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Traditional Agricultural Knowledge as a Commons

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ABSTRACT

In this chapter we explore the governance of traditional agricultural knowledge (TAK) under the commons framework, or the idea that knowledge can be governed as a commons, i.e., as a resource used by a group of people who have self-developed a set of rules to manage the social dilemmas derived from the resource collective use. To illustrate the governance of TAK under the commons framework, we present two case studies in which TAK is shared by communities of users who operate at different scales. The first case illustrates the local governance of TAK as commons by a close community with tight social bonds; the second case provides an example of how digitalized TAK could be governed by a peer-to-peer governance system and become part of the global digital commons. We conclude by exploring the degree to which a commons-based governance can be considered a contestation to commodification and enclosure movements that threaten the maintenance of TAK systems, and thus supports people's ability to sustain environmentally and culturally adapted food systems.

1. Introduction

Traditional¹ knowledge systems consist of the information, beliefs, traditions, practices, institutions, and worldviews developed and sustained by indigenous and rural communities. Traditional knowledge systems are often seen as an adaptive strategy to the environment in which communities live and include information, practices, and institutions related to many spheres of community's life, from medicinal to astronomical or agricultural information (Berkes, Colding, and Folke 2000; Reyes-García, Guèze, et al. 2016). As an adaptive strategy, these knowledge systems provide place-based communities with information to deal with everyday life issues, while considering the long-time maintenance of the ecological system in which they are embedded. Traditional agricultural knowledge (TAK) refers to the locally-adapted systems developed by farmers and other place-based communities around the world through their interaction with nature in order to support food production in a way that is environmentally and culturally adapted to the specific characteristics of each context (Malezieux 2012; Gilles et al. 2013; Vandermeer and Perfecto 2013). TAK systems encompass information about how to recognize and efficiently manage agricultural landscapes and agroecosystem elements (i.e. knowledge on storage and culinary characteristics of crop landraces) (Riu-Bosoms, Calvet-Mir, and Reyes-García 2014; Calvet-Mir, Calvet-Mir, and Reyes-García 2010).

Over the last decades, components of traditional knowledge systems have been incorporated in the development of commercial products, and thus commodified. Some well-

¹ Despite the controversy around it, we use the term 'traditional' (rather than 'local' or 'customary') when referring to the knowledge systems presented here to emphasize the long-term historical continuity of these bodies of knowledge and the importance of social processes in their transmission and maintenance. The term 'traditional' does not imply being archaic or pre-modern, as traditional knowledge systems are highly dynamic and adaptive (Reyes-Garcia et al. 2014).

known examples of these processes include the patenting of traditional medicinal knowledge by pharmaceutical companies (Soejarto et al. 2005; Heinrich 2015) and the appropriation of TAK with commercial purposes (Whitt 1998; Brush 2004). This highly contested move has raised concerns about the need to develop benefit-sharing agreements between knowledge holders and commercial companies (Siebenhuner, Dedeurwaerdere, and Brousseau 2005; Engels, Dempewolf, and Henson-Apollonio 2011), but -more importantly- it has led to a harsh debate on how to protect traditional knowledge systems from misappropriation (Shiva 1997; Macilwain 1998; Moran, King, and Carlson 2001). Although at a practical level the debate seems to revolve around the relation between local people and commercial companies, at a more theoretical level the debate ultimately concerns the governance of traditional knowledge systems. Some authors have argued that the contribution of traditional knowledge holders should be protected through the application of some sort of Intellectual Property Rights (Brush 2004). Other authors, however, oppose the privatization of knowledge already in the public domain, suggesting that this knowledge should be governed as a public good (Smale et al. 2004; Shiva 2004). Departing from these two positions, in this chapter we explore the potential of a third approach to the governance of traditional knowledge: the commons framework, or the idea that traditional knowledge systems could also be peer-governed by knowledge users.

The idea that knowledge can be governed under the commons framework is not new *per se*. For several years, scholars working on the governance of digital knowledge have argued that knowledge –defined as intelligible ideas, information, and data regardless of the form in which it is expressed or obtained – should be considered under the commons framework (Boyle 2003; Hess and Ostrom 2007; Bollier and Helfrich 2014). Here we follow this line of thought and explore two examples in which TAK is conceived and managed under the commons framework.

In the next section, we discuss the theoretical framework supporting the idea that knowledge can be governed as a commons, i.e., as a resource used by a group of people who have self-developed a set of rules to manage the social dilemmas derived from its collective use. We then illustrate the governance of TAK under the commons framework presenting two case studies. The first case illustrates local governance of TAK as commons by a close community with tight social bonds; the second case provides an example of how digitalized TAK could be governed by a peer-to-peer governance system. Given the contrast between the two cases, we then discuss how the commons framework could also contribute to articulate the sharing of TAK at different scales. We conclude by exploring the degree to which a commons-based governance can be considered a contestation to commodification and enclosure movements that threaten the maintenance of TAK systems, and thus people's ability to sustain environmentally and culturally adapted food systems (Boyle 2003; Lakshmi Poorna, Mymoon, and Hariharan 2014).

2. Is traditional agricultural knowledge a commons?

While the term 'commons' has been alternatively used to refer to resources or goods, to a social process, or even to a worldview (Bollier and Helfrich 2014; Kostakis and Bauwens 2014), one of its most standard uses is to refer to the institutional approach that governs the production, use, management and/or preservation of shared resources according to which people manage such resources by negotiating their own rules through social or customary traditions, norms, and practices (Ostrom 1990; Frischmann, Madison, and Strandburg 2014). As resources managed under a public approach (i.e., public goods), resources managed under the commons approach are collectively owned, but -differently than public goods- they are managed by self-organized communities for their collective benefit and not by government institutions (Quilligan 2012). A

distinctive aspect of the commons approach is that it emphasizes that social dilemmas, or situations in which there is a conflict between immediate individual self-interest and long-term collective interest, can be solved through resource-use management rules self-defined by the users (Ostrom 1990; MacKinnon 2012; Siefkes 2012). Another distinctive characteristic of the commons approach is that, under this governance system, resources are managed to ensure long-term maintenance of the resource use value, for which it is important that management is oriented to prevent resource degradation (Kostakis and Bauwens 2014).

The term ‘knowledge commons’ refers to the application of the commons approach to governing the production, use, management, and/or preservation of knowledge or information (Frischmann, Madison, and Strandburg 2014; Hess and Ostrom 2007). Within this context, we aim to explore whether TAK can be considered as a knowledge commons, in the sense of being shared and collectively governed by a group who receives non-monetary utility from its existence and reproduction. To explore whether TAK can be considered a commons, we follow Kostakis and Bauwens (2014) who proposed that one needs to examine four interlinked components to understand any commons scheme: 1) the resource; 2) the community who shares it; 3) the rules and property regimes that govern people's access to the resource; and 4) the use value created through the social reproduction or preservation of the resource. In the remaining of this section, we analyse these four components in relation to knowledge systems in general and TAK in particular, before analysing them in more detail in relation to our two case studies.

The resource: The institutional approach of the commons was originally developed in relation to material, degradable resources. This approach uses the rival nature of material goods (i.e., goods could only be possessed or consumed by a single user) to explain the emergence of

users' self-defined management rules, in an attempt to avoid resource depletion. Differently to material resources, but similar to other types of socially transmitted knowledge (Boyd, Richerson, and Henrich 2011), TAK is an immaterial non-rival resource developed through social –not individual- processes, i.e., through the cumulative effort of generations of farmers experimenting, improving, and adapting crops and techniques through trial and error and on farm verification. Why should users develop management rules for a non-rival good (i.e., a good that can be used or consumed by one person without reducing the amount left for others)?

A potential answer to this question lies in the inextricable link between TAK and tangible resources (i.e., seeds, agricultural landscapes, tools and practices), that create opportunities for enclosing TAK, and the dramatic process of privatization those tangible resources (primarily seeds) have experienced over the past 100 years (Halewood 2013). Thus, as information stored in a book or a CD, TAK is often embodied in tangible resources such as seeds. Firms can protect the seeds they create either through Plant breeder's rights (PBR), covered in the UPOV Conventions, or through patents as stipulated in the Paris Convention of 1883, or -since the signing of the TRIPS Agreement in 1994- through a combination of both (Shiva 2004; Ghijssen 2009). Furthermore, they can do so without recognizing the farmers' role in the development of the original varieties (Ceccarelli, Guimarães, and Weltzien 2009; Kloppenburg 2010; Luby et al. 2015). While initiatives such as the convention on biological diversity (CBD) and the international treaty for plant genetic resources of food and agriculture (IT-PGRFA) aim to subject the access to germplasm and associated knowledge to particular rules for benefit sharing, the terms for access continue to be uncertain (Ghijssen 2009, Frison & Coolsaet, this volume), and often farming communities have no recognised rights on the plants they grow (Brush 2004; Thomas et al. 2011). Given the scarce recognition of TAK under the current legal framework,

management rules that protect the free exchange of seeds and associated knowledge seem to be relevant. Indeed, initiatives such as the Open Source Seed Initiative (OSSI) (www.osseeds.org) seek to provide an alternative to pervasive intellectual property rights agreements that restrict freedom to use plant germplasm so to ensure that germplasm, and associated knowledge, can be freely exchanged now and into the future (see Kloppenburg 2010; Luby et al. 2015).

The community: The second component that constitutes knowledge as a commons is the community who shares it. Although, at least in theory, knowledge is a non-rival good which could be shared with and used by other people without reducing the amount left for others, in practice, knowledge is mostly shared within specific communities (see for example Salpeteur et al. 2015). Thus, TAK has typically been mostly shared within a community of users linked by tight social bonds and who often shares the same geographical environment. In this sense, a growing body of empirical research has been able to monitor the flow of seeds among farmers showing that the exchange of agricultural knowledge and crop propagation materials is intertwined with social aspects such as ethnicity, social differentiation, or gender relations (e.g. Labeyrie, Rono, and Leclerc 2014; Kawa, McCarty, and Clement 2013; Reyes-García et al. 2013). Because TAK is embedded in local cultures, resources, and practices and because –until recently- it was rarely transmitted in written form but rather stored in social memory and shared through daily practices, its spread outside the close community was rare. Geographical and social barriers (e.g., language, mores, and ethnicity) acted as boundaries delimiting the community sharing TAK, which cannot be understood, performed, or managed without considering its intrinsic social character.

The rules and property regimes: The third component relates to the rules that govern the access and management of the resource production and use within, and potentially beyond, the community. Several studies suggest that local and rural communities often manage their agrobiodiversity collectively, i.e., through collective use and knowledge exchange practices (e.g. Aw-Hassan, Mazid, and Salahieh 2008; Abay, de Boef, and Bjørnstad 2011; Labeyrie et al. 2016). In that sense, a growing body of research shows that the exchange of seeds is governed by collectively constructed rules regulating access to seed and associated TAK. For example, a recent study on sorghum seed exchange networks in Mount Kenya found a tendency to exchange seeds with members of the same residence and ethnolinguistic group, with measurable effects on crop genetic diversity across communities (Labeyrie et al. 2016). Similarly, Thomas and Caillon (2016) show that the circulation of plant materials and associated knowledge is affected by the social status of farmers, with higher-rank individuals giving more plants and therefore contributing more to the resilience of the community. These studies suggest that, although access to TAK could be theoretically unlimited, indeed social rules define such access and the way in which TAK is disseminated, enjoyed, and reproduced.

It should be noted, however, that while the social characteristics of TAK make it costly for non-community users to access the resource, in the absence of strict mechanisms allowing the community to exclude outsiders from using the resource, accessing it is not difficult. Under the commons framework, access to TAK by external actors, who appropriate, extract exchange value, and potentially exclude community members from use rights, could be considered a form of free-riding, where one reaps benefits from the commons without contributing to their maintenance. In that sense, the movement to enclose and commodify TAK through patent laws, plant variety protection laws, contractual restrictions accompanying seed sales, or bilaterally

oriented access and benefit shared laws could be considered a form of free-riding from agricultural companies, as they restrict the use of TAK developed by a community in order to generate private benefits (Halewood 2013). Indeed, this type of appropriation constitutes one of the most important social dilemmas for management of TAK as commons.

The use value: The last component proposed by Kostakis and Bauwens (2014) to understand the commons scheme relates to the use value created through the social reproduction and preservation of the resource, rather than through the exchange value that is normally generated when commodities are created and transferred according to market rules. Kostakis and Bauwens (2014) argue that the governance of resources under the commons framework is not based on the production of exchange value but rather on the production of use value. There is enough evidence to maintain that TAK systems not only have an immediate use value for individual farmers, but that they are oriented towards the production, hybridization, use and reuse of knowledge to support environmentally sustainable and culturally adapted food systems in a way that cannot be monetized without subverting the idea of the commons itself (Malezieux 2012, Gilles et al. 2013, Vandermeer and Perfecto 2013).

In a large variety of settings, from places with no access to contemporary agricultural technologies (Brookfield et al. 2003) to rural areas of industrialized countries (Calvet-Mir et al. 2016), farmers rely on the TAK to take decisions regarding subsistence-oriented agricultural production. Maintaining this body of knowledge, however, does not only provide private benefits, but more generally it generates social and environmental benefits, as the maintenance of the knowledge system strengthen the collective resilience and contribute to the reproduction of the community itself (e.g. reproductive labour), and contributes to the maintenance of local

agrobiodiversity (Vogl and Vogl-Lukasser 2003; Reyes-García et al. 2007; Federici 2010). Even if individual farmers can make profit from holding TAK because they can sell their produce to the market, the fact that this knowledge returns always to the community guarantees a collective benefit that exceeds that of the individual members. TAK and its shared nature and practice add the maintenance and the exchange of knowledge to the production of use value, and therefore go beyond the monetary possibilities that are conceived by the notion of market value.

The examination of the four interlinked components proposed by Kostakis and Bauwens (2014) to understand the governance of a resource under the commons framework suggests that TAK (despite being normally governed by small and closed communities) shares similarities with other knowledge commons in the sense that can be collectively governed by a group that is constructed around and performs certain management rules and that profits from non-monetary value obtained from the existence and reproduction of TAK.

3. Local governance of TAK as a commons. The seed exchange network in Vall Fosca

In this section we use information from a previous study (Calvet-Mir, Calvet-Mir, and Reyes-García 2010; Calvet-Mir et al. 2011; Calvet-Mir et al. 2012; Calvet-Mir, Gómez-Bagetthun, and Reyes-García 2012) to analyse the management of TAK as a commons by a close community with tight social bonds. Specifically, we focus on landrace knowledge (resource) held by gardeners of Vall Fosca, a rural Pyrenean valley of Northeastern Spain (community) and managed through an informal social network of seeds exchange (rules and participatory property regime) promoting cultural identity and social cohesion within the community and likely enhancing agrobiodiversity conservation (use value).

Vall Fosca is a Pyrenean valley, of about 200 km² and 1000 inhabitants. It has traditionally been a farming area, where most households practiced stockbreeding and home gardening. Home garden products were mostly grown for household needs and normally not commercialized. As part of household activities, women customarily managed home gardens and were the main seed and TAK holders. According to our informants, before the 1970s, when accessibility to the market town improved, seed self-storage and exchange were the most common ways to procure seeds. Nowadays, as much as 80% of plants in the studied gardens have a commercial origin (Calvet-Mir et al. 2011), but since landraces seeds are not commercialized, they can only be acquired via self-storage or exchange, a practice not regulated under current Spanish legislation.

Traditional landrace knowledge includes information on the appropriated sowing, planting, and harvesting calendar, the type of manure and rotations adequate for each landrace, and instructions for storing or using the plant (Calvet-Mir et al. 2010). Information from a 10-month fieldwork in the area suggests that, typically, landraces knowledge is not transmitted in a vacuum, but in association with the landraces themselves. Moreover, the transmission of landraces and associated knowledge mostly occurs within the inhabitants of the valley who manage a home garden (n=76) and who spontaneously link to one another through the exchange of landraces seeds to form a social network of seeds exchange (*sensu* Borgatti et al. 2009), in which some gardeners living outside the research area also take part (n=35) (Calvet-Mir et al. 2012b). The close examination of network members suggests that the community within which seeds and TAK exchange happens is restricted to people with close social (i.e., family, friends) and geographical bounds (i.e., neighbours). In other words, the community of Vall Fosca

landraces users is based on informal rules of landraces seed exchange shaped by geographical and social proximity.

Regarding the rules that govern landraces use and production, we found that there were no institutionalized decision makers, although the most active gardeners within the network of exchange were also those who cultivated more landraces and had more traditional agricultural landrace knowledge (Calvet-Mir et al. 2012b). These knowledge holders were mainly women and people that had cultivated a home garden for more than 25 years (i.e. experienced gardeners). We also found that the network had a low density of exchanges and was fragmented (implying that not all the people of the network are connected via seed exchange) (Calvet-Mir et al. 2012b). For example, we observed a marked geographical distribution of the network ties, with most network members settled in the valley and clustered around five small networks, three of them corresponding to exchanges among people from the most geographically isolated villages who mainly exchange seeds among themselves. Fragmentation hampers the possibility of an individual to access all the landrace knowledge circulating in the network, while low density implies few interactions between gardeners.

Finally, landraces knowledge might have important social and environmental use values. Our findings suggest that landraces knowledge is associated to the preservation of cultural identity, as gardeners interviewed mentioned the maintenance of local traditions as an important reason to conserve landrace knowledge (Calvet-Mir et al. 2011). Landraces knowledge is also associated to the creation, maintenance, and strengthening of social relations. For example, gardeners in Vall Fosca multiply their seeds not only for their own planting needs, but also so they have enough to offer to friends and relatives. Gifts of local landraces and the sharing of knowledge about them are locally highly appreciated. It is also likely that, as in other areas of

the industrial world (Vogl and Vogl-Lukasser 2003), the exchange of landraces in Vall Fosca favours overall agrobiodiversity given that, as landraces are reproduced and circulated outside the market system, they provide an alternative source of agrobiodiversity.

In sum, landraces knowledge in Vall Fosca seems to circulate through a network of users, who ensure the preservation of landraces and associated knowledge (Reyes-García et al. 2013). Such network is –mostly- locally based and constructed around a social fabric that has created informal governance mechanisms for landraces and associated knowledge management. These management rules promotes culturally adapted food systems and respect the right of farmers to produce and exchange their own seeds and knowledge.

4. P2P governance of digitalized TAK Commons. The CONECT-e platform

When referring to traditional knowledge (and TAK specifically), we often think of closely bounded communities living in rural areas, such as gardeners in Vall Fosca. However, the technological revolution opens the possibility of making TAK accessible to all kinds of users around the globe. Indeed, there have already been some attempts to digitalize TAK, mostly with the objectives either to preserve it in databases or to promote its use in alternative food production systems (Lakshmi Poorna, Mymoon, and Hariharan 2014; Cox 2015). The digitalization of the knowledge commons has implications regarding its governance (Boyle 2003). In this section, we explore one initiative aiming to digitalize TAK in order to prevent both its erosion and its enclosure. As in the previous section, the resource is landrace knowledge; however, in this case it is shared via a user-based internet platform (the community) and managed through P2P governance mechanisms (rules).

CONNECT-e (www.conecte.es) is a Wikipedia-like citizen science initiative in Spain aiming to gather and share traditional ecological knowledge. According to its founders, this project was born out of two coexisting needs: 1) to encourage citizen's contribution to the Spanish Inventory of Traditional Ecological Knowledge (a static bibliographic compilation of ethnobotanical referenced knowledge (Pardo-de-Santayana et al. 2014) and 2) to create a dynamic inventory of traditional ecological knowledge associated to them in order to contest misappropriation/enclosure issues. Thus, the platform gathers not only TAK (knowledge on local landraces' names, uses and management, among other information) but also traditional knowledge regarding wild plants, animals, ecosystems and climate change indicators. The structure of the digital platform regarding landraces knowledge has been designed following both scientific and civil society inputs (with various seed exchange network NGOs tightly collaborating with the project).

Despite the fact that the digitalization of knowledge commons loosens the boundaries of excludability and the idea of a community linked by close social ties (such as in Vall Fosca), there is little doubt that there still exists a community of users in CONNECT-e. In this case, the community is formed by the registered users that contribute with their TAK to the platform. Although the project is financed by the Spanish government, information displayed is accessible to the whole online community and thus it does not belong to the state. Moreover, the platform operates outside market rules of use and distribution. However, as in other cases of digital commons, such as Linux or Wikimedia Foundation, there is a core community formed by those who have created the tool and who take decisions on the governance of this digitalized common.

Most of the decisions taken by the platform management group support the implementation of typical P2P governance mechanism: promoting equipotentiality, heterarchy, holoptism, openness, networking, and transparency (Kostakis 2010). In CONECT-e, membership is open and widespread, encouraging the free collaboration of all users (potentially anyone with an internet connection and TAK), thus supporting openness and equipotentiality. Although users are geographically dispersed, some of them are organized in physical networks (e.g., local seed networks, students from agrarian schools). Moreover, features such as “following” or “commenting” promote the creation of a digital social network that can potentially be stronger than the broader community. The platform is also characterized by a high degree of transparency, with users being able to track all editions and comments, as well as to get a horizontal view of all the components of the project (holoptism). Thus, CONECT-e does not function hierarchically, but rather allows diverse teams or individuals to participate in the platform at the same time and in different directions (heterarchy).

Thanks to its structure, CONECT-e contributes to the expansion of the benefits and beneficiaries (in terms of use value) of traditional landrace knowledge by harnessing knowledge from its close and territorial boundaries and making it available to a geographically dispersed extended community. It also contributes to preserving TAK as a commons at the same time that offers the opportunity of cross-pollination of information, trials, and experimental learning.

As the project was launched at the time of writing (March 2017), it is difficult to foresee which social dilemmas may be associated with its functioning and expansion. However, drawing on previous examples, such as Wikipedia, we can foresee some social dilemmas related to the implementation of the P2P governance in CONECT-e. Firstly, CONECT-e has ‘contributors’

and ‘editors’, who acquire this status through meritocracy (either based on academic or contribution records). This distinction could lead to the emergence of benevolent dictatorships or to conflicts between inclusionists and deletionists (Kostakis 2010). For example, under current rules, editors can decide to delete a specific TAK contribution made by a user, leading to possible biases and bottlenecks regarding the expansion of the platform’s content.

Another potential social dilemma associated to CONECT-e relates to the idea that low excludability (and thus potential free-riding) may lead to a lack of incentives to contribute new knowledge (Boyle 2003). In that sense, the lack of economic incentives and the gap between knowledge holders (mainly elders) and the digital environment in which CONECT-e is set might result in a lack of participants sharing knowledge in CONECT-e. Although CONECT-e only gathers previously generated knowledge (and does not necessarily require creative or innovative efforts), one could argue that, as it happens with any classic public good that can be copied freely without paying the creator (free riding), it needs economic incentive mechanisms for sustaining collaboration. It is too early to know to what extent this social dilemma might affect CONECT-e, as it is also true that despite potentially being a threat, examples such as Wikipedia or Encyclopaedia of Life suggest that the project could still work without these incentives.

5. Discussion

Although operating at different scales, the seed exchange network of Vall Fosca and the CONECT-e platform could be seen as multiple layered or even as nested series of governance that guarantee overall preservation of TAK. Ostrom (1990) identifies nested enterprises of governance as one of the design principle of robust, long-enduring, common-pool resource institutions. Such resource systems often exist in complex institutional settings in which smaller

commons are nested within larger ones (Ostrom 2005). The concept has evolved from the natural resource commons framework to the knowledge commons framework taking into account the local-regional-global scales, being envisioned as different groups functioning at various levels within locally provided but globally shared resources (Hess and Ostrom 2007). This principle of nested series of governance contributing to the sustainability of the commons resembles the concept of federated networks (Networkcultures 2016) or heterarchical hybrid modes of organization (Kostakis 2010) that are used in the digital commons, where knowledge is circulated via a distributed network (P2P) of one or various centralized networks (entities that aggregate content). The idea is that autonomous sub-entities (such as the network of gardeners in Vall Fosca) can aggregate to form one single larger entity sharing knowledge (i.e., the CONECT-e platform). When applied to the real world, the nested/federated mode of organization could guarantee the exchange of different types of TAK within the multi-layered network, engaging people into a continuous learning process whereby TAK can be updated and adapted from the bottom (Bodin, Crona, and Ernstson 2006), while assuring coordination to cope with social dilemmas (Prell, Hubacek, and Reed 2009). Moreover, this type of governance could help avoid the loss of knowledge that is not useful for people (and is not exchanged anymore) within the sub-entity of the P2P network thanks to the possibility of storing it and making it available for others within a superior governance unit (Reyes-García, Balbo, et al. 2016). For example, some of the traditional landrace knowledge in Vall Fosca is being lost due to gardener's lack of time for making a seed bank: if stored in the CONECT-e platform, this knowledge could be updated, shared and used by others outside Vall Fosca, maintaining TAK alive and expanding its boundaries.

However, it is also true that globally sharing TAK that is locally provided can generate social dilemmas which are not present or not acknowledged in governing TAK with only one level. For example, the tight connections that ensured appropriate management of TAK in Vall Fosca through peer-pressure and monitoring might become looser when the community of people sharing knowledge enlarges to include people without any social tight (as in the case of CONECT-e). The low level of excludability that characterizes digitalized knowledge commons may lead to conflictive issues in terms of protection of local TAK that is gathered and stored in CONECT-e. Although some authors argue that the mere existence of databases could already protect the knowledge in case of misappropriation by actors interested in acquiring private intellectual property rights over it (Lakshmi Poorna et al. 2014), others argue that in order to fully protect TAK and its commons nature, a licensing that follows a copy left approach (such as the General Public Licensing, used commonly to secure copyleft over open source software) should be implemented (see for example the ideas on Open Variety Rights; Deibel 2013). Following this approach, TAK content in CONECT-e is protected under the Creative Commons Attribution -ShareAlike 4.0 International License², which allows reproduction but only under the same licensing system. In our opinion, this solution may offer a powerful tool to counter-act against knowledge commons enclosure.

6. Conclusion

we have explored the degree to which traditional agricultural knowledge is constructed and managed under the commons framework offering two examples where TAK is shared by communities that operate at contrasting scales (local and global). Taking each case study

² <https://creativecommons.org/licenses/by-sa/4.0/>

independently, we have examined how various components of TAK (i.e., the community sharing the resource, the rules governing access, and the value created by it) provide arguments to support 1) that TAK has been traditionally managed under a commons framework (in the case of Vall Fosca) and 2) that, even when TAK shifts from the local to the global digital world (the CONECT-e platform), can still be managed as a commons. In the last part we discussed potential links between the two cases and provided insights on how a nested commons governance framework could facilitate the interaction between local and global knowledge commons, thus helping us contextualize commoning as a social process (Kostakis and Bauwens 2014). As such, the approach has the potential to overcome the various intellectual property rights limitations that, in many situations, turned seeds and their associated knowledge into objects of exclusionary property (Dafermos and Vivero Pol, 2015).

By uncovering the features that justify considering local and global TAK as a knowledge commons, we have out-ruled the idea that TAK is an unmanaged resource, an idea in line with what (Hardin 1968) presented to describe the tragedy of the common pool resources and typically used as an argument in favour of the commons enclosure (Boyle, 2003). Both in Vall Fosca and CONECT-e we found a “regime for ensuring that the artifacts of community based productive efforts remain under the control of that community” (Kostakis and Bauwens 2014). Considering that the commons framework offers an alternative paradigm and creates a space of interaction that is different from that of the market or of the state (Bollier and Helfrich 2014, Kostakis and Bauwens 2014), including TAK under the commons framework is more than an intellectual exercise: it is a political stand. If considered, perceived, practiced and governed as a commons, TAK should not be subjected to the rules of the market nor to state-fostered initiatives, but rather be part of the “Commons”.

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References

- Abay, Fetien, Walter de Boef, and Åsmund Bjørnstad. 2011. Network analysis of barley seed flows in Tigray, Ethiopia: supporting the design of strategies that contribute to on-farm management of plant genetic resources. *Plant Genetic Resources* 9 (4):495-505.
- Aw-Hassan, Aden, Ahmed Mazid, and Hisham Salahieh. 2008. The role of informal farmer-to-farmer seed distribution in diffusion of new barley varieties in Syria. *Experimental Agriculture* 44 (3):413-431.
- Berkes, F., J. Colding, and C. Folke. 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications* 10 (5):1251-1262.
- Bodin, O., B. Crona, and H. Ernstson. 2006. Social networks in natural resource management: What is there to learn from a structural perspective? *Ecology and Society* 11 (2).
- Bollier, D., and Silke Helfrich, eds. 2014. *The wealth of the commons: A world beyond market and state*. London: Levellers Press.
- Borgatti, S., A. Mehra, D. J. Brass, and G. Labianca. 2009. Network Analysis in the Social Sciences. *Science* 323:892-895.
- Boyd, Robert, Peter J. Richerson, and Joseph Henrich. 2011. The cultural niche: Why social learning is essential for human adaptation. *Proceedings of the National Academy of Sciences of the United States of America* 108:10918-10925.
- Boyle, J. 2003. The Second Enclosure Movement and the Construction of the Public Domain. *Law and Contemporary Problems* 66:33-74.
- Brush, Stephen B. 2004. *Farmers' Bounty: Locating Crop Diversity in the Contemporary World*. Yale: Yale University Press.
- Calvet-Mir, L., M. Calvet-Mir, J. L. Molina, and V. Reyes-García. 2012. Seeds exchange as an agrobiodiversity conservation mechanism: A case study in Vall Fosca, Catalan Pyrenees, Iberian Peninsula. *Ecology and Society* in press.
- Calvet-Mir, L., E. Gómez-Bagetthun, and V. Reyes-García. 2012. Beyond food production: Ecosystem services provided by home gardens. A case study in Vall Fosca, Catalan Pyrenees, northeastern Spain. *Ecological Economics* 74:153-160.
- Calvet-Mir, Laura, Maria Calvet-Mir, and V. Reyes-García. 2010. Traditional ecological knowledge and landraces in situ conservation in high mountain home gardens of Vall Fosca, Catalan Pyrenees, Iberian Peninsula. In *Tradiciones y transformaciones en etnobotánica.*, edited by M. L. Pochettino, A. H. Ladio and P. M. Arenas. Buenos Aires, Argentina: CYTED.
- Calvet-Mir, Laura, Maria Calvet-Mir, Laura Vaqué-Nuñez, and Victoria Reyes-García. 2011. Landraces in situ Conservation: A Case Study in High-Mountain Home Gardens in Vall Fosca, Catalan Pyrenees, Iberian Peninsula. *Economic Botany* 65 (2):146-157.
- Ceccarelli, S., E. P. Guimarães, and E. Weltzien, eds. 2009. *Plant Breeding and Farmer Participation*. Rome: FAO.
- Cox, D. . 2015. Farm Hack : A Commons for Agricultural Innovation. In *Patterns of Commoning.* , edited by D. Bollier and S. Helfrich: The Commons Strategy Group and Off the Common Press.
- Dafermos, G. , and J. L. Vivero Pol. 2015. Sistema agro-alimentario abierto y sostenible para Ecuador. In *Buen Conocer-FLOK Society: Modelos sostenibles y políticas públicas para una economía social del conocimiento común y abierto en Ecuador*, edited by D. Vila-Viñas and X. E. Barandiaran. Quito Instituto de Altos Estudios Nacionales.

- Deibel, E. . 2013. Open Variety Rights: Rethinking the Commodification of Plants. *Journal of Agrarian Change* 13:282-309.
- Engels, Johannes M. M., Hannes Dempewolf, and Victoria Henson-Apollonio. 2011. Ethical Considerations in Agro-biodiversity Research, Collecting, and Use. *Journal of Agricultural & Environmental Ethics* 24 (2):107-126.
- Federici, S. . 2010. Feminism and the politics of the commons in an era of primitive accumulation, . In *Uses of a Whirlwind: Movement, Movements, and Contemporary Radical Currents in the United States.*, edited by T. C. Collective. Oakland, CA,: AK Press.
- Frischmann, Brett M., Michael J. Madison, and Katherine J. Strandburg, eds. 2014. *Governing Knowledge Commons*. Oxford: Oxford UP.
- Ghijzen, H. 2009. Intellectual property rights and access rules for germplasm: benefit or straitjacket? *Euphytica* 170 (1-2):229-234.
- Gilles, Jere L., Justin L. Thomas, Corinne Valdivia, and Edwin S Yucra. 2013. Laggards or Leaders: Conservers of Traditional Agricultural Knowledge in Bolivia. *Rural Sociology* 78 (1):51-74.
- Halewood, M. . 2013. What kind of goods are plant genetic resources for food and agriculture? Towards the identification and development of a new global commons. *International Journal of the Commons* 7.
- Hardin, Garret. 1968. The tragedy of the commons. *Science* 162 1243-1248.
- Heinrich, Michael. 2015. New Medicines Based On Traditional Knowledge: Indigenous and Intellectual Property Rights from an Ethnopharmacological Perspective. In *Ethnopharmacology*: John Wiley & Sons, Ltd.
- Hess, Charlotte, and Elinor Ostrom, eds. 2007. *Understanding Knowledge as a Commons. From Theory to Practice*: The MIT Press.
- Kawa, Nicholas C., Christopher McCarty, and Charles R. Clement. 2013. Manioc Varietal Diversity, Social Networks, and Distribution Constraints in Rural Amazonia. *Current Anthropology* 54 (6):764-770.
- Kloppenburg, J. 2010. Impeding Dispossession, Enabling Repossession: Biological Open Source and the Recovery of Seed Sovereignty. *Journal of Agrarian Change* 10 (3):367-388.
- Kostakis, V. . 2010. Identifying and understanding the problems of Wikipedia's peer governance: The case of inclusionists versus deletionists. *First Monday* 15:1-11.
- Kostakis, V., and M. Bauwens. 2014. *Network society and future scenarios for a collaborative economy*: Palgrave Macmillan.
- Labeyrie, Vanesse, Bernard Rono, and Christian Leclerc. 2014. How social organization shapes crop diversity: an ecological anthropology approach among Tharaka farmers of Mount Kenya. *Agriculture and Human Values* 31 (1):97-107.
- Labeyrie, Vanesse, Mathieu Thomas, Zachary K. Muthamia, and Christian Leclerc. 2016. Seed exchange networks, ethnicity, and sorghum diversity. *Proceedings of the National Academy of Sciences* 113 (1):98-103.
- Lakshmi Poorna, R., M. Mymoon, and A. Hariharan. 2014. Preservation and protection of traditional knowledge - diverse documentation initiatives across the globe. *Current Science* 107 (8):1240-1246.
- Luby, C. H., J. Kloppenburg, T. E. Michaels, and I. L. Goldman. 2015. Enhancing Freedom to Operate for Plant Breeders and Farmers through Open Source Plant Breeding. *Crop Science* 55 (6):2481-2488.

- Macilwain, C. 1998. When rhetoric hits reality in debate on bioprospecting. *Nature* 392 (6676):535-+.
- MacKinnon, Rebecca. 2012. *Consent of the Networked. The worldwide struggle for Internet freedom*: Basic Books.
- Malezieux, Eric. 2012. Designing cropping systems from nature. *Agronomy for Sustainable Development* 32 (1):15-29.
- Moran, K., S. R. King, and T. J. Carlson. 2001. Biodiversity prospecting: Lessons and prospects. *Annual Review of Anthropology* 30:505-526.
- Networkcultures 2016, <http://networkcultures.org/unlikeus/resources/articles/what-is-a-federated-network/>. Last accessed: 23/12/2016.
- Ostrom, E. 2005. *Understanding Institutional Diversity*. Princeton: Princeton University Press.
- Ostrom, Elinor. 1990. *Governing the Commons. The Evolution of Institutions for Collective Action*. 1281. Cambridge: Cambridge University Press.
- Pardo-de-Santayana, M., R. Morales, L. Aceituno-Mata, and M. Molina. 2014. *Inventario Español de los Conocimientos Tradicionales relativos a la Biodiversidad*. Madrid, Spain: MAGRAMA.
- Prell, C., K. Hubacek, and M. Reed. 2009. Stakeholder Analysis and Social Network Analysis in Natural Resource Management. *Society & Natural Resources* 22 (6):501-518.
- Quilligan, J. B. 2012. Why distinguish common goods from public goods? In *The Wealth of the Commons: A World Beyond Market & State*, edited by D. Bollier and S. Helfrich. Amherst: Levellers Press.
- Reyes-García, V., V. Vadez, S. Tanner, T. Huanca, W. R. Leonard, and T. McDade. 2007. Ethnobotanical skills and clearance of tropical rain forest for agriculture: A case study in the lowlands of Bolivia. *Ambio* 36 (5):406-408.
- Reyes-García, Victoria, Laura Aceituno-Mata, Laura Calvet-Mir, Teresa Garnatje, Erik Gomez-Baggethun, Juan J. Lastra, Ricardo Ontillera, Montserrat Parada, Montserrat Rigat, Joan Valles, Sara Vila, and Manuel Pardo-de-Santayana. 2014. Resilience of traditional knowledge systems: The case of agricultural knowledge in home gardens of the Iberian Peninsula. *Global Environmental Change-Human and Policy Dimensions* 24:223-231.
- Reyes-García, Victoria, Andrea L. Balbo, Erik Gómez-Baggethun, Maximilien Gueze, Alex Mesoudi, Peter J. Richerson, Xavier Rubio-Campillo, Isabel Ruiz-Mallén, and Stephen Shennan. 2016. Multilevel processes and cultural adaptation: examples from past and present small-scale societies. *Ecology and Society* 21 (4).
- Reyes-García, Victoria, Maximilien Guèze, Isabel Díaz-Reviriego, Romain Duda, Álvaro Fernández-Llamazares, Sandrine Gallois, Lucenteza Napitupulu, Martí Orta-Martínez, and Aili Pyhälä. 2016. The Adaptive Nature of Culture: A Cross-Cultural Analysis of the Returns of Local Environmental Knowledge in Three Indigenous Societies. *Current Anthropology* 57 (6):761-784.
- Reyes-García, Victoria, Jose Luis Molina, Laura Calvet-Mir, Laura Aceituno-Mata, Juan J. Lastra, Ricardo Ontillera, Montse Parada, Manuel Pardo-de-Santayana, Montse Rigat, Joan Valles, and Teresa Garnatje. 2013. "Tertius gaudens": germplasm exchange networks and agroecological knowledge among home gardeners in the Iberian Peninsula. *Journal of Ethnobiology and Ethnomedicine* 9.
- Riu-Bosoms, Carles, Laura Calvet-Mir, and Victoria Reyes-García. 2014. Factors enhancing landrace in situ conservation in home gardens and fields in Vall de Gosol, Catalan Pyrenees, Iberian Peninsula. *Journal of Ethnobiology* 34 (2):175-194.

- Salpeteur, M., H. Patel, A.L. Balbo, X. Rubio-Campillo, M. Madella, P. Ajithprasad, and V. Reyes-García. 2015. When Knowledge follows the blood. Kin Groups and the Distribution of Ecological Knowledge in a Community of Semi-nomadic Pastoralists Gujarat (India). *Current Anthropology* 56 (3):471-483.
- Shiva, Vandana. 1997. *Biopiracy. The Plunder of Nature and Knowledge*. Boston: South End Press.
- Shiva, Vandana. 2004. Trips, Human Rights and the Public Domain. *The Journal of World Intellectual Property* 7 (5):665-673.
- Siebenhuner, B., T. Dedeurwaerdere, and E. Brousseau. 2005. Introduction and overview to the special issue on biodiversity conservation, access and benefit-sharing and traditional knowledge. *Ecological Economics* 53 (4):439-444.
- Siefkes, C. 2012. Beyond digital plenty. Building blocks for physical peer production. *Journal of Peer Production*.
- Smale, M., M. R. Bellon, D. Jarvis, and B. Sthapit. 2004. Economic concepts for designing policies to conserve crop genetic resources on farms. *Genetic Resources and Crop Evolution* 51 (2):121-135.
- Soejarto, D. D., H. H. S. Fong, G. T. Tan, H. J. Zhang, C. Y. Ma, S. G. Franzblau, C. Gyllenhaal, M. C. Riley, M. R. Kadushin, J. M. Pezzuto, L. T. Xuan, N. T. Hiep, N. V. Hung, B. M. Vu, P. K. Loc, L. X. Dac, L. T. Binh, N. Q. Chien, N. V. Hai, T. Q. Bich, N. M. Cuong, B. Southavong, K. Sydara, S. Bouamanivong, H. M. Ly, T. Van Thuy, W. C. Rose, and G. R. Dietzman. 2005. Ethnobotany/ethnopharmacology and mass bioprospecting: Issues on intellectual property and benefit-sharing. *Journal of Ethnopharmacology* 100 (1-2):15-22.
- Thomas, Mathieu, and Sophie Caillon. 2016. Effects of farmer social status and plant biocultural value on seed circulation networks in Vanuatu. *Ecology and Society* 21 (2).
- Thomas, Mathieu, Julie C. Dawson, Isabelle Goldringer, and Christophe Bonneuil. 2011. Seed exchanges, a key to analyze crop diversity dynamics in farmer-led on-farm conservation. *Genetic Resources and Crop Evolution* 58 (3):321-338.
- Vandermeer, John, and Ivette Perfecto. 2013. Complex Traditions: Intersecting Theoretical Frameworks in Agroecological Research. *Agroecology and Sustainable Food Systems* 37 (1):76-89.
- Vogl, C. R., and B. Vogl-Lukasser. 2003. Tradition, dynamics and Sustainability of plant species composition and management in homegardens on organic and non-organic small scale farms in alpine Eastern Tyrol, Austria. *Biological Agriculture & Horticulture* 21:349-366.
- Whitt, L. A. . 1998. Biocolonialism and the commodification of knowledge. *Science as culture* 7:33-67.