source Seed initiative, and representatives from the seed-exchange network RegioSaatCoop in Germany were part of the transdisciplinary workshop, where features of Seed Commons were discussed.

In the following, we focus on the network MASIPAG based in the Philippines and the organic breeding initiative Kultursaat from Germany as two in-depth case studies to deduce core features of Seed Commons. MASIPAG is a large rice-farmer-breeder network from the Global South, which combines aspects of community seed banks, seed sharing networks and farmer-led breeding. Kultursaat, on the other hand, is a biodynamic breeding initiative from the Global North that embraces decentral breeding for an organic agriculture and rejects the private enclosure of varieties.

To describe the organizations in detail, extensive data was collected and systematically screened. For Kultursaat, ten qualitative, semi-structured in-depth interviews were carried out in 2018, with breeders and coordinators of the organization. They were complemented by minutes of the association's biannual meetings in 2017 and 2018, where the researchers were present as observing participants, and by Kultursaat's brochures and online representation. For MASIPAG, eight semi-structured in-depth interviews with farmers and staff were carried out during a research stay in February 2019. In addition, daily minutes were taken during a ten-day workshop with the initiative. The data was coded and qualitatively analyzed using the software MaxQDA. The three levels of Commons (the resource, social relations, and institutions) (Helfrich & Bollier 2015) were used as a deductive conceptual starting point and categories were refined inductively in a recursive coding process. The following sections present the results, by describing first Kultursaat and then MASIPAG with a focus on Commons aspects in the organizational structures, the social practices and regarding their value-base.

4.1. Kultursaat e. V.

Kultursaat breeds vegetable, herb and flower varieties for commercial cultivation and hobby gardeners. It is an association of independent breeders, who self-govern their breeding efforts. A guiding principle of the initiative is the conviction that varieties are cultural heritage and common goods that should not be privatized but governed collectively and responsibly (Kultursaat e.V. 2018).

For Kultursaat, the value of cultural heritage encompasses the responsibility for contemporary crop plant biodiversity, farmers' rights to use seed freely and have access to seed knowledge and intergenerational responsibility to maintain future societies' needs for food. In relation to past generations of farmers and breeders, Kultursaat's breeders honor the heritage of plant genetic diversity, which was historically developed by farmers and was openly accessible. Since variety development builds on the outcome of past farmers' work, the breeders see it as their responsibility to preserve crop biodiversity through cultivation (in-situ) and to openly dispense novel varieties. This practice enables current farmers to continue developing crop plants, as they are free to save and breed seeds. Furthermore, Kultursaat's breeders perceive it as the responsibility of the current generation to preserve current biodiversity, in order for future generations to have equal access to healthy varieties, especially in view of climate change. The preservation of biodiversity both entails

diversity amongst plants, as well as within a plant's genome. Kultursaat's values have implications for the breeding process, the legal arrangements and the organizational structure of the initiative:

Kultursaat rejects private property rights on seeds and varieties. No legal variety protection is claimed for new varieties, i.e. the members of the initiative waive any royalties and make their varieties freely available. In Germany, it is obligatory to register any commercially grown variety. Kultursaat hence registers its varieties to its non-profit association rather than to individual breeders or third-party companies. This limits appropriation and ensures that varieties remain common property. So far, Kultursaat's approach has been successful, as the initiative has not faced enclosures of their varieties. However, the increasing number and often unclear scope of patents, being granted on conventionally-bred varieties, presents a potential threat of enclosure.

According to Kultursaat's guiding principles, breeding efforts should not be aimed at profits. The financing of their projects stems from donations, grants, research funding and breeding contributions from multipliers and organic retailers. As income sources such as licenses and replication fees do not apply and the breeding of regionally adapted varieties implies small sales markets, long-term financing of the breeding activities by Kultursaat is challenging. Specifically, cooperation models along the value chain (e.g., investing a certain percentage of retailers' revenues from organic vegetable sales into Seed Commons initiatives) provide a promising approach, but require further investigation.

Kultursaat's breeders deliberately use the traditional breeding techniques of selection and crossbreeding. These result in open pollinated varieties that are reproducible, and thus limit gardeners' and farmers' dependence on seed companies. To not restrict the further use of varieties and to recognize the plants' intrinsic value, breeding methods that in any way limit the reproductive ability or phenotypical stability of the offspring and thus lead to biological variety protection (e.g. F1 hybrids) are rejected. In addition, organic breeding is a norm of the organization. Apart from aligning with their personal beliefs, organic breeding ensures the biological accessibility of seeds for farmers, as the resulting varieties are reproducible and stable. Rather than producing few high-yielding varieties for the global seed market, the members of Kultursaat aim to breed genetically diverse plants that are locally adapted (Kultursaat e.V. 2018).

Kultursaat is organized in a decentralized network structure and the initiative aims to keep flat hierarchies. The association is aware of the importance of a functioning community for their work, which is reinforced by promoting values of trust, transparency, appreciation and respect. Decisions on finances, organizational matters and breeding goals are taken collectively in annual meetings and working groups focused on specific crops. Breeders are often gardeners by profession and all breeding projects take place on-farm, with the aim of taking into consideration growers' knowledge and needs.

The breeding process itself is made transparent to other breeders and consumers. Information on variety development – including methods, selection criteria and parent varieties – is recorded and partially made available to the public. The members of the initiative also share practical knowledge with new breeders through a two-year long course that is free of charge. This introduces newcomers to the techniques of organic breeding and enables direct access to the breeders' network.

4.2. MASIPAG

MASIPAG (Farmer-Scientist Partnership for Development) is a Philippine network of farmers, scientists and non-governmental organizations that promotes small-scale organic farming with the aim of achieving farmer empowerment, leading to food security and seed sovereignty. The network collects and breeds varieties – primarily rice – in a farmer-led approach (Medina 2011). Since its founding in 1985, MASIPAG has worked with over 30.000 farmers in more than 60 Filipino provinces who have collected and bred over 2.000 rice varieties. Their aim is to preserve and develop varieties, which are specifically adopted to organic farming systems and regional environmental conditions, in order to support local food security and contribute to the long-term conservation of agrobiodiversity. To employ a necessary minimum of coordinating staff, MASIPAG is financially supported by European non-governmental organizations.

The network is characterized by a bottom-up approach of decentralized governance. Groups of 10–50 farmers – so called People's Organizations (POs) – form the basic governance structure. Currently there are over 500 different POs. They are financially and organizationally independent but are encouraged to adopt democratic decision-making structures. Representatives of each PO organize in Provincial Consultative Bodies (PBCs) which coordinate provincial activities and trainings, monitor progress and serve as conflict resolution bodies. On the regional and national level, annual assemblies are the highest decision-making bodies and decide on strategic matters and programming. Regional management teams and a national

executive committee coordinate the activities of the different governance levels. In addition, thematic committees (e.g. on sustainable agriculture or climate change resilience) on provincial and regional levels provide technical expertise. In all committees and decision-making bodies, farmers outnumber scientists and MASIPAG staff, to ensure a farmer-centered approach. The strong focus on farmers' decision-making capacity is based on the belief that responsibility, transparency and self-organization are prerequisites for farmers' independence and empowerment.

Knowledge exchange and farmer-training are at the core of MASIPAG's activities. All POs undergo basic trainings in organic agriculture including soil fertility management, alternative pest management and diversified farming. They also learn about MASIPAG's farmer-scientist approach, which teaches farmers responsibility for their own knowledge collection and knowledge production as part of farmer empowerment. Once a PO has been successfully established, farmers can request optional, more advanced trainings, for example on breeding, marketing and business planning or climate change resilience. Trainings are carried out by other MASIPAG farmers (farmer-trainers), who have been trained to pass on their knowledge and experience. In addition, MASIPAGs 'Farmer Developed and Adapted Technologies' program, aims at documenting and proliferating knowledge and innovations throughout the network. Upon establishment, all POs are supported to set up a trial farm on which they test which varieties are especially suited for their regional climatic and environmental conditions. This ensures the use of diverse varieties and equips farmers with the experience and knowledge of selecting locally adopted varieties. Beyond practical aspects of seed provision, trial farms serve to create farmer communities, as farmers have to jointly organize variety assessment and selection. Over time, these communities are reported to strengthen and support each other additionally, for example by providing workforce through a practice called 'Bayanihan' or simply collective work in the adoption of organic farming practices.

National and regional back-up farms continuously plant over 2000 rice varieties to ensure their long-term availability, including for future generations, and provide breeding material for new varieties. All varieties are planted and characterized at least every three years (in-situ conservation), to ensure their quality and vitality. The back-up farms also supply each newly developed trial-farm with a random selection of 50 different varieties. Established POs are supplied with additional varieties every couple of years or upon request, to support their process of diversification. At the same time, the PO's trial farms continuously test these varieties for local suitability and climate change resilience and report to the back-up farms.

The network strictly rejects patents and any other form of private property rights on seeds. Seeds are considered sacred, and are exchanged and shared freely within the network. Seed exchanges are a central activity at meetings from local to national scales and are regarded as a defining cultural practice. Over three-quarters of MASIPAG farmers engage in seed exchange practices (c.f. Bachmann, Cruzada & Wright 2009). Seeds are also shared with non-MASIPAG farmers, once they have been informed about MASIPAG's core values of sacred seed and organic agriculture, and regarding knowledge on seed saving. Commercialization of seeds is not tolerated, and there is no financial compensation for farmers engaging in breeding efforts. Breeding and seed production are thus not a source for farmers' income generation. However, replacing costly hybrid or certified seeds with farmer-saved seeds and synthetic fertilizers and chemical pesticides with low- to no cost organic fertilizers and natural pest management, allows MASIPAG farmers to substantially reduce their input costs (c.f. Velasco 2019).

Breeding of new varieties used to be carried out by associated scientists at the national back-up farm under farmers' participation, but is now entirely farmer-led. The network works with approximately 600 traditional varieties, 1300 MASIPAG varieties (bred at the back-up farm) and 500 farmer-bred varieties. Farmer-breeders exchange experiences and techniques at periodic regional and national breeder forums. All MASIPAG and farmer-led varieties are open-pollinated and bred through bulk selection method (Medina 2011). The network strictly rejects genetically modified and hybrid varieties, and engages in political activities to lobby against genetic modification of plants. Varieties bred by MASIPAG members belong to the network as a whole and are collectively managed, but breeders' initials are included in the variety name to recognize breeders' work. MASIPAG and farmer-led varieties are not officially registered with the Filipino National Seed Industry Council or the Filipino Community Seed Registry, out of fear of appropriation by organizations with commercial interest and in order to provide an alternative to the existing system. The network keeps control over its varieties, but freely shares them – under the premise that variety names are kept the same – with anyone supporting their basic principles related to organic agriculture, seed handling and farmers' rights. While so far, MASIPAG has not faced enclosures, its de-facto protection of seeds does not provide a legal protection from enclosure through intellectual property rights, such as variety protection and patents.

5. Core criteria of Seed Commons

From the literature overview of core topics and types of Seed Commons, the empirical in-depth case studies of Kultursaat and MASIPAG, and the discussion of preliminary results at various workshops, we derive and discuss four core criteria that characterize diverse Seed Commons arrangements at local and regional scales (see **Table 1** and **Figure 2**). These are: (1) collective responsibility, (2) protection from private enclosure, (3) collective, polycentric management, and (4) sharing of formal and practical knowledge.

(1) Collective responsibility

The first criterion of Seed Commons refers to the responsibility for the protection, provision and development of seeds and crop diversity at the plant species and genetic level. On the individual level, this entails farmers' and breeders' rights to use, multiply and develop seeds freely. Behind this premise lies the idea that the best protection of agrobiodiversity is its decentralized use. Collectively, this criterion encompasses in-situ conservation of crop biodiversity and the development of locally adapted varieties that promote diversity and resilient, ecologically sustainable food systems.

The collective responsibility to conserve and develop plant genetic diversity as a common concern of humankind is central in a number of international treaties (Dedeurwaerdere 2013; Frison 2016; Halewood 2013). At the local and regional scale, the literature highlights the contribution of seed exchange networks, informal seed systems, community seed banks and organic agriculture to the conservation of plant genetic diversity and resilience (Coomes et al. 2015; Pautasso et al. 2013; Thomas et al. 2011; Vernooy et al. 2014).

In the two case studies, collective responsibility is explicated as part of the mission statement and goals of the initiatives. Further, it becomes evident in the personal motivations of the participating farmers and breeders. Collective responsibility for seeds and plant genetic diversity is derived from the intrinsic value of seeds and varieties regarded as sacred and cultural goods. In addition, the initiatives place their commitment in the context of larger objectives of social-ecological sustainability (supporting rural livelihoods in the case of MASIPAG, promoting organic agriculture in the case of Kultursaat) and intergenerational justice (such as, improving resilience in the face of climate change). The responsibility for maintaining crop genetic diversity is realized in MASIPAG's network of national and regional back-up farms and local trial farms for preserving rice varieties as well as in the maintenance of conservation vegetable varieties by Kultursaat.

The collective responsibility for preserving crop diversity has implications for the protection mechanisms, breeding process, organizational structure and knowledge management of Seed Commons arrangements, which are described by the three further Seed Commons criteria.

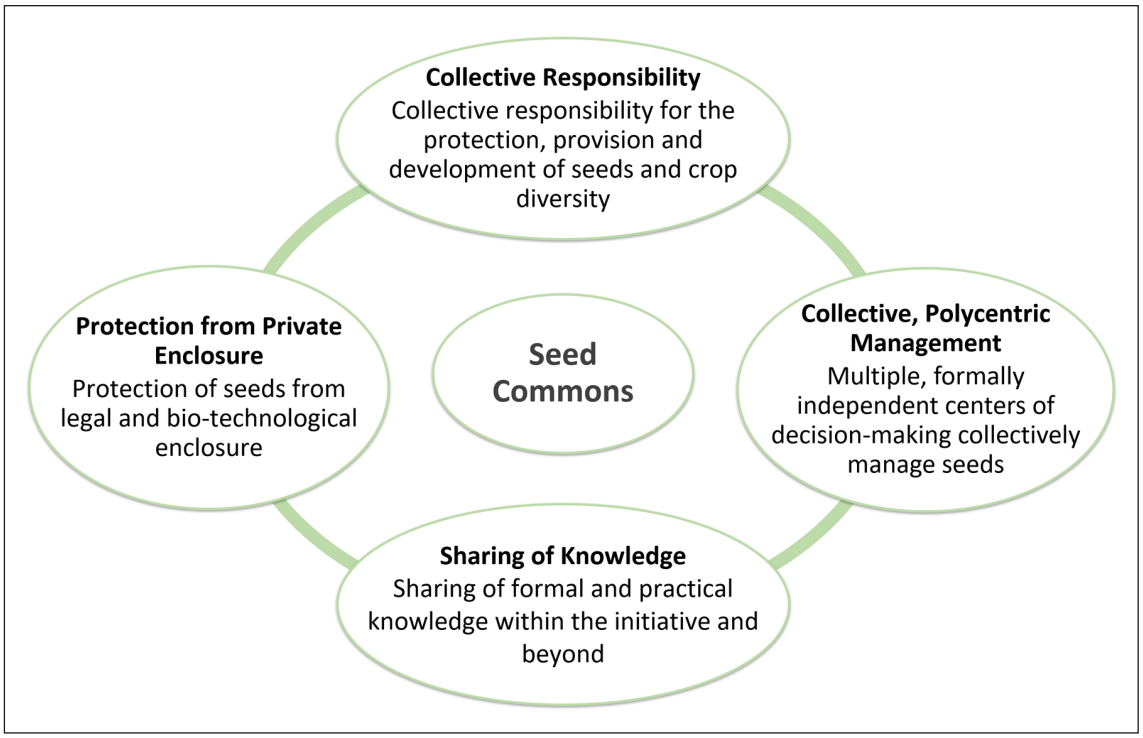

Figure 2: Core criteria of Seed Commons (own elaboration).

Table 1: Illustration of Seed Commons criteria with case studies and wider literature (own elaboration).

Seed Commons Criteria	Illustration with MASIPAG & Kultursaat	Illustration with wider literature
Collective Responsibility	· Recognition of the intrinsic value of seeds, regarded as sacred and cultural goods · Commitment to social-ecological objectives (conservation of genetic diversity, development of varieties for organic agriculture)	· Collective responsibility to conserve and develop plant genetic diversity recognized in international treaties (Dedeurwaerdere, 2013; Frison, 2016; Halewood, 2013) · contribution of seed exchange networks, community seed banks and organic agriculture to the conservation of plant genetic diversity and resilience (Coomes et al., 2015; Pautasso et al., 2013; Thomas et al., 2011)
Protection from Private Enclosure	· Rejection of the use of patents and variety protection as means of legal enclosure · Rejection of biotechnological breeding approaches not (easily) understood, used or controlled by farmers (such as GMOs and Hybrid F1)	· Critique of private enclosure and commodification of seeds and genetic resources (Aoki, 1998; Brandt & Schleissing, 2016; Chiarolla, 2008) · Open source seed models (Kloppenburg, 2014; Kotschi & Horneburg, 2018; Montenegro de Wit, 2019).
Collective, polycentric management	· Collective decision-making on common values and overall objectives/strategy of the initiatives · Multiple, independent levels of decision-making on specific breeding goals and operational matters · Collective breeding/adaptation at multiple locations & seed exchanges	· Collective management of seeds in community seed banks and seed exchange networks (Coomes et al., 2015; Pautasso et al., 2013) · Farmer-led, decentral participatory breeding approaches (Dawson et al., 2008; McGuire et al., 1999)
Sharing of knowledge	· Both formal and practical kowledge on the characteristics, breeding and cultivation of seeds are shared within the community and beyond	· Emphasis of the central role of formal and practical knowledge in seed exchange networks (Pautasso et al., 2013; Reyes-Garcia, et al., 2019) and community seed banks (Vernooy 2014)

(2) Protection from private enclosure

The second criterion entails the protection of seeds from private enclosure both today and in the future. It is an answer to legal and bio-technological enclosures, such as private intellectual property rights (variety protection and patents) and the increasing use of seeds with bio-technological restrictions of reproducibility or stability. Both aspects are important to guarantee the access of farmers and breeders to seeds and related knowledge that is essential for their proper use. Seed Commons therefore refrain from legal variety protection and work with stable and reproducible seeds.

A critique of private enclosure of seeds and genetic resources, and the commodification of nature in general, is a central feature of discussions related to Seed Commons in the wider literature (Aoki 1998; Brandl & Schleissing 2016; Chiarolla 2008). In this context, open source seed models and Creative Commons licenses are discussed as potential instruments to protect seeds from future enclosure (Deibel 2013; Kloppenburg 2014; Kotschi & Horneburg 2018; Montenegro de Wit 2019; Reyes-García et al. 2018).

Protection from private enclosure is strongly visible in the two case studies described above. Both initiatives reject the use of variety protection or patents as a means to exclude other people from the use of seeds. Nevertheless, the precise ways to do so differ: Kultursaat protects its varieties from enclosure by registering them officially with the Federal Office of Plant Varieties in the name of its non-profit association. This registration is legally required in Germany in order to market seeds. The link to the non-profit organization guarantees that breeding goals are not directed towards profit, but instead towards common welfare. MASIPAG does not officially register its varieties and refrains from the commercial use and a generation of profit from breeding and seed production.

Both Kultursaat and MASIPAG also avoid the use of biotechnological breeding approaches that could limit the access to seeds and their reproduction, since they cannot be (easily) understood, used and controlled by farmers (such as GMOs and Hybrid F1). Consequently, the initiatives focus on the breeding of open-pollinated seeds or work with dynamic populations and heterogeneous material. The protection from private enclosure contributes to (food) sovereignty, which is an important value and goal of MASIPAG, and reflects the importance of seeds for human life and dignity emphasized by both initiatives.

The literature and the two cases show that there are different approaches to protect seeds from enclosure, ranging for instance from copyleft licenses to listing in official registers. MASIPAG and Kultursaat have not yet faced issues with enclosure of their seeds by companies, but a potential threat, in particular through patents, remains. Similarly, the shift away from a license-approach to a pledge of the Open Source Seed Initiative in the USA points to some core challenges and contradictions associated with copy-left licenses on seeds, especially issues with designing a legally defensible license suitable for seed packaging, and moral and practical concerns of seed practioners.[8] A more detailed reflection and consequent refinement regarding the strengths and weaknesses of different approaches for protecting seeds from enclosure is needed.

(3) Collective, polycentric management

The third criterion highlights the collective, polycentric management of seeds. We understand Polycentricity as governance of multiple, interdependent but formally independent centers of decision-making (Ostrom 2010; Ostrom, Tiebout & Warren 1961). Collective, polycentric management entails collectively devised rules, norms, and shared practices for the management of seeds, combined with independent polycentric operation and decision-making structures. While key goals and values are agreed upon collectively at the communal level, decentral sub-structures hold independent decision-making power in many operational aspects. In this way, regionally adapted breeding and (in-situ) conservation of seeds becomes possible. Moreover, the sharing of seeds between the organizational entities is an important practice in Seed Commons.

The criterion of collective, polycentric management is easily recognizable in most of the research in the context of local commons-based seed initiatives. Both community seed banks (Coomes et al. 2015) and local seed exchange networks (Coomes et al. 2015; Pautasso et al. 2013) pursue collective management, maintenance and exchange of seeds for local use, often within a wider polycentric network to ensure ongoing in-situ conservation and adaptation. Similarly, farmer-led participatory breeding approaches support regionally-adapted breeding (Dawson et al. 2008; McGuire et al. 1999). As described above, these approaches have been recognized for their contribution to social-ecological sustainability and food sovereignty (Altieri et al. 2012; Kloppenburg 1988; Peschard 2014; de Schutter 2009).

Collective, polycentric management is an essential feature of Kultursaat and MASIPAG. Both initiatives take central decisions regarding strategic or organizational matters, breeding goals and financing in collective annual assemblies. At the same time, they have multiple organizational levels that allow for autonomous decision-making and an adapted development of seeds. For MASIPAG, the organizationally and financially independent POs, which are coordinated through Provincial Consultative Bodies, as well as regional and national assemblies, are central in this regard. For Kultursaat, the decentralized network structure and the relative independence of breeders developing varieties on-farm in multiple breeding locations similarly allows for regional adaptation. In both cases, the organizational structure and decentral breeding efforts are intended to support a re-democratization.

(4) Sharing of formal and practical knowledge

This forth criterion points to the importance of knowledge governance in Seed Commons. It encompasses both the sharing of formal knowledge with regard to all steps of the breeding and cultivation process (transparency on parental generations, breeding methods and variety characteristics) and the sharing of practical knowledge, specifically practical skills in breeding, seed multiplication and plant cultivation. Providing practical skills and formal breeding knowledge in combination with access to the biophysical seeds strengthens the sovereignty of farmers regarding seed production (Sievers-Glotzbach et al., forthcoming).

[8] See Montenegro de Wit (2019) for a more detailed discussion of challenges associated with the Open Source Seed initiative in the USA.

The literature emphasizes the role of seed exchange networks for knowledge transmission, in particular with regard to practical knowledge (Pautasso et al., 2013; Reyes-Garcia, et al. 2019). Community seed banks are an additional way, in which Seed Commons contribute to the transmission of formal agricultural biodiversity knowledge (Vernooy 2014).

Sharing formal knowledge is a core element in both Kultursaat's and MASIPAG's work. However, they differ regarding their interaction with external actors: Kultursaat documents and publicly discloses information on newly developed varieties (including breeding methods, selection criteria, and parent varieties), thereby making this knowledge accessible to a global user community. In contrast, MASIPAG does not register its rice varieties to protect both the knowledge and the material from enclosure by the formal seed system. Consequently, MASIPAG shares the breeding knowledge and variety characteristics only within its network, through formal and informal practices of seed sharing, and with farmers outside of the community that commit to MASIPAG's values. This indicates the high relevance of Traditional Agroecological Knowledge[9] in MASIPAG's work, as knowledge is tightly entangled with certain beliefs and worldviews.

Both organizations offer practical trainings free of charge, thereby sharing practical skills in plant breeding and cultivation, specifically by training young breeders in biodynamic (organic) vegetable breeding (Kultursaat), and peasant farmers in organic agricultural practices, breeding, marketing and climate change resilience (MASIPAG). Further, both initiatives include farmers' practical knowledge (e.g., regarding local environmental conditions and plant traits) in the breeding process, following approaches of participatory plant breeding (Almekinders et al. 2007; Dawson et al. 2008).

6. Seed Commons from a conceptual perspective

After deriving four core criteria of Seed Commons primarily from in-depth empirical case studies, the following section will reflect on how Seed Commons transcend the existing conceptual categories in the Commons discourse. We do so by integrating features of Traditional Commons, New Commons (specifically, Knowledge Commons and Global Commons), and Commoning.

6.1. Characteristics of Seed Commons from a traditional commons perspective

Traditional commons scholarship has focused on the collective management of natural resource systems, where it is possible, but costly to exclude potential beneficiaries (low excludability), and the use of the resource decreases its availability for other users (high substractability) (Ostrom 1990, 2005). A common-property regime, meaning collectively defined rules, norms and institutions regulating the joint preservation, maintenance and consumption of such common-pool resources, is needed to avoid an over-use and degradation of the resource system (Ostrom 1990, 2005).

Aspects of traditional commons are most strongly reflected in the criterion of 'collective, polycentric management'. It describes the importance of collectively designing rules and norms for the common management of seeds, a feature that discussions on common-property regimes highlight. In farmer-based seed exchange networks and community seed banks, the respective resource system refers to the existing pool of varieties[10] present in (more or less specific) regional boundaries, used and shared among an identifiable group of farmers. Many Commons scholars have also highlighted the importance of polycentricity for an effective and sustainable management of Commons, which is important for decentral, participatory and regionally-adapted breeding approaches (Andersson & Ostrom 2008; Ostrom 2005, 2010; Thiel 2017).

When regarded through a traditional Commons lens, a specific seed is the respective resource unit that individual farmers can appropriate and use for cultivation on their own fields. Seeds and varieties are inherently linked, with a seed being the biophysical carrier material of the genetic code and hereditary function of a variety (Halewood 2013). The common-property regime in this context refers to the institutional, often informal rules that regulate the exchange and maintenance of varieties. Subtractability is an issue only if rules fail, because if farmers take seeds from the common pool without sharing their seed harvest, the resource system degrades. Excludability is somewhat limited, since varieties can be reproduced easily. For example, for vegetables, seeds can be extracted from the fruits. For crops, seeds are identical with

[9] Hereby, we follow the definition by Calvet-Mir (2018, 3214) that Traditional Agroecological Knowledge (TAeK) "refers to the cumulative and evolving body of knowledge, practices, beliefs, institutions, and worldviews about the relationships between a society or cultural group and their agroecosystems". Therewith, TAeK also includes practices, knowledge and beliefs on the handling of seeds.

[10] In this chapter, the term varieties is used in its biological sense to highlight the genetic and immaterial aspects of a specific population of cultivated plants with similar characteristics, not the legal understanding of varieties following the DUS criteria.

the harvest. Nevertheless, the advantages of receiving seeds with information on the varieties and their cultivation in a direct exchange can be an incentive to engage in systems of direct seed exchanges.

Seeds and varieties have material components (the seeds), cultural aspects (the past and present contribution of humans to breeding) and informational aspects (DNA sequences, knowledge regarding breeding and cultivation), which are strongly interdependent (Dedeurwaerdere 2013; Frison 2018; Halewood 2013). Due to these diverse features, the sustainable management of seeds faces particular challenges, which are different from traditional Commons. In contrast to most natural resources, varieties are generally considered to be non-subtractable (Halewood 2013). Use of the resource (on-farm cultivation and selection) leads to adaptation of varieties to local conditions and individual preferences, and thereby, as long as a small part of the resulting seed harvest is shared, to a maintenance and improvement of the variety pool. As most varieties are adapted to particular environmental conditions or human needs, they depend on human involvement. Therefore, they tend to degrade and disappear when they are not actively managed and cultivated by humans (Fowler & Mooney 1990; Wilkes 1988). The resulting fundamental collective action problem hence shifts from over-use to under-provision, a classical feature of New Commons.

6.2. New Commons: Knowledge Commons and Global Commons aspects of Seed Commons

With the application of Commons approaches beyond regionally-based natural resources to new fields such as global goods (i.e. the High Seas), digital goods (i.e. Wikipedia), knowledge and cultural goods (i.e. education, music), the concept of New Commons was coined (Hess 2000, 2008). In this literature, Commons are described as organizing principles that allow for the collective creation and sustainable management of resources through (more or less) defined user communities (ibid.). Commons are not given as such, but are actively created (Helfrich 2012; Hess 2008).

Global Commons are a specific type of New Commons in international, supranational, and global resource domains, such as the atmosphere and the deep sea (Joyner 2001; Mudiwa 2002; Soroos 2001). Varieties as expressions and carriers of biodiversity have been described as a Global Commons in the scientific literature (Dedeurwaerdere 2013; Halewood 2013). Similarly, actors of local Seed Commons initiatives often perceive seeds and biodiversity as a Global Commons, for which responsibility should be taken both at the local and global level. This is reflected in the Seed Commons criterion of 'collective responsibility'.

For New Commons, in particular Cultural and Knowledge Commons, the process of creation gains importance besides the management of the resource. Knowledge Commons refer to the "institutionalized community governance of the sharing and, in some cases, creation, of information, science, knowledge, data, and other types of intellectual and cultural resources" (Frischmann et al. 2014: 3). The conservation and further development of the resource pool (breeding of improved varieties and reproduction of high quality seeds) can be costly and time intensive, especially in the case of rare varieties, or those where reproduction is effortful. The concept of Knowledge Commons can help to better understand participatory breeding efforts in Seed Commons (Sievers-Glotzbach et al., forthcoming). Knowledge and information are present in all steps of breeding and the management of varieties, though being highly interlinked with the material counterparts in the genetic codes of the varieties. Accordingly, 'collective, polycentric management' in Seed Commons is always connected to the sharing of knowledge. An analytical differentiation between the processes of creation and management can be helpful, though both processes are highly interlinked (Wolter & Sievers-Glotzbach, 2019). Within a polycentric breeding community, the sharing of knowledge is essential for optimal breeding results. This includes transparency both on the breeding process (genetic information, parental lines, breeding methods and process) and the characteristics of the varieties themselves (variety characteristics, cultivation requirements). Regarding the management of resulting varieties as commons, sufficient information is needed to allow the full use of varieties in cultivation and future breeding efforts.

Knowledge, which has been shown above to be an integral part of the breeding and management of seeds, has similarly been described as a Global Commons (Hess & Ostrom 2007). Especially when varieties and related knowledge are shared with a potentially global user community, as in the case of Kultursaat, breeding and conservation efforts contribute to the maintenance and improvement of Global Commons, such as agrobiodiversity (Dedeurwaerdere 2013; Halewood 2013). While seeds can potentially also be managed as Global Commons, the criteria developed here are intended to characterize local Seed Commons initiatives. For an application on global Seed Commons, the criteria would need to be reviewed and adapted to the global scale.

6.3. Characteristics of Commoning: Seed Commons as a social practice

Rather than focusing on specific attributes of goods and property rights regimes, the conceptualization of commons as self-organized and needs-oriented social processes of 'Commoning' highlights the centrality of social functions, including democratic participation and autonomy (Euler 2018; Müller 2012; Vivero-Pol 2017). Relationships and values within Commons communities are assessed regarding their transformative potential, as they protest existing institutions by creating living alternatives (Sato & Soto Alarcón 2019; Tummers & MacGregor 2019). Food Commons in particular have been described as a counter-hegemonic movement against neoliberalist tendencies of commodification and enclosure (Vivero-Pol et al. 2018).

The proposed Seed Commons criteria shift the focus from the management of the resource to the social processes of community building and the creation of viable alternatives to conventional seed markets. The empirical studies of MASIPAG und Kultursaat show active processes of Commoning, i. e. of creating communities that allow for the long-term, sustainable management of seeds and varieties aimed at important social functions such as empowerment, self-determination of farmers, and food sovereignty. 'Protection from private enclosure' is an active response to the increasing privatization and commodification of seeds. 'Collective, polycentric management' provides farmers' and breeding communities with autonomy to develop solutions adapted to their specific needs. Finally, 'sharing of knowledge' largely depends on local social mechanisms of knowledge transmission and social learning, especially concerning Traditional Agroecological Knowledge (Sievers-Glotzbach et al., forthcoming). Taken together, the Seed Commons criteria can be understood as social practices of Commoning, which challenge dominant paradigms of individual property and technological innovation (see Vivero-Pol et al. 2018). As of now, their transformative impact is still limited, but the building of robustness, the strengthening of networks and on-going advocacy for the change of policies could enhance their transformative potential (see Sievers-Glotzbach & Tschersich, 2019).

7. Conclusion

Based on terminological work, a literature overview, the empirical in-depth study of two organizations from the Philippines and Germany, and discussions with societal stakeholders and the scientific community, we have identified four core criteria that characterize diverse Seed Commons arrangements at local and regional scales: (1) collective responsibility, (2) protection from private enclosure, (3) collective, polycentric management, and (4) sharing of formal and practical knowledge.

Discussing these Seed Commons criteria in the context of different commons approaches, we found that Seed Commons transcend the distinction between traditional (natural resource) Commons and New Commons approaches. The complex nature of seeds and varieties, consisting of biophysical, informational and cultural elements, implies that their collective governance needs to consider aspects of different commons categories. Traditional commons aspects are reflected in the Seed Commons criterion of collective, polycentric management, and in types of Seed Commons that focus on the use, maintenance and exchange of seeds. Practically, access to the biophysical seed needs to be connected to the sharing of associated knowledge to provide the basis for purposive seed activities. Perhaps of even greater importance, Seed Commons initiatives normatively place their activities in the context of resisting attempts to enclosure and preserving agrobiodiversity as a Global Commons. Hence, reaching beyond resource characteristics, the Seed Commons criteria reflect practices of Commoning, which aim to fulfill social functions such as farmer empowerment and food sovereignty. To advance the thorough analysis of such 'Hybrid Commons', a review of existing analytical frameworks for diverse Commons categories or understandings in light of their potential for integration or mutual enrichment is needed, taking into consideration their different assumptions and epistemological foundations.

The identification of Seed Commons criteria and the conceptual classification of Seed Commons is the result of mutual learning processes among researchers from different disciplines and stakeholders from outside academia. The practical partners involved in the *RightSeeds* project cover the main existing approaches in the field of Seed Commons. Moreover, the two organizations Kultursaat and MASIPAG, chosen for the in-depth empirical study, integrate elements from most types of Seed Commons. Therefore, the Seed Commons conceptualization can be claimed to be robust and transferable to both the scientific debate and societal practices (Lang et al. 2012). A further strength of this transdisciplinary approach is that organic breeding organizations have been included as a type of Seed Commons not often addressed in previous empirical studies. Nevertheless, as in any qualitative study, there is a bias because of the necessity to select specific cases. Therefore, an application of the developed criteria to other initiatives, for instance in other regions, and their subsequent review and refinement, is needed. The criteria developed to characterize local

Seed Commons initiatives are, in principle, also relevant for global Seed Commons. An in-depth reflection will be required to assess and adapt the developed criteria to the global scale.

The Seed Commons criteria point to general sustainability potentials and governance challenges, which can help to highlight the importance of Seed Commons initiatives for achieving core sustainability objectives, and to address systemic barriers that impede their upscaling. The protection of seeds from private enclosure guarantees farmers access to seeds, and the sharing of practical skills and formal breeding knowledge provides associated knowledge, thereby strengthening core elements of food sovereignty. Moreover, expressing and practically taking responsibility for the protection, provision and development of crop diversity, combined with the collective governance and development of seeds in polycentric structures, suggests that social-ecological resilience in agricultural systems is supported. Further empirical research is needed to assess the social-ecological effects of Seed Commons. Many Seed Commons initiatives are confronted with similar practical challenges: Existing instruments that aim to secure the protection of newly developed varieties from private enclosure, such as registration on non-commercial organizations and the use of open source licenses or pledges, still have to be evaluated regarding their effectiveness. Moreover, additional instruments need to be developed. A further challenge is the long-term financing of the Seed Commons organizations, especially with regard to breeding activities. Because of the rejection of private property rights, income sources such as license and replication fees do not apply. Regionally adapted varieties, a result of polycentric, decentral breeding structures, go along with small sales markets, posing further financing challenges.

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Competing Interests

The authors have no competing interests to declare.

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