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The Contribution of Traditional Agroecological Knowledge as a Digital Commons to Agroecological Transitions: The Case of the CONECT-e Platform

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Abstract: Traditional agroecological knowledge (TAeK) refers to the cumulative and evolving body of knowledge, practices, beliefs, institutions, and worldviews about the relationships between a society or cultural group and their agroecosystems. These knowledge systems contribute to maintaining environmental and culturally sensitive food systems and have been considered very relevant for agroecological transitions, or the processes of scaling-up and -out agroecology. However, TAeK's erosion and enclosure threatens its use and reproduction, which in turn might affect TAeK's potential contribution to agroecological transitions. Here, we explore how transforming TAeK, and particularly TAeK on landraces, into a digital commons can contribute to its maintenance and protection, and thus to agroecological transitions. We do so by analyzing the CONECT-e platform, an initiative for digitally storing and sharing TAeK in a participatory way. One year after being launched, CONECT-e has documented 452 geographically distinct landraces from 81 different species. The information shared in this platform is well-structured, clear, and reliable; it thus allows for the replication of the knowledge reported. Moreover, because CONECT-e makes the documented information freely available and protects it with a copyleft license, placing information in this platform could help one face landrace misappropriation issues. CONECT-e, or similar initiatives, could contribute to agroecological transitions via maintaining TAeK under the digital commons framework, making it accessible to all society and avoiding enclosure processes.

Keywords: agri-food system; agroecology; agroecosystem; copyleft license; enclosure; erosion; landrace; local knowledge; misappropriation; social-ecological system

1. Introduction

Traditional Agroecological Knowledge (TAeK) refers to the cumulative and evolving body of knowledge, practices, beliefs, institutions, and worldviews about the relationships between a society or cultural group and their agroecosystems (adapted from [1]). Examples of TAeK include practices and beliefs related to agroecosystem management [2,3], knowledge about landraces [4,5], or cosmovisions and institutions regulating the management of resources used in agriculture such as water [6]. TAeK is culturally transmitted from generation to generation, and it evolves and adapts to the local environment and the cultural contexts [7–10]. TAeK systems encompass information about how to recognize and efficiently manage agricultural landscapes and elements of the agroecosystem in environmentally and culturally adapted ways [9,11]. While TAeK draws from historical and intergenerational continuity in resource management, it should not be considered static or in isolation from other knowledge systems [12]. Rather, TAeK is constant changing and has shown the capacity to adapt and co-exist with other farming systems, including industrial agriculture, in a dynamic process that encompasses a complex mix of knowledge replication, loss, addition, and transformation [12]. Recent work suggests that, as with other types of knowledge [13–15], TAeK has been traditionally managed as a common resource: a resource governed by a group of people who have self-developed rules to handle the social dilemmas derived from its collective use, i.e., situations in which there is a conflict between immediate individual self-interest and long-term collective interest [9].

Researchers have highlighted that knowledge embedded in traditional agricultural systems is relevant for social-ecological sustainability [16], particularly in situations of change or when uncertainty is high [12]. For example, researchers have argued that considering current demographic, economic, and cultural changes, the conservation of diversified agroecosystems (e.g., dehesas, home gardens) requires the maintenance and application of TAeK [12,17,18]. TAeK has also been reported to be very relevant for agroecological transitions or the processes of scaling-up and -out agroecology. Indeed, different bodies of research have documented the relevance of TAeK for the ecological, cultural, economic, social, spiritual, and political dimensions of agroecological transitions [19–24]. A particular domain of TAeK that can be very relevant to agroecological transitions is TAeK on landraces [25]. We define landraces as a group of plants of a particular botanical taxon selected by farmers from among domesticated or wild species, resulting in crops that are adapted to the local environmental conditions and the local agrarian culture [26–29]. TAeK on landraces includes information regarding landraces' morphologic, agronomic, and sensorial characteristics that guides the local evaluation and selection criteria. It also comprises landrace management practices (e.g., sowing, planting, harvesting calendar, type of manure, rotations, and storing) and uses (e.g., culinary, fodder, and medicinal) [30].

TAeK on landraces can contribute to the different dimensions of agroecological transitions. Being dynamic populations adapted to changing local environmental conditions and requirements [31,32], landraces have a low dependence on external inputs like pesticides or fertilizers [33–35]. In that sense, TAeK on landraces includes pest and soil control management practices that build on the interaction between the natural elements of the agroecosystem and thus offers an alternative to the use of chemical pesticides and fertilizers. TAeK on landraces also allows landraces maintenance and thus fosters cultivated biodiversity and promotes agroecosystem redesign using a biodiversity intensive strategy [36]. These characteristics make landraces and their associated knowledge very relevant to the ecologic and economic dimensions of agroecological transitions. Furthermore, landraces and their associated knowledge are part of the contemporary's natural and cultural heritage [37], which is deeply rooted in the socio-cultural identity of agrarian communities [28] and part of their biocultural memory, or the current expression of a long historical legacy of interrelationships between human beings and nature [38,39], including the circulation of crop species and biological innovations [40]. This relation makes landraces and their associated knowledge very relevant to the social and cultural dimensions of agroecological transitions. Additionally, some landraces and their associated knowledge allow farmers to reduce production costs and achieve premium prices that are able to economically sustain alternative or traditional -non-industrial- farming practices [5], for which landraces can also

contribute to the economic dimension of agroecological transitions. Lastly, peasant communities understand the need for and fight to have access to landraces and associated TAeK so that they can use them as an alternative to genetically modified organisms (GMOs) and hybrid seeds controlled by corporations [23,41]. This concern makes landraces and their associated knowledge very relevant to the social and political dimensions of agroecological transitions.

Different voices have underlined the threats that TAeK systems face due to their erosion and enclosure [25,42,43]. TAeK on landraces is rapidly eroding due to factors such as loss of inter-generational communication [2] or the industrialization of the agricultural system [18]. Moreover, enclosure issues, such as misappropriation of names or the establishment of landrace's patents granted to breeders or companies, are of great concern to farmers, NGOs, and scientists who have raised voices demanding the protection of landraces and their associated knowledge under a "commons" framework [9,25,44].

Because of the role of TAeK on landraces in facilitating agroecological transitions, its erosion or misappropriation might have potentially negative implications for these processes [45]. Several approaches have been proposed to prevent the erosion and misappropriation of TAeK on landraces, including the application of Intellectual Property Rights to compensate farmers [44] or the management of landraces as public goods [46]. Here, we analyze an approach that tries to include TAeK on landraces under the digital commons framework, in which knowledge is possessed and shared collectively and remains openly available [47]. Specifically, we analyze the potential of the CONECT-e platform, an initiative for digitally storing, sharing, and protecting traditional knowledge in a participatory way, as a way to prevent TAeK on landraces erosion and to contest its enclosure [9]. We analyze how CONECT-e can contribute to (1) document TAeK on landraces, (2) sharing this knowledge in a reproducible format, and (3) protecting it from enclosure. In the last section, we discuss how achieving these goals can contribute to agroecological transitions and the limitations that this approach might face.

2. Materials and Methods

2.1. The CONECT-e Platform

CONECT-e (www.conecte.es) is a citizen science initiative funded by Spanish public institutions aiming to obtain civil society collaboration in the documentation and sharing of traditional ecological knowledge and practices. CONECT-e was born out of the need to encourage citizen's participation in the Spanish Inventory of Traditional Ecological Knowledge (a static bibliographic compilation of ethnobotanical knowledge [48,49]). The current version of the platform, launched publicly in February 2017, includes sections focusing on traditional knowledge regarding plants, landraces, and ecosystems. A Creative Commons Attribution-ShareAlike 4.0 International License (CC BY-SA 4.0) protects all the content of CONECT-e platform. This license requires that any product using original or modified content from CONECT-e is protected under the same copyleft license, thus impeding the establishment of copyrights or trademarks over it. The need to create a dynamic inventory of landraces and associated knowledge to contest enclosure issues motivated the creation of the section on landraces. This section mainly documents information on landraces names, uses, and management. The structure of CONECT-e's landrace section has been co-created by scientists from Spanish universities and research centers (UAB, UB, UAM, UOC, ICTA, IBB, and IMIDRA) working on the Spanish Inventory of Traditional Ecological Knowledge and members of a civil society organization that promotes the commons management of landraces and farmer´s varieties in the agri-food system, the Spanish Seed Network: *Red de Semillas "Resembrando e Intercambiando"* (RdS; http://www.redsemillas.info/).

2.2. Data Collection and Analysis

We used different data collection and data analysis methods to achieve the three objectives of this work. First, to assess whether CONECT-e contributes to the documentation of TAeK on landraces, we explored the information entered by users in the CONECT-e platform. We considered an entry as a

creation of content of any kind. The CONECT-e platform is linked to a database with tables collecting information on users' profile, users' activity, and content provided by users. Here, we analyze the content introduced by users in the landrace section between February 2017 and March 2018. This dataset includes information required to identify the landrace, including landraces' name, species, and location. It also includes eight different sections: (1) vernacular name, (2) description, (3) traditional use, (4) traditional management, (5) images, (6) map, (7) references, and (8) seed providers. Each section has different fields. For example, the section on vernacular names has five different fields: (i) Spanish name, (ii) Catalan name, (iii) Basque name, (iv) Galician name, and (v) other names. In total, there are 41 fields in the eight sections. We used descriptive statistics to analyze these variables and assess the level of landraces documentation in the platform.

Second, to assess whether CONECT-e has contributed to the sharing of TAeK on landraces, we analyzed the quality and reproducibility of the information in the platform and the number of visits to the landrace' pages. Regarding the content quality, CONECT-e uses several filters to assure information accuracy. Specifically, users are encouraged to provide photographs of the landraces (Figure 1), to locate the municipalities where the landrace is cultivated and used, and to report the different names that a landrace might receive in each location (Figure 2). Locating the landraces not only provides a visual representation of the geographical distribution of the landrace, but it also helps in identifying synonymies. Moreover, a team of editors validates all the information entered in CONECT-e before it is made publically available. All these tools help to verify and validate the information, contributing to the accuracy of the information displayed on the platform. To analyze the quality and the reproducibility of TAeK on landraces documented in CONECT-e, we used content analysis. Specifically, we selected the text in the "description", "traditional management", and "seed providers" sections, since information in these sections would allow a user to replicate in the field the knowledge entered in the platform. We obtained 528 text pieces, with an average content length of 125 characters, with some content being as short as six characters. We conducted a systematic reading of these data looking for the presence of meaningful patterns potentially indicating accuracy and reproducibility. We analyzed if the content gave enough details and was sufficiently well written to allow for an external reader to put it in practice. We then selected textual quotes extracted from these text pieces to exemplify the quality and reproducibility of TAeK on landraces documented by CONECT-e. We also analyzed the number of visits to CONECT-e's pages. For this, we used Google Analytics, a software that uses tracking codes and cookies to acquire information on a website's user [50] and produced summary metrics regarding the number of visits to the landrace page and its different sections.

Figure 1. Landraces photographs at CONECT-e's front-page.

Figure 2. Map displaying the municipalities where the landrace mongeta del ganxet (*Phaseolus vulgaris*) is cultivated.

Finally, to assess whether CONECT-e can protect TAeK on landraces from enclosure, we used literature review, desktop research, and informal conversations (face-to-face and via mail) with members of the RdS to identify which landraces documented in CONECT-e have suffered from enclosure issues. The three authors who are members of the RdS reviewed all the landraces documented and noted those that could have experienced enclosure. We then gathered information through informal conversations with members of the RdS and grey literature (i.e., press release, reports, and articles) to catalog the landraces threatened and characterized the enclosure's processes.

All the analysis was fed by our involvement in the Spanish Inventory of Traditional Knowledge on Agricultural Biodiversity, since five of the authors of the present article are part of the project, and by our active participation in the RdS, since three of the authors are lively members of the organization. Participation in these two initiatives grants us a deep understanding of the dynamics of TAeK on landraces in Spain.

3. Results

One year after its launch, the CONECT-e platform had more than 150,000 visits, 467 users registered, and over 19,000 entries. From all the visits to the platform, 27,057 (18.04%) corresponded to visits to the landraces pages. From the users registered, 40 (8.6%) created or modified content on landraces, producing a total of 1892 entries (or 10% of the total entries in the platform).

3.1. Landraces Documented in CONECT-e

CONECT-e users documented 452 geographically distinct landraces from 81 different species and 86 taxa. The crop species with more landraces were tomato (*Solanum lycopersicum*), with 68 landraces (or 15.04% of the total); bean (*Phaseolus vulgaris*), with 45 landraces; and pepper (*Capsicum annuum*), with 34 different landraces documented (Table 1).

The CONECT-e platform documented landraces located in 96 (29.4%) of the 327 Spanish regions ('*comarcas*' in Spanish) and 14 of its 17 autonomous communities (Figure 3). The regions with more landraces documented were Isla de La Palma (38 landraces) and Norte de Tenerife (35 landraces), both in the Canary Islands. Other regions with a high number of landraces documented were Lozoya-Somosierra (Madrid) with 34 landraces and Mallorca (Balearic Islands) with 32 landraces. The unequal geographic distribution does not necessarily represent a highest number of landraces in

these regions, since CONECT-e does not register all the landraces of one region but just the landraces that the users entered.

Table 1. Crop species with more than five landraces documented in CONECT-e.

Scientific Name	English Common Name	Number (%) of Landraces
Solanum lycopersicum	Tomato	68 (15.04)
Phaseolus vulgaris	Bean	45 (9.96)
Capsicum annuum	Pepper	34 (7.52)
Prunus dulcis	Almond	21 (4.65)
Brassica oleracea	Cabbage, broccoli, and cauliflower, among others	19 (4.20)
Solanum melongena	Eggplant	17 (3.76)
Pyrus communis	Pear	16 (3.54)
Solanum tuberosum	Potato	16 (3.54)
Malus domestica	Apple	15 (3.32)
Lactuca sativa	Lettuce	14 (3.10)
Allium cepa	Onion	13 (2.88)
Zea mays	Corn	9 (1.99)
Citrus sinensis	Orange	8 (1.77)
Cucumis melo	Melon	8 (1.77)
Ficus carica	Fig	8 (1.77)
Vitis vinifera	Grape	8 (1.77)
Pisum sativum	Pea	7 (1.55)
Vicia faba	Broad bean	7 (1.55)
Cucurbita maxima	Pumpkin	6 (1.33)

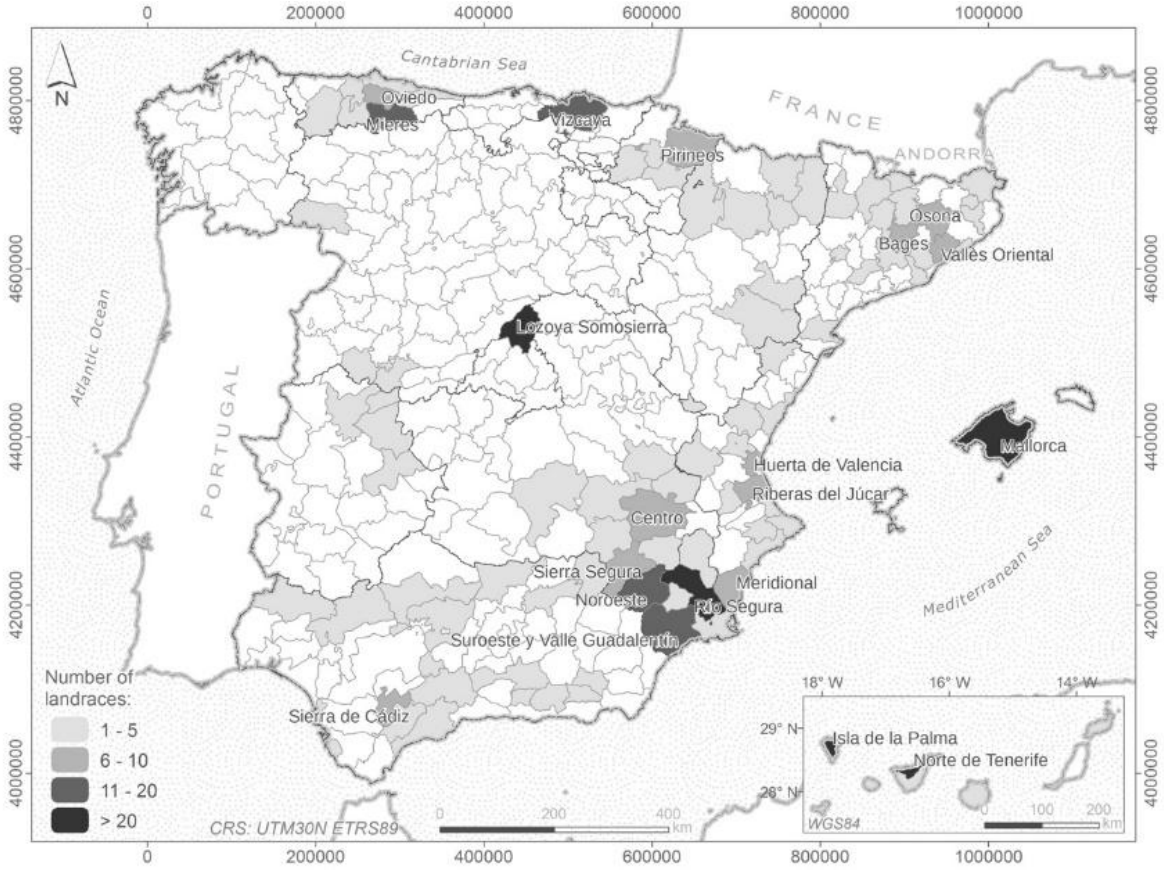

Figure 3. Geographical distribution of landraces documented in CONECT-e.

Users contributed information in 39 of the 41 possible fields. The fields for which participants contributed more data were "images", with 521 photos uploaded, and "traditional uses and management", with 434 entries on the location of landraces' traditional uses and management. These were followed by the fields "plant description and part used", with 116 entries, "Spanish vernacular names", with 115 names recorded, "references and links", with 83 entries documenting references on specific landraces, "taste, flavor and texture", with 63 entries, and "crop cycle", with 55 entries indicating the adequate time for sowing, planting, or harvesting. Some fields, such as "Galician vernacular name" (one of the official languages in the Spanish state) or "medicinal", "fuel", and "construction uses", had no entries.

3.2. TAeK on Landraces Shared in CONECT-e

About one-fourth of the total number of entries on landraces (528 entries or 27.91%) corresponded to information entered in one of the three sections that would allow applying the knowledge documented (i.e., description, traditional management, and seed providers). Moreover, 127 landraces (28%) had at least one entry in one of these three sections, and 54 (12%) had four or more information entries in one or more of the fields from these sections. The landraces with more information on these sections were "mongeta del ganxet" (*Phaseolus vulgaris*, bean); "patata fina" (*Solanum tuberosum*, potato), with information from 16 fields out of 19 possible; and "judía plancheta" (*Phaseolus vulgaris*, bean), with 13 fields completed.

The content analysis of these entries showed that the information gathered is well-structured, clear, and reliable. The information registered might allow the replication of the knowledge reported. For instance, the field on "crop cycle" in the "description" section allowed for the inclusion of TAeK on the sowing, planting, and harvesting periods of each specific landrace. Users added this detailed information for some landraces, such as in the case of "guindilla de Zalla" (*Capsicum annuum*, pepper). Data includes the specific months when this landrace is sowed in the seedbed, transplanted, and harvested. Similarly, the field "pest and diseases" on the "traditional management" section allowed for the entering of accurate descriptions of the most prominent pest and diseases of each landrace, as well as evaluations of the landrace's adaptation to the agroecosystem. In the case of "nabo de Morcín" (*Brassica napus* var. *rapifera*, rutabaga), users entered information acknowledging that this is a very resistant landrace, although it can suffer the attack of crucifer flea beetle (*Phyllotreta cruciferae*) when growing at high temperatures. Finally, in the section on "seed providers", users entered the name of specific landrace's suppliers. In the case of "lechuga moruna" (*Lactuca sativa*, lettuce), "La Troje" association (www.latroje.org) can provide both seeds and seedlings.

Regarding the dissemination of this content, we found that the most visited sections in the landraces' pages were "description" and "vernacular names" (3303 and 2129 visits each), while the least visited sections were "seed providers" (920), "map" (809), and "documents" (462). Considering the information gathered and the number of visits, the most "popular" landraces are "mongeta del ganxet" (*Phaseolus vulgaris*, bean), with 181 entries and 319 visits; "boniato saucero" (*Ipomoea batatas*, sweet potato), with 37 information entries and 751 visits; and "bubango" (*Cucurbita pepo*, zucchini), with 42 entries and 727 visits. Other highly popular landraces are "patata fina" (*Solanum tuberosum*, potato), with 38 entries and 164 visits; "nabo de Morcín" (*Brassica napus* var. *rapifera*, rutabaga), with 33 entries and 526 visits; "pero de Aragón" (*Malus domestica*, apple), with 24 entries and 400 visits; and "tomaca quarentena" (*Solanum lycopersicum*, tomato), with 19 entries and 162 visits. These seven most popular landraces came from seven different regions of Spain and six different autonomous communities.

3.3. Threatened Landraces Documented in CONECT-e

Three of the landraces documented in CONECT-e suffer or have suffered from enclosure: "tomàtiga de ramellet" (*Solanum lycopersicum*, tomato), "bubango" (*Cucurbita pepo*, zucchini), and "mongeta del ganxet" (*Phaseolus vulgaris*, bean). These three landraces resemble one another in that they are very popular in their territories and are much in demand by local consumers. Moreover, their

vernacular names are attached to a significant cultural richness around their use and management and represent a sign of cultural identity in the regions where they grow. Interestingly, these landraces were among the best described in the platform, most likely due to the interest of the different local seed networks in documenting these landraces thoroughly in their efforts to protect them.

In the cases of "tomàtiga de ramellet" and "bubango", two companies tried to appropriate the name of these landraces to market commercial varieties under these names, thus benefiting from the popularity of the landraces. "Tomàtiga de ramellet" is a landrace from Mallorca Island very rooted in the traditional gastronomy, as it is the only tomato that can be preserved throughout the winter. The landrace is also used for the preparation of one of the most typical dishes of the island: bread with tomato and oil. In 2010, two seed companies proposed to create a Protected Geographical Indication (PGI) under the name "tomàtiga de ramellet". This PGI, however, would include a hybrid variety that had neither the landrace capacity for conservation nor its smell or taste. To avoid the misappropriation of the name, in 2012 the "Associació de Varietats Locals de les Illes Balears" (Association of landraces from Balearic Islands, part of RdS) registered the "tomàtiga del ramellet" as a conservation variety in the Commercial Variety Register of the Spanish Ministry of Agriculture (MAPAMA) [51]. However, hybrid varieties are nowadays sold under the name of "tomàtiga d´enfilar" (in which "enfilar" refers to the traditional management practice of tying the "tomàtiga del ramellet" with a thread to keep them during the winter in a cool and dry place) [52]. Our informants from the RdS stated that given that registration as a conservation variety could help protect landraces and landrace's names from misappropriation, the RdS promotes the active registration of landraces, especially of those under risk of misappropriation. However, registration requires a high level of landrace homogeneity, a characteristic not found in many landraces, for which only a small percentage of landraces can be registered under this legal category.

A second variety that faces misappropriation issues is "bubango", a landrace from Tenerife (Canary Islands), whose historical references go back to 1770 [53]. This landrace has recognized quality and prestige as part of the traditional Canarian gastronomy. In recent decades, commercial varieties of round zucchinis are being sold under the name of "bubangos". These varieties have different quality and type of management than the original bubango [54], but the use of the name allows companies to set a higher selling price [55]. The "Red Canaria de Semillas" (Canary Seed Network, part of the RdS) has worked on the cultivation, multiplication, and description of the landrace to proceed to its registration in the registry of conservation varieties of the Spanish Ministry of Agriculture. Moreover, it has engaged in documentation, communication, and denunciation campaign to halt the misappropriation of its name (http://www.redsemillas.info/operacion-bubango/).

The case of "mongeta del ganxet" is slightly different, as in this case the appropriation of the landrace name implies a monopoly that could limit farmers' rights over the landrace. "Mongeta del ganxet" is a landrace cultivated in different regions of Catalonia, where it is very appreciated for its organoleptic features. The creation of a Protected Designation of Origin (PDO) in 2006 limited to a few regions the area where the landrace could be cultivated, thus limiting farmer's rights to produce and trade their landrace outside the PDO. Some experts argued that this limitation might lead to the genetic erosion of "mongeta del ganxet", since, to be part of the PDO, the landrace must have particular morphologic features, excluding the large variability within the landrace population managed by farmers [56]. The documentation of this landrace in 138 municipalities in CONECT-e (Figure 2) evidences that the cultivation of "mongeta del ganxet" extends beyond the limits of the PDO.

4. Discussion

In this article, we analyze the potential of an online platform to contribute to the documentation, sharing, and protection of TAeK on landraces, a body of knowledge that plays a vital role in agroecological transitions. In this section, we elaborate on the findings presented above to help answer a fundamental question raised from agroecological scholars: "In what ways can we recapture

the knowledge developed over centuries of traditional agricultural production experience" [19] (p. 101) so that it contributes to agroecological transitions? [45].

Results presented here suggest that participatory online projects, such as CONECT-e, hold the potential to document a considerable amount of TAeK on landraces, mostly by compiling scattered information in a shared online space. Indeed, the collaborative collection of TAeK on landraces can contribute to creating synergies among data obtained through standard ethnobotanical methods (e.g., inventories, semi-structured interviews) [57]. For example, using the same definition of landrace than in CONECT-e, previous ethnobotanical studies in Spain have gathered information on 133 [26], 39 [28], or 10 landraces [5]. Meanwhile, CONECT-e documented 452 geographically distinct landraces. While ethnobotanical studies are a primary input for the platform, the compilation of dispersed landrace knowledge offers a higher potential to overcome the TAeK erosion than the partial documentation of this knowledge [16]. Altieri and colleagues [58] stated that, for scaling-up and -out agroecology, it is very important to preserve and rescue traditional agroecosystems' cultural and ecological foundations, including the accumulated knowledge and experience related to the management and use of agrobiodiversity. This preservation and rescue of TAeK needs adequate tools, and we argue that a tool like CONECT-e offers vast potential to document knowledge. Notwithstanding, achieving widespread documentation of landraces largely depends on civil society participation, for which the continuous dynamization of CONECT-e seems to be a requirement for success. Only a constant exchange between researchers, farmers, consumers, and civil society organizations will allow the development of CONECT-e's potential. Of particular importance is the participation of strong citizen organizations such as the RdS, since the effort to document landraces depends on their collective work of monitoring landraces and reacting to misappropriation threats.

We also found that TAeK on landraces was introduced in CONECT-e in a well-structured and clear way, making it potentially reproducible. In a context of a worldwide increase of small farmers [59], it is necessary to provide tools that allow farmers to gain increased access to TAeK. This need is increased in European territories, where there has been a higher and longer lasting agricultural intensification process than in other parts of the world, and where farmers do not always inherit TAeK from their close kin and kith, as was done in the past [43,60]. In such a context, a tool like CONECT-e might ease the sharing of TAeK on landraces, information that might be critical for those newly engaging in agroecological transitions [42]. Furthermore, by sharing TAeK on landraces, CONECT-e could enhance the conversion of industrialized agroecosystems to more diverse agroecosystems, a fundamental step in agroecological transitions [36]. TAeK on landraces could also provide security to farmers against diseases, pest, droughts, and other stresses without them having to revert to the use of agrochemicals; the information might also allow farmers to exploit the full range of agroecosystems existing in each region [58,61]. It should be noted, however, that despite the potential contribution of tools like CONECT-e to agroecological transitions, these transitions largely depend on the massive adoption of a diversity of agroecological alternatives [42]. In that sense, although CONECT-e can be a tool for sharing landrace knowledge, farmers might continue facing difficulties in cultivating the landraces due to the European and Spanish regulations on plant material reproduction. These regulations are a paramount obstacle mainly to artisanal seed producers and organic farmers [62]. Artisanal seed producers face two main problems to legalize their activity: (1) the regulations in force demand from them the same requirements as for large seed companies, both regarding the quantity of seed produced and infrastructures and (2) they usually work with unregistered landraces. Organic farmers also face problems cultivating landraces due to organic farming regulations [63] that require the use of organically certified seed, which excludes non-registered landraces.

Finally, CONECT-e has the potential to help protect TAeK on landraces by applying a commons governance system, a move that goes in the direction of fostering an emancipatory movement aiming to increase the power and control of farmers over their own resources and production, a critical foundation for scaling agroecological transitions [23]. In this line, CONECT-e aligns with other initiatives that seek the scaling-up and -out of agroecology [64] through the digital commons movement [47]. These

initiatives include open-software platforms such as Katuma, an initiative that promotes agroecological production and consumption under the framework of the social and solidarity economy using a local version of the Open Food Network tool (https://openfoodnetwork.org/) [65], or P2P Food Lab's, an initiative aiming at empowering citizens in the development of innovative and sustainable solutions that try to re-establish the ties between food production and consumption and educate the public about agroecology [66], or initiatives such as the Farm Hack that seek to document, share, and improve farm tools and associated knowledge with the conviction that transforming agricultural technology into a commons would result in a more adaptive, open, and resilient food system [67].

By making TAeK largely accessible to a community of users who should follow certain management rules, CONECT-e promotes the digital documentation, sharing, and protection of TAeK under the digital commons framework. In this framework, information and knowledge resources are created and possessed collectively or shared between a community that tends to be non-exclusive, that is, making knowledge available (usually free of charge) for third parties. Moreover, the community of people who share this knowledge favors its free use and reuse, instead of exchanging it as a commodity [47]. The digital commons approach then contests the enclosure of the knowledge commons and deconstructs the idea of intellectual property rights [13].

In the real world, the commons approach to knowledge has legal implications. For example, some authors argue that the mere existence of databases could already protect the knowledge in case of misappropriation [68]. However, others say that is necessary to implement a licensing that follows a copyleft approach (such as the General Public Licensing, used commonly to secure copyleft over open source software) to safeguard TAeK and its commons nature (see for example the ideas on Open Variety Rights; [69]). Since landrace knowledge in CONECT-e is protected under the Creative Commons Attribution-ShareAlike 4.0 International License, CONECT-e may offer a powerful tool to counteract against TAeK on landraces commons enclosure. Moreover, this type of registration can be used to account for the 'notorious previous existence' of a landrace and associated knowledge (as it provides an openly available inventory of existing landrace knowledge). Then, being documented in CONECT-e makes varieties non-eligible for formal registration as a protected variety (provided for by the Law 3/2000 of the Spanish Ministry of Agriculture: https://www.boe.es/buscar/doc.php?id=BOE-A-2000-414) [25]. Notwithstanding, CONECT-e cannot prevent misappropriation on its own; instead, it is just a tool to be used by civil society organizations to fight against privatization processes. To counteract the enclosure of TAeK on landraces, it would be necessary (1) to have mechanisms in place for cross-checking that varieties submitted for registration in national registers are not already included in CONECT-e (or similar tools), (2) to guarantee a network of monitors who could detect misappropriation processes, and (3) to have the resources to engage in legal proceedings when misappropriation is observed [25].

CONECT-e has started the online compilation of TAeK on landraces in Spain, capturing the attention of potential users. The project now depends on public funding, which has been secured to guaranty CONECT-e's continuity in the nearby future. However, the project will not be successful unless CONECT-e becomes relevant for farmers, consumers, and agrobiodiversity-related organizations so they are motivated to participate in it. The challenge is not trivial, given that CONECT-e targets traditional knowledge holders who, in the Spanish context, typically are people with strong linkages to the rural world and/or elderly people with limited skills in the use of information and communication technologies. Further dynamization of the platform and increasing collaboration with a large number of stakeholders is required to develop strategies for enlarging CONECT-e's impact. The effort, however, also needs to be sustained in the long term and spread through the Spanish territory, for which continuous funding for the coordinating team need to be secured in the long term. To become a digital common, CONECT-e also faces the challenge to improve user's participation, not only in information sharing but also in decision making.

5. Conclusions

Digitally documenting and sharing TAeK can make widely accessible a body of knowledge developed over centuries in traditional small-scale agroecosystems, potentially contributing to agroecological transitions. Digitally documenting and sharing TAeK might also contribute to efforts concerning its protection and contest knowledge commons enclosure, thus helping farmers and social movements to thwart misappropriation processes. This article is relevant for an international audience as (1) it documents and discusses an innovative initiative that digitally documents, shares, and helps protect TAeK on landraces under the digital commons framework and (2) it presents the potential contributions of this tool to scale-up and -out agroecology. However, although CONECT-e, and alike tools, can contribute to agroecological transitions, these tools alone are not sufficient to deal with the dominant economic and institutional interests promoting research and development under the conventional agroindustrial approach. As other authors emphasize (e.g., [42]), to embrace agroecological alternatives it is necessary to make broad reforms in policies, institutions, and research and development agendas. These reforms should include the cultivation of organic landraces, the open and widespread use of the knowledge generated in research institutions, and the establishment of different regulations for profit-oriented seed companies and for farmers or artisanal seed producers. Finally, we argue that institutional support to local agriculture and groups that carry out the community management of landraces as a political strategy for food security and sovereignty, such as the RdS, is necessary to prevent TAeK on landraces erosion and reach long-term social-ecological sustainability of agri-food systems.

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