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Article

Crop Diversity Management System Commons: Revisiting the Role of Genebanks in the Network of Crop Diversity Actors

Sélim Louafi ^{1,2,*}, Mathieu Thomas ^{1,2}, Elsa T. Berthet ^{3,4,5}, Flora Pélissier ^{1,2}, Killian Vaing ^{1,2},
Frédérique Jankowski ^{6,7}, Didier Bazile ^{6,7}, Jean-Louis Pham ⁸ and Morgane Leclercq ^{1,2,9}

- ¹ Agricultural Research Centre for International Development (CIRAD), UMR Genetic Improvement and Adaptation of Plants Institut (AGAP), 34398 Montpellier, France; mathieu.thomas@cirad.fr (M.T.); pelissierflora@gmail.com (F.P.); killian.vaing@hotmail.fr (K.V.); morgane.leclercq.1@ulaval.ca (M.L.)
- ² AGAP Institut, Université de Montpellier, The French Agricultural Research Centre for International Development (CIRAD), Institut National de la Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE), Institut Agro, 34398 Montpellier, France
- ³ UMR SADAPT, Université Paris-Saclay, INRAE, AgroParisTech, 75231 Paris, France; Elsa.Berthet@inrae.fr
- ⁴ USC 1339, Centre d'Études Biologiques de Chizé, INRAE, 79360 Villiers-en-Bois, France
- ⁵ UMR 7372 Centre d'Études Biologiques de Chizé, Centre National de la Recherche Scientifique & Université de La Rochelle, 79360 Beauvoir-sur-Niort, France
- ⁶ CIRAD, UMR Savoirs, Environnement et Sociétés (SENS), 34398 Montpellier, France; frederique.jankowski@cirad.fr (F.J.); didier.bazile@cirad.fr (D.B.)
- ⁷ SENS, CIRAD, IRD, Université Paul Valéry Montpellier 3, Univ Montpellier, 34199 Montpellier, France
- ⁸ Diversity—Adaptation—Plant Development (DIADE), University of Montpellier, French National Research Institute for Sustainable Development (IRD), 34000 Montpellier, France; pham@ird.fr
- ⁹ Faculté de Droit, Université Laval, Québec, QC G1V 0A6, Canada
- * Correspondence: selim.louafi@cirad.fr



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Abstract: This paper rethinks the governance of genebanks in a social and political context that has significantly evolved since their establishment. The theoretical basis for the paper is the commons conceptual framework in relation to both seed and plant genetic resources. This framework is applied to question the current policy ecosystem of genetic research and breeding and explore different collective governance models. The concept of crop diversity management system (CDMS) commons is proposed as the new foundation for a more holistic and inclusive framework for crop diversity management, that covers a broad range of concerns and requires different actors. The paper presents a multi-stakeholder process established within the context of the two recent projects CoEx and Dynaversity, imagining possible collective arrangements to overcome existing deadlocks, foster collective learning, and design collaborative relationships among genebanks, researchers, and farmers' civil society organizations involved in crop diversity management.

Keywords: crop diversity; plant genetic resources; seed commons; global commons; Third Place; genebank; seed policy; governance; Social Ecological System (SES)

1. Introduction

One of the fundamental characteristics of subsistence seed systems is the multi-functionality of farmers in seed management. Farmers are multipliers, breeders, producers, and conservators, and are the main architects of the evolution of crop diversity in agricultural landscapes [1]. The modernization of agriculture from the end of the 19th century until the Green Revolution in the middle of the 20th century has gradually led to a specialization of tasks. With the birth of the professions of breeder, genebank manager, and seed multiplier, the farmers' role has been restricted to agricultural production [2].

This segmentation of tasks has accompanied the development of highly selective breeding methods, one component of modern industrial agriculture that relies on intensive, high-input production systems. While it generated important productivity growth in many

areas of the world, this trend has also raised concerns about the risk of genetic erosion as a result of the replacement of diverse traditional varieties with homogeneous, certified varieties [3–7].

Following various discussions and initiatives that have mainly taken place under the umbrella of the Food and Agricultural Organization of the UN (FAO) in the 60s, the Consultative Group on International Agricultural Research (CGIAR) was established in 1971 under the auspices of the World Bank, with the support of US foundations and donor countries. It initially consisted of a global network of genebanks that would collect and conserve the maximum diversity available for a specific category of crops, considered as essential for food security [5].

At that time, this institutional and operational response was considered as the most efficient to respond to the potential loss of genetic diversity as well as the need to make such diversity available to breeders of new high-yielding varieties under the Green Revolution. (*"The subcommittee recommended the establishment of an international Board for Plant Genetic Resources to support and coordinate the creation of a network of plant genes collections. The program was designed to help conserve characteristics which might be of value in breeding plants with higher yields, better food value or greater resistance to pests and diseases. To the extent possible, the Board would utilize existing international, regional and national research institutes for the establishment, maintenance and utilization of the necessary genetic resource collections."* ([8], p. 3)) Although this solution has secured the long-term conservation of (some) crop diversity and stimulated the deployment of such diversity in research and breeding programs, it has also generated scientific and political tensions over the legal status of the collections established by the CGIAR, ultimately questioning the benefits of this *ex situ* approach for farmers of the Global South. (During the FAO Council in November 1979, a request initially made by Mexico and supported by the majority of Developing Countries was made to the Director General of the FAO to carry out two studies: the first aimed at providing the elements to reach an agreement between governments rather than between scientific institutions to guarantee free access to plant genetic resources for food and agriculture (PGRFA), and the second aimed at studying the possibility of creating an alternative international bank of PGRFA under the aegis of the FAO. Despite violent criticisms from some developed countries, this request was taken up by resolution 6/81 of the 21st FAO Council in 1981, which formally initiated a political negotiation process for the establishment of a framework for PGRFA conservation, use, and exchange. This process resulted, at the 22nd FAO Council in November 1983, in the establishment of an International Undertaking, which provided for the creation of an intergovernmental Commission on plant genetic resources to monitor its implementation [4,5,9]).

Global policy discussions around these themes took place under the umbrella of FAO, which led to the creation of the Commission on Genetic Resources for Food and Agriculture (CGRFA), in 1983, and to the *Agreement to place CGIAR Center In-Trust Collections under the Auspices of FAO*, in 1994, and culminated with the establishment of the *International Treaty on Plant Genetic Resources for Food and Agriculture*, in 2002. The operation of genebanks has also been impacted by access and benefit-sharing under the *Convention on Biological Diversity* and its *Nagoya Protocol* as well as by international agreements on intellectual property rights (Trade-Related Aspects on Intellectual Property Agreement, International Union for the Protection of New Varieties of Plants).

In parallel to these formal legal evolutions, a number of technical standards, codes of conducts, and procedures developed by the CGRFA and/or the CGIAR provided soft law instruments and policies for the establishment, maintenance, and long-term operation of genebanks [10–13].

Finally, the creation of the Global Crop Diversity Trust in 2004 provided the financial mechanism, through an endowment fund, for the long-term support of genebank activities (Popova [14] notes that half a billion dollars has been invested by governments and the private sector in the work of the Crop Trust since 2004, including in an endowment fund that provides long-term funding to key globally significant genebanks) and the establishment

of a “(...) rational—i.e., based on defined roles and international collaboration, while also being cost-effective—i.e., avoiding unnecessary duplication of efforts among players” (<https://cdn.croptrust.org/wp/wp-content/uploads/2017/02/Our-Case.pdf>, accessed on 25 August 2021).

Despite the marked heterogeneity in their origin, design, size, content, status, and duration and their modes of operation (see [15]) for a proposal of a broad typology of crop diversity genebanks and [16] for a more technical description of the diversity of genebanks according to their conservation methods), these three layers of policy, technical, and financial mechanisms constitute the common governance framework under which most of these genebanks operate. Besides, they all face common challenges of decreased public support to fulfill their public good mission, along with increased transaction costs related to both legal requirements (in relation to new collection or distribution) and quality control procedures related to traceability, documentation, and maintenance [16–18].

These challenges occur in a technological and political context that has dramatically evolved compared to the situation prevailing at the establishment of modern genebanks in the 70s [19]. First, on the technological side, advances in science and technology have ushered in an explosion of bio-information. It is possible to rapidly and cheaply obtain the digital DNA sequence for genetic materials, creating a new research environment increasingly embedded in big data. The advances have rapidly highlighted the existing limitations in current institutions to effectively store and handle data of this size and complexity. In response, funding agencies, the private sector, and other research consortia have begun to establish genomics centers which act as data repositories, but also provide technical services and in some cases operate as hubs of collaborative research [20].

In parallel, large-scale global problems such as food security and nutrition, disease mobility, climate change, biodiversity, poverty, and terrorism have increased the demand for broad global participation in science [21,22]. Science has become increasingly collaborative at a large scale [23–26]. As the Covid-19 crisis has showed, addressing these global crises requires finding a more open, inclusive, and equitable participation in research and innovation to resolve the tensions among openness, innovation, and equity [27]. When projected into the broader picture of new macro-policy goals and genomics research and innovation, the foundational governance frameworks for genetic resources and genebanks insufficiently address major issues such as power imbalance, the uneven distribution of use capacities among different sets of actors, the variety of incentives in using genetic diversity and related data, as well as barriers in collaborations and disconnection between policy and the state of technology [27].

In the current context, few stakeholders express some level of satisfaction with the current status quo in the existing global policy framework related to seed and plant genetic resources and associated information: some farmers’ organizations complain about the restriction to seed exchanges; scientists feel limited in their access to and use of genetic resources; genebank managers complain in their ability to collect new material and distribute it; private companies claim that the uncertain legal environment limits their capacity to invest in research.

This paper is a very first step to build new governance perspectives for a dynamic and collective management of crop diversity in genebanks that addresses contemporary complexities. It is in line with and builds upon other initiatives or work streams that attempt to provide a more integrative and coherent approach to seed systems and provide the framework, tools, and mechanisms to reconcile the conflicting logics carried by the various stakeholders at different scales. Examples of such approaches include, inter alia, the Robust Seed System framework [28], the Integrated Seed System and Development framework [29], the Resilient Seed System approach [30,31], the Pluralistic Seed System approach [32,33], the Seed4Resilience initiative (<https://www.croptrust.org/project/seeds-for-resilience/>, accessed on 25 August 2021), Global Open Source Seed Initiative (<https://opensourceseeds.org/en/gossi>, accessed on 25 August 2021) or the Oxfam Novib’s Sowing Diversity = Harvesting Security (SD = HS) program (<https://sdhsprogram.org/>,

accessed on 25 August 2021).

Reviewing and comparing these different frameworks and initiatives is out of the scope of this paper. By tackling these issues from different angles, each initiative, program, or approach brings important contributions on the practical, policy, or academic sides. We argue that this paper offers a complementary perspective on the following two levels: its focuses on genebanks as part of a broader perspective about the evolving role and responsibility of the research sector in society to increase the quality, effectiveness, and legitimacy of solutions to societal and environmental challenges [34,35]. We consider that genebanks, usually integrated in research organizations or universities, have an important role to play in operating as hubs for the threefold challenge of ensuring long-term conservation, fostering scientific advance, and organizing and managing the complex institutional environment related to plant genetic diversity and related data. In order to do so, a collective governance approach needs to be extended beyond the usual actors (classically, scientists and breeders) in order for genebanks to be able to mediate among interdependent communities involved in crop diversity management and who have increasing difficulties in collaborating smoothly in the current context. As Westengen et al. noted [32], “[w]orking through alternative channels, genebanks can increase their actual and perceived relevance among groups that otherwise consider genebanks far removed from the production system”. This issue goes beyond farmers’ direct use of genebank material, and we consider that enhancing the relationship between farmers and farmers’ organizations, researchers, and genebanks requires a more profound change of perspective, that would challenge the established division of labor between on-farm and ex situ conservation.

The second feature of our approach is its combination of both a conceptual and a pragmatist model of deliberation. The conceptual approach derives from the combination of the literature on commons and social-ecological systems in relation to both seeds and plant genetic resources and described in terms of the interaction between resource systems resource units, users, and governance systems acting at multiple levels within the same system. The framework is applied to question the current policy ecosystem of genetic research and breeding and offers an alternative conception to seed systems appropriate for accommodating a diversity of values and perspectives about the way the problem is framed. The pragmatist model of deliberation considers in “[t]he precise contours, definition and full meaning of a problem are often uncertain and contested, prompting inquiry into the problem and deliberation about what it means and how to solve it” [36] (p. 153). It also recognizes the diversity of values at stake and puts emphasis on “creativity of action”, “value of experimentation”, and “active search for governance forms that improve the quality of public policies and democratic governance” [36] (p.154). In the pragmatist view, the participation in concrete problem-solving is part of the inquiry. This inquiry is conceived as a social experimentation whereby participants have an opportunity to constantly learn and co-generate new meanings that better reflect the diversity of actual practices in the field, potentially challenge existing assumptions, and contribute to guide social change through the creation of futures that are new to all participants [37–39]. The pragmatist approach applied here relied on various complementary methods, including an anticipation method and a collective design method.

This paper first proposes an overview of the literature to show that the conceptual frameworks of seed commons and global plant genetic resource commons are difficult to reconcile because they do not apply the same scale and do not necessarily involve the same stakeholders. Building upon the multi-stakeholder projects CoEx (which is a four-year (2016–2020) collaborative project funded by the Agropolis Foundation and built up as a collective and multi-actor inquiry on crop diversity management systems in West Africa. This project gathered researchers from various disciplines as well as farmers’ organizations and NGOs in France, Canada, Senegal, Mali, Niger, and Burkina Faso with the overall objective to provide a more accurate picture of actual practices surrounding seed acquisition, uses, and exchange, beyond the usual “formal” and “informal” binary division that still predominates in international and national legal and policy frameworks.

The concept of crop diversity management system was developed both to describe the functioning of seed systems and to redefine the collaborative frameworks between the research sector and the agricultural sector), the concept of crop diversity management system (CDMS) commons is proposed as a way to overcome the limitations that were previously identified and to enable a more inclusive and dynamic perspective on the collective action challenges related to crop diversity in which breeding, ex situ conservation, and on-farm management are all part of a crop diversity management system. The last part seeks to illustrate, as part of the joint efforts of the CoEx and Dynaversity projects (the DYNAmic seed networks for managing European diVERSITY (DYNAVERSITY, see <http://dynaversity.eu/>, accessed 23 July 2021) was funded under the European Union's Horizon 2020 Research and Innovation program and aim at analyzing and describing the actors involved in plant genetic conservation for agriculture, in order to suggest management and governance models and to construct new forms of networking. It facilitates the exchange and integration of scientific as well as practical knowledge on how to best manage diversity in agriculture and in the entire food chain, restoring evolutionary and adaptation processes.), how to operationalize this concept through a collective experiment involving farmers and farmers' organization, genebank managers, and researchers concerning the management of crop diversity. The aim of this approach is to test whether this new conceptual framework applied to the governance of genebanks can help redefine their role and place in a larger network of actors.

2. Interests and Limits of the Current Commons Approach Applied to Seed and Plant Genetic Diversity

Among the research underlying the “commons” characteristics of seeds and plant genetic resources, we can distinguish two major trends. On the one hand, some authors put forward the notion of “Seed Commons” [40] to refer to various crop-diversity-related approaches based on commons governance. Although these authors underline that this notion covers a wide range of different realities at different scales, they tend to focus mainly on local and regional levels, covering initiatives such as (local) seed exchange networks, Community Seed Banks, as well as Participatory Plant Breeding initiatives in which breeding farmer networks collaborate with scientists. This literature highlights the diversity of existing collective actions and of communities; it also raises the variety of challenges related to seed management, be they conservation, production, or sharing, as well as knowledge governance [41]. The social processes of “commoning” are thoroughly described and are usually presented as a “counter-hegemonic movement against neoliberalist tendencies of commodification and enclosure” [42] (p. 432).

This literature also underlines the complexity of issues related to seeds that are altogether material and immaterial, private and public, natural and designed. It recognizes that Seed Commons transcend the conceptual categories usually found in the Commons literature [40]. More specifically, the collective management of the biophysical seeds relates to the concept of traditional Natural Resource Commons [43], the collective sharing of the associated knowledge to Knowledge Commons [44], and the conservation and sustainable use of PGRFA to Global Commons [45–47]. Based upon a multi-stakeholder process involving two different local initiatives in Germany and the Philippines, Sievers-Glotzbach et al. [40] identify four criteria to characterize seed commons: collective responsibility; protection from private enclosure; collective, polycentric management; and the sharing of formal and practical knowledge.

However, these authors recognize that these criteria apply more to local initiatives than to global commons. As they underline [40] (p. 430), “for an application on Global Seed Commons, the criteria would need to be reviewed and adapted to the global scale”. Indeed, Seed Commons studies have mainly been conducted on local networks, tending to leave aside a range of institutional actors and initiatives involved in genetic resource management at national and international levels.”

These national and international levels are precisely the focus of the second trend of the commons literature. It qualifies PGRFA as a Global Commons [46–48] that requires global

collective action at the international, supranational, and global levels for their conservation and sustainable use. Indeed, PGRFA and associated knowledge are conceived as essential inputs to the research and breeding process and play a major role in global food security and sustainable agriculture. This literature, though not disconnected from the previous one, highlights the characteristics of the commons of PGRFA to point out the importance of existing treaties and governance systems to counteract the increasing risk of PGRFA enclosure [46,47]. More specifically, the Multilateral System of Access and Benefit Sharing (MLS) of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is a reflection and recognition of the strong interdependency of countries and stakeholders regarding the genetic diversity they hold and its associated knowledge. It is perceived as a global expression of a collective management system for the common pooling of the genetic resources held in international and national genebanks [5].

In both seed and global genetic diversity commons frameworks, the relationships between farmer communities and genebanks are poorly considered. The global PGRFA commons approach underlines the importance of recognizing the role and voice of farmers in crop diversity management; yet it does not provide any practical insights to foster interactions between genebanks and farmer communities, apart from the recognition of their contribution and the need for strengthening their capacity [46]. The Seed Commons view shifts the consideration of “resources” as commons to the community engaged in a “commoning” initiative (“Commoners”) [49]. However, by remaining focused on user communities already sharing a common desire to get out of an instrumental relationship and appropriation of the resource, they do not provide any clues to solve the problems of collective action played out on a global scale. Besides, little attention is paid to the plurality of views on the resources and on the diversity of motivations related to the use and circulation of crop diversity. This explains why, “as of now, the transformative impact of Seed Commons is still limited” ([40]).

Eventually, both approaches grapple with what constitutes the rationale for breeding, namely the distinction made between genetic resources (input) and seeds (products of innovation). On one side, the notion of commons is conceived as a shield to the risk of enclosure of seeds involved in the use of IPRs. On the other side, the notion of commons is conceived as a shield to the risk of enclosure of genetic resources by considering the resources that enter the innovation process, namely PGRFA, as part of the public domain.

In this context, no wonder that the two systems mostly function in silo and that attempts to connect the two remain limited to scattered initiatives [32,50]. A series of binary divides that have accumulated over time is associated with these two approaches of the commons (seeds v. genetic resources; on-farm v. ex situ; informal v. formal; farmers’ rights v. breeders’ rights to name a few) and shapes all current political discourse on crop diversity.

Understandably, genebanks have been instrumental in promoting the global plant genetic resources’ commons approach and its conceptual, technical, and administrative mechanisms remain profoundly associated to this vision. Although global instruments such as the ITPGRFA have carved out some spaces to promote this approach, the relationship with more stringent rules coming from the Nagoya Protocol as well as new tensions arising from the status of digital sequence information exacerbate the challenge for genebanks to manage this complex institutional environment and continue both enriching their collections and distributing material.

More fundamentally, Louafi and Welch [51] noted that the current regulatory framework governing the exchange of genetic resources, including the most commons-friendly one, fails to account for the broader social environment within which mutually beneficial relationships build norms of trust and reciprocity in collaboration and resource exchange networks. Germplasm exchange tends to be approached as a single transaction that occurs between individual actors or organizations for specific objectives rather than as part of broader and sustained collaborations. Yet these collaborations on a larger scale and with a broader range of actors are increasingly needed to address complex problems on a global

scale. They involve the integration, pooling, and management of multiple types of interdependent resources, beyond the single genetic resource and related information, such as technical resources (equipment, software, scientific, and technical human capital resources), organizational or administrative resources (e.g., conflict resolution services), and the social capital available through relations between individual collaborators [51].

In this context, it is interesting to reflect on the possibilities for governance development that capture and reflect the ongoing challenges of a more dynamic and collective management of crop diversity in genebanks, and to determine the conditions under which genebanks could play a role in mediating among interdependent communities that have difficulties in collaborating smoothly in the current context. For this to happen, a new framework able to reconnect the two existing commons frameworks is needed.

3. A Renewed Conceptual Framework: The Crop Diversity Management System as a Commons

As previously stated, a new conceptual framework able to reconcile the seed and global PGRFA commons is needed to help imagine a more fruitful collaboration between genebanks and the diversity of actors involved in crop diversity management, primarily farmers and farmers' organizations.

This framework was developed in the context of the CoEx project and based on the concept of social-ecological systems (SES), that accounts for the intertwined social and biological dimensions of resource management [21,52–55]. The social-ecological seed system focuses on the relationships and interplays between resources (seed, crops), actors (farmers, sellers, community seed bank managers, researchers, breeders, etc.) and institutions (understood as the rules, accepted norms, and standard procedures according to which individuals and organizations think and act) within a specific environment defined as a socio-ecological context [56]. The SES framework allows for the development of a more interconnected view of crop diversity, that accounts for environmental, cultural, social, and economic factors [57]. It also helps move away from a resource-centered approach and focus on the variety of relationships between resource systems, resource units, users, and governance systems, acting at multiple levels within the same system, and without any established hierarchy. Using this framework, two ways to overcome the existing limitations of seed and global PGRFA commons are envisaged.

3.1. From Seed and PGRFA to Crop Diversity

The first is to revisit the entity to which the commons apply. Following Ostrom [43], we can distinguish the resource system, in this case the agricultural species or crop diversity, from the flow of resource units that this system produces and that allows for the continuity of agricultural activity, in this case seeds or PGRFA (Leclercq and Louafi, under review). Only the resource system can qualify as a commons, not the flow of resource units that users can privately use: to consume for their subsistence, to use as an input for their production, or for research and breeding or to sell as goods.

The problem of applying a commons approach to resource units reinforces the artificial division between PGRFA, on the one hand, and seeds, on the other, the former being used for conservation and breeding purposes, while the latter are considered for production purposes. In the current system, the former are seen as part of a global commons that the ITPGRFA has enshrined in its Multilateral System. The latter are produced, inspected, and controlled in order to supply the seed market. Such vision promotes a linear vision of the use of crop diversity, from genetic resources characterization to varietal creation and then to seed multiplication and distribution.

In many cases, as for cereals, seeds are both a means for production (input) and a product (output). The very same resource could be used either directly, as input for production purposes, or as input for research and breeding purposes. Through domestication and selective breeding, crop diversity has been continuously mobilized over many successive generations and the genetic gains are cumulative. As pointed out by Schloen et al. [58], "the improvement of [crop diversity] is a process of incremental innovation, in which one

innovative step is added on to another, and where a product is not the end point of a development process, but rather an intermediate step in an ongoing chain of improvement. In the course of this continuous improvement process, [crop diversity] is frequently exchanged across communities, countries and regions, and different people in different places contribute their share to the incremental innovation being achieved". The dispersed contribution to incremental innovations makes it difficult to draw a clear line between upstream and downstream creators. The fact that genebanks conserve various types of plant material, like landraces, historical varieties, pre-breeding material, or improved lines, is an illustrative example of this incremental process.

Considering that the same resources could be used for production or conservation and breeding purposes means that, from a biological point of view, the innovation contained in many products developed from one particular resource is potentially freely available to others for further use in research and development [58]. This makes it difficult to draw clear lines between use and innovation or between providers and users. To draw this line, biological or legal means are called up in the form of respectively hybrid varieties that force farmers to buy seeds every year to obtain stable results, and/or in the form of the granting of intellectual property rights. Besides, the differentiation and specialization between breeding and production, on the one hand, and between conservation and production, on the other hand, also made it easier to draw such lines. However, it is important to note that although the use of intellectual property rights for the protection of plant varieties has been extended worldwide since the Marrakech agreement, in 1994, international trade law offers states the possibility to develop a *sui generis* system for the protection of varietal innovations [59], and the specialization of conservation vs. breeding vs. production activities is far from being generalized for all the crops and all the regions of the world. From a social and biological point of view, these dividing lines remain artificial in many parts of the world. Resources continuously cross and genes flow over time among the so-called seeds and genetic resources and among certified/protected seeds and farmer seeds.

For all these reasons, it is important to acknowledge that a resource unit approach in which resources are characterized only from a biological point of view irremediably generates dividing lines that prevent a systemic approach able to reflect the variety of relationships and feedback loops between resources and actors as concretely experienced by various actors around the world. Instead, we propose the use of the notion of crop diversity to refer to this resource system. Crop diversity represents a unifying concept between seed and global PGRFA and could be defined as all cultivated biological entities (whatever their characteristics) at a given scale (field, farm, village, province, country, sub-region, global). It can be characterized at different levels of organization of living organisms.

Yet, it would not be sufficient to stop here and refer to the crop diversity commons since, as noted by Frischmann et al. [60], "commons do not refer to a resource or a place, or a community but to a form of community management or governance". This is why we propose that crop diversity be included in a broader system called the crop diversity management system.

3.2. From Seed or Global Genetic Diversity Commons to Crop Diversity Management System Commons

We consider the crop diversity management system (CDMS) as a commons in the sense of an institutional arrangement for sharing/exchanging resources among members of a more or less large community. The CDMS is an inherently social phenomenon, which takes place at a wide range of scales and in a complex context where several institutions/rules/standards overlap. The CDMS faces a variety of barriers to collective action that could arise from the nature of the resources, the nature of the community, or the conflicting nature of values and institutions, rules, and standards.

The CDMS and its dynamics have been apprehended within CoEx according to three dimensions specific to the socio-ecological system in which they are embedded: biological (the diversity of cultivated plants), social and economic (the diversity of actors and modes of seed acquisition), and political (the diversity of values and rules that organize the

circulation of seeds). Such a framework makes it possible to resituate the CDMS beyond the sole economic dimension on which seed systems characterization is usually focused.

Besides, since crop diversity has been (and continues to be) shaped by humans, seeds or PGR cannot be considered only in their biological dimensions. They come from a history that is always linked to human societies and always embedded in specific social contexts. Taking into account the temporal dimension is essential for a good understanding of CDMS. Indeed, crop diversity cannot be considered only as a stock of alleles that can be mobilized by a limited group of actors for future innovations. It has to be considered also as the product of a continuous process of coevolution between crops, environments, and societies, and in which, through their interactions, various forms of use, valorization, or circulation play an important role [57]. In other words, the CDMS offers a broader and less linear view in which breeding is not the only end goal but only one form of crop diversity management among others.

Finally, CDMS could also be characterized by their spatial dimension. Crop diversity has historically circulated on very large scales and continues to circulate in a very dynamic way through individuals and human groups, who move them, in the course of their lives, from one place to another, or who circulate them between themselves. A holistic analysis should make it possible to account for the different levels of management and organization of diversity, from the plot/farm to the entire region or globe, via the village, the agrosystem, or the country. Along this perspective, the systemic approach of the CDMS offers a way to make more explicit the relationships or the interactions between unit resources and actors. Three key processes could be considered in relation to crop diversity: (1) seed access, (2) seed production, (3) seed supply. For each of them, it is necessary to define the actors and the crop diversity used in a specific temporal window and a given area. It is also possible to describe the rules and institutions that govern each of the interactions between resources and actors. For instance, in the case of seed access, it is possible to characterize at a village scale the different actors that provided seeds during the last campaign or for the last 5 to 10 years. To do that, and in order to avoid problems with diverging views about how seeds are qualified or named, the concept of seed lot is preferred. For each of these seed lots, we could describe which kinds of material was obtained (landraces or improved material, certified seeds or not, morphological/agronomical characteristics, quantity, etc.) for any species and varieties, from whom they received it, through which channel, following which kind of transaction or rules.

In total, CDMS helps avoid the centralized and unidirectional perspective conveyed by a PGRFA commons perspective as well as the localized and club approach of the seed commons. (A club approach (see [61]) is classically characterized by a low rivalry of the resources (difficult to overexploit) combined with a high excludability, whereby the commoners are part of a group that can be defined as a club, as potential users need to fulfil specific conditions to enter it—usually under the form of payment, but we rather refer here to the adherence to shared values. As noted by Sievers-Glotzbach et al. [40], the local commons usually share the same concern of protection from private enclosure and the shared responsibility of the commoners as the essential element around which these commons initiatives thrive) It offers a more horizontal and distributed approach to governance, that goes beyond the simplistic binary vision limited to a face-off between the informal farming system (associated to the local seed commons) and the formal innovation system (associated to the global genetic diversity commons). In this confrontation, the role of the research sector is limited to the conservation of genetic diversity in *ex situ* conditions and its characterization for the sake of utilization by breeders and relies on a single linear logic, from genetic resources characterization to varietal creation and then to seed distribution.

By breaking the predominant hierarchical and unidirectional vision of crop diversity management, we argue that the CDMS notion could help address the challenge of an enhanced coexistence and coordination of the different communities of actors managing different sets of resources under different sets of rules. Such coordination among the

different subsystems is essential for crop diversity use beyond the sole relationship between genebanks and breeders, upstream (R&D), and between farmers and seed companies, downstream (distribution).

4. Genebank Governance and Collective Action Challenges Regarding the Crop Diversity Management System

Following the CDMS perspective, genebanks can be considered at the crossroad of different actors dealing with crop diversity. Indeed, they provide or receive crop diversity and related information from other genebanks and researchers involved in the characterization of crop genetic diversity, but also from plant breeders, farmers, gardeners, and community-based organizations dealing with crop diversity. They can also function as a brokering organization, as they collaborate both with local and global actors as well as with profit and non-profit actors. Indeed, they act locally when they collect seeds in farmers' fields or when they provide local landraces to community seed banks, and they act globally when they contribute to the MLS of the ITPGRFA. However, the level of formalization and harmonization of the rules varies greatly depending on the type of actors.

To what extent could genebanks have a role to play in mediating among interdependent communities that have difficulties in collaborating smoothly in the current context? To what extent could the CDMS commons framework help revisit the role and responsibility of genebanks in a crop diversity management system? How could this approach help bring the discussion about seed systems back to a more holistic and non-conflicting track?

A collective of academic and non-academic partners under the banner of the CoEx and Dynaversity projects put in place a collective process to address these questions following a pragmatist model of deliberation.

4.1. Implementation of the Collective Design Process

A small inter-sectoral group within the CoEx project aimed at exploring new CDM practices, new roles for genebanks, and new governance principles for CDMS. To this end, two workshops were organized in November 2019 and June 2020. They gathered, respectively, 21 and 25 participants, representing a plurality of actors in the conservation and management of crop diversity from Europe (France, Italy, Switzerland), West Africa (Niger, Senegal, Ivory Coast, Burkina-Faso, Mali), and North Africa (Tunisia, Algeria). These participants were researchers from various disciplines (geneticists, sociologists, anthropologists . . .), genebank managers, farmer members of Community Seed Banks, seed artisans, and representatives of non-governmental organizations. None of these actors were used to working together on these governance issues. Both workshops used methods fostering dialog and co-construction between participants and helping to think out of the box and overcome fixation biases [61,62].

During the first workshop organized in Southern France, the participants were invited to imagine several scenarios regarding the role of genebanks in 2030, drawing upon an anticipation method [63]. Several desirable and non-desirable scenarios were established and, ultimately, two desirable visions were selected for further exploration: the "Cosmo-ethical" and the "Pluragouv" scenarios. The former places the socio-cultural dimensions at the heart of the CDMS process, involving a paradigm shift in our relationship with nature and fostering co-evolution by anchoring innovation in local practices. The latter is conceived as a pluralist system of crop diversity global conservation, structured in networks with a multi-actor governance able to respond to both local and global issues. The "Cosmo-ethical" scenario was further explored, and this work made it possible to confront the different visions of the participants and to build a shared diagnosis on the expectations regarding the possible evolutions of the role of genebanks in the CDMS landscape.

Following this workshop, the initiative leaders wished to "land" the vision imagined during the first workshop on the role of genebanks through a series of concrete actions to be implemented. They chose to apply a participatory design method, the KCP (Knowledge-Concept-Proposal) method [64,65]. This collective design method was set up to lead a large and heterogeneous group to collectively build an innovation strategy. It relies on collective

design workshops that foster knowledge sharing (Phase K), the exploration of innovative ideas (Phase C), and the elaboration of concrete projects (Phase P). The KCP method was chosen to overcome the diverging views between CDMS actors and the binary division between *ex situ*/*in situ* conservation and possibly results in concrete proposals. It has been adapted to meet the collective objectives and constraints. Due to the covid-19 health crisis context, the workshop was organized through videoconference over three mornings. The K phase, of knowledge sharing was skipped for time reasons and because it was considered as done in the first workshop. During the C phase, of idea exploration, the participants were invited to explore three proposals drawn from the first workshop: “a decentralized genebank”, “genebank as a commons”, “a network of systems and approaches to crop diversity”. Split into subgroups, the participants were invited to generate and organize ideas. During the P phase, of project development, each subgroup chose an action to be developed.

4.2. Outcomes of the Collective Design Process

Most action proposals resulting from this workshop were organizational innovations and were beyond the scope of the strict governance of genebanks. The workshop revealed a common objective for the different participants: building a space of multi-actor interactions in order to set up collaborative actions and work together, as well as establishing more tailored material and knowledge-sharing rules for these collaborations. To achieve these objectives, intermediate objectives were identified: (1) clearly characterizing social diversity within CDMS, and (2) consolidating knowledge and promoting the sharing of experiences between CDMS actors.

Based on the results of the KCP workshop, a roadmap was developed by the organizing team. This roadmap contained both short-term and long-term actions. In the short term, it was felt necessary to continue increasing the mutual understanding and trust between the different actors involved, through the establishment of a common language, cross-visits, regular meetings, and the development of a common charter. Similarly, the participants expressed the need for a participatory mapping of the different types of actors involved in CDMS and an identification of potential new actors to be included in this process through a snowball method.

These short-term actions aim at feeding two long-term projects: (i) the co-construction of a collaborative research project between the different actors (collection managers, researchers, NGOs, and farmers’ organizations) to address simultaneously technical issues related to crop diversity management and, just as importantly, governance aspects related to the very context of collaboration within this project; (ii) elaborate the contours and terms of reference of a possible Third Place, built as a space of intermediation between the diversity of actors and institutions, of the exchange of knowledge and skills, and of the constitution of a community of practice.

The rationale for such Third Place is based on the observations that both mutual ignorance and multiple institutional, administrative, and regulatory obstacles persist and prevent the engagement in smooth collaborative activities. It was felt that, in the current context, genebanks are not in a position to fully play a mediating role among various actors and that a Third Place could constitute a “safe” space that recognizes the coexistence of a variety of crop diversity management practices and allows innovative practices to thrive. Interactions and collaborations between the different actors that make up this space would be facilitated by avoiding the reliance on both preconceived perceptions of others’ interests and pre-existing institutional and/or legal solutions to collaboration (usually imposed by the most powerful actors). In line with a democratic experimentalism approach, the search for new modalities of collaboration is conceived as part of the collective learning process in which everyone brings valuable perspectives to the decision-making around governance issues (such as material and knowledge sharing, inclusion of new partners, connection with existing projects, etc.). Hence, the Third Place would move beyond focusing only on knowledge brokering and demand articulation to organize the collective exploration

process of problem and solution framing with respect to a specific context and set up rules and create arrangement to increase the cooperative capacities of actors through joint actions.

5. Conclusions

In building the governance framework under which genebanks operate, only certain aspects of the resource system and the need of specific stakeholders have been considered.

This gave rise to two different conceptions of commons that do not connect to each other. The first one is promoted by local communities sharing the same values and interests and in which crop diversity is seen as a multiplicity of local crop diversity commons for which rules of exchange are tailored to the specific needs of each specific community. The second one considers the genetic components of crop diversity as a global commons that should be freely shared worldwide for enhanced use for innovation purposes. This division of labor corresponds to the divide established between in situ/on-farm and ex situ conservation and prevents the consideration of the dynamic relationship between the two, in which the input and output of one are the output and input of the other.

This paper proposes a more holistic and inclusive framework for the crop diversity management system, able to cover a wider range of concerns and needs of the actors using and producing crop diversity. This framework was used for a new multi-stakeholder process to expand the roles of genebanks in enhancing the collaboration mainly among three different types of actors involved in the management of crop diversity, namely farmers and farmers' organizations, genebank managers, and researchers. The participants of the series of workshops envisaged the creation of a Third Place, as a collective arrangement able to overcome the existing deadlock and foster collective learning on ways to design more collaborative relationships between genebank managers, research, and farmers' civil society organizations involved in crop diversity management. Since the Third Place is in an experimental phase, the end result of this process is still uncertain and could ultimately be very limited to a specific context. Nevertheless, in line with the pragmatist approach, it is believed that its relevance does not necessarily derive from any particular solution that would presumably be limited to a particular context, and hence provisional. Rather, the value of the framework lies in the process itself, starting from the collective recognition that (1) the framing of the problem is in itself problematic, (2) the inquiry should include the diversity of values at stake, and (3) problem-solving efforts are part of an open-ended iterative, learning, and design process conceived as a collective experimentation in which any solution is considered as a hypothesis to be tested and constantly refined and initial objectives may be revised. In the view of the authors, crop diversity management is less a matter of promoting a specific solution against many other alternatives and more a matter of democratic experimentalism that prioritizes the quality of the deliberation and exploration process in a given scale of action (local, national, regional, global, or any possible combination of these).

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