Values, norms and practices in Plant biodiversity-based research and innovation commons

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Abstract

In contrast with new opportunities opened up by molecular sciences and bio-informatics that enable to generate and provide ready access to huge amounts of biological datasets, researchers are facing increasing complexity, cost and uncertainty with regard to access to, use and exchange of biological material and information. Combination of global technical, policy and legal issues as well as broader social values and motivations (such as reputation benefits or reciprocity relationships) are key features impacting the circulation and integration of valuable material and information on biological diversity across countries, institutions and individuals.

This paper focuses on concrete biodiversity-based research initiatives that try to increase generation, use and exchange of biological knowledge commons. Three contrasted collaborative initiatives, implemented at different governance levels and drawing on different levels of formalization, are analyzed:

— the GENESYS initiative, a treaty-based international information system that consists in a world-wide meta-information system on plant genetic resources for food and agriculture compiling data from existing national, regional or international genebank information systems in support of the International Treaty on PGRFA;
— the Pl@ntNet initiative, a self-regulatory participatory information system that aims at establishing a highly distributed computational plant identification and collaborative digital system on tropical and Mediterranean plants;
— the ARCAD initiative, a shared research and conservation platform between willing public research institutions that consists in an open multi-function (conservation, research and training) platform devoted to the assessment and better use of crop diversity in Mediterranean and tropical regions in support of development objectives.

Comprehensive assessment of these three network initiatives is undertaken using parameters derived from systematic work on generic design principles of governance of global research commons. The analysis of the various institutional options highlights the mixed nature and diversity of values, norms and practices in biodiversity-based research commons. Ultimately, it suggests that cooperative behaviors in relation to sharing of biological material and information are made easier thanks to the fact that they are embedded in broader collaborative research platforms. By managing to fully capture the non-monetary benefits of the relationships involved, these platforms better reflect the normative practices and needs of the scientific communities involved in biodiversity-based research commons in a global context.
**Introduction**

In contrast with new opportunities opened up by molecular sciences and bio-informatics that enable to generate and provide ready access to huge amounts of biological datasets, researchers are facing increasing complexity, cost and uncertainty with regard to access to, use and exchange of biological material and information.

While the number of pooling initiatives (of material, of data, of technologies) is increasing — reinforced by the reduction of public spending on research —, two major policy evolutions are disrupting cooperative behavior in biodiversity-based research, namely access and benefit sharing and intellectual property rights policies. By overemphasizing monetary incentives, these two frameworks inadequately match the needs and expectations of the research community (Dedeurwaerdere et al., 2012).

Coping strategies to respond to these new rules and regulation involve the implementation of highly heterogeneous initiatives that run counter the establishment of international cooperation necessary to cope with increasingly globalized issues such as biodiversity conservation or food security.

This paper deals with knowledge-sharing processes in biodiversity-based research projects and with the kind of governance mechanisms that applies for to gain cooperation within the various communities. It aims at increasing our understanding about different collective arrangements proposed to promote the widest possible access to scientific information in the research process while maximizing the reciprocal benefits expected in any practice exchange. This paper focuses on concrete biodiversity-based research initiatives that try to increase generation, use and exchange of biological knowledge commons. Three contrasted collaborative initiatives, implemented at different governance levels and drawing on different levels of formalization, are analyzed:
— the GENESYS initiative, a treaty-based international information system that consists in a world-wide meta-information system on plant genetic resources for food and agriculture compiling data from existing national, regional or international genebank information systems in support of the International Treaty on PGRFA;

— the Pl@ntNet initiative, a self-regulatory participatory information system that aims at establishing a highly distributed computational plant identification and collaborative digital system on tropical and Mediterranean plants;

— the ARCAD initiative, a shared research and conservation platform between willing public research institutions that consists in an open multi-function (conservation, research and training) platform devoted to the assessment and better use of crop diversity in Mediterranean and tropical regions in support of development objectives.

Combination of global technical, policy and legal issues as well as broader social values and motivations (such as reputation benefits or reciprocity relationships) are key features impacting the circulation and integration of valuable material and information on biological diversity across countries, institutions and individuals. Comprehensive assessment of these three network initiatives is undertaken using the Institutional Analysis and Development Framework and social capital theory.

The first section briefly presents the theoretical literature and analytical framework derived from the commons and social capital theories. Patterns of interactions that increase researchers’ capacity and ability to share data and knowledge are considered. The next section proposes an analysis of the three initiatives in order to highlight in the last section some findings in terms of governance.
I. Conceptual framework

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Analysis of knowledge producing activities has focused on transformations of knowledge production and flow within academic sector and amongst different spheres of society, in particular industrial and governmental spheres (the triple helix model of Leydesdorff and Etzkowitz, 1996) or with society at large (Mode 2’ of the production of scientific knowledge of Gibbons et al. 1994).

Other extensive works have focused on how norms and institutions of science have been affected by ethical or innovation policy changes. The growing importance of IPR has been extensively studied (Rai, 1999).

In biodiversity-based research, new regulations arising from the Convention of Biological Diversity, in particular the Access and Benefit Sharing and traditional knowledge components, have raised some concerns about their potential impact on research (Gomez Pampa, 2004; Jinnah and Jungurt, 2009). Some initial analysis have been conducted after the recently adoption of the Nagoya Protocol on Access and benefit sharing (Dedeurwaerdere et al., 2012 and Kamau and Winter, 2010).

Commons framework has been applied for knowledge biodiversity commons, such as microbial commons (Hess, Ostrom, 2006; Dawyndt, Dedeurwaerdere and Swings, 2006, Reichman, Dedeurwaerdere, Uhlir, 2011). The IAD framework provides a comprehensive conceptualization of governance parameters influencing resource exchange and use in a context of increased restrictions. It highlights the action arena, the physical attributes, the rule in use, the attributes of communities and patterns of interactions to explain how specific outcome such as knowledge sharing is achieved.

Patterns of interactions are described using social capital theory. Social capital theory account for Assets/Organisational resources rooted within social relationships that can improve the efficiency of
coordinated action (Adler, Kwon, 2002). They constitute resources embedded within networks of human relationships (Nahapiet and Goshal, 1998). Unlike other forms of capital, social capital is owned jointly by the parties in a relationship, and no one player has, or is capable of having, exclusive ownership rights (Nahapiet and Goshal, 1998). A focus on social capital in relation to knowledge sharing shifts the attention from individuals sharing knowledge to communities as knowledge-sharing entities (Huysman and Wulf, 2005).

Based on Nahapiet and Goshal (1998) and Adler and Kwon (2002) and the reconciled version provided by Huysman and Wulf (2005), three dimensions of social capital are considered to analyse pattern of interactions for knowledge and data sharing.

- Structural dimension: who shares knowledge and how is knowledge shared? Structural opportunity to share knowledge
- Cognitive dimension: what knowledge is shared? cognitive ability to share knowledge
- Relational dimension: why and when is knowledge shared? relation-based motivation to share knowledge
II. Knowledge commons in biodiversity-based research projects

The three case studies are described and compared in relation to the main issues of governance mechanisms for knowledge commons.

1. General description

The Pl@ntnet project seeks to resolve the problem of scattered taxonomic data. It aims to develop cutting-edge transdisciplinary research at the frontier between integrative botany and computational sciences, based on the use of large datasets, knowledge and expertise in plant morphology, anatomy, agronomy, genetics, taxonomy, ecology, biogeography and practical uses. It provides free, web-based, easy-access software tools and methods for plant identification and the aggregation, management, sharing and utilisation of all kinds of plant-related data. It also promotes citizens’ involvement as a powerful means to enrich databases with new information on plants and to meet the needs for capacity building in agronomy, botany and ecology.

The ARCAD project is a consortium initiative involving three French agronomic research institutes. It aims to set up a new open multi-function platform (conservation, research and training) devoted to the assessment and better use of plant agro-biodiversity in Mediterranean and tropical regions. ARCAD particularly focuses on the relationship between crop diversity and the processes of domestication and adaptation to the agricultural environment.

The Genesys project addresses the challenge of making key information on germplasm collections readily available. This has repeatedly been identified as a key to increasing use. The project has three components: developing information standards to describe the characteristics of genetic resources that are of most interest to users; deploying a genebank data-management system that is appropriate for users in developing countries; and developing a global accession-level information system.
2. **Physical and institutional context**

As research-based projects, these three projects are sharing knowledge-based resources in more or less formalised way. Unlike ARCAD, Pl@ntnet and Genesys are IT-based projects that do not manage biological resources as such. Primary data and software are consequently the main information-based resources shared by these two projects. Conversely, ARCAD could be seen as a more classical research project that manages the whole spectrum of resources: ideas, data, and research facilities (genebanks, laboratories, research tools).

The three projects are led by the biological/agronomic research community where open sharing norms remain strong. However, some major differences exist with regard to the proximity of applied/commercial concerns and/or the previous existence of enclosure movements in the area of research. The community involved in the Pl@ntnet project is largely composed of botanists interested in plant identification and description. Although there are potential direct applications of the information and knowledge produced by the project, strong open sharing norms still apply in this case. ARCAD and Genesys deal with genetic resources that have been the subject of intense policy debates and where rules and regulations already apply in terms of ABS and IPR. This policy framework has already introduced some important changes in behaviour within the scientific community in relation to the exchange and use of germplasm. In particular, the use of a material transfer agreement for every exchange of material is becoming the norm. However, at this stage, no clear rules have been applied to the information attached to the material. It is still unclear how these changes have affected the data linked to genetic resources that are used and exchanged (Bronwyn Parry, 2004). In all cases, the GR research community involved in the ARCAD or Genesys is used to the extreme sensitivity of data and material sharing in their daily work. This is reinforced in both cases by the projects’ transnational and inter-institutional dimension.
These observations are counter-balanced by the scope of the community brought together by the three projects. A gradient is observed: ARCAD brings together a limited scope of more or less homogenous academics despite differences in their institutional affiliations. It functions as an elite club of a few selected scientists. At the other extreme, Genesys has a global and universal scope and, at least potentially, brings together all GR users worldwide. Pl@ntnet is situated somewhere in between: it is also a club-led initiative, although its membership is potentially extremely wide because it involves the participation of citizens from around the world.

3. Patterns of interactions

In practice, what are the actors and actions related to data/information/knowledge management and sharing in the three projects? What are the patterns of interactions followed?

a) Structural opportunity to share knowledge: who shares knowledge and how is knowledge shared? {infrastructure}

In the ARCAD project, data production, management, processing and sharing is organised by the project member—i.e. almost exclusively researchers from advanced agronomic research institutes. This elite club has complete control over knowledge production and transfer. Data sharing is initially limited to the club with the aim of organising it into a structured set of expertise that tackles frontier research on minor tropical and Mediterranean crops. A classical division of labour is organised with work-packages and regular meetings, workshops and seminars on crosscutting issues. This ensures that knowledge circulates widely among project members and with people outside the project as well. In addition to these research activities, the plan is to develop an operational resource centre that will be responsible for conserving and distributing biological resources, as well as training and hosting capacities targeted to capacity-building for partners in developing countries.

Implementing IT-based data-sharing mechanisms is central to the Pl@ntnet and Genesys projects. However, while both initiatives seek to centralise information in one place (be it a database
or a portal), they have two quite divergent strategies of information and data production, management and sharing. The same kind of elite club approach used by ARCAD also applies to Genesys although the geographical coverage and scope are much wider, if not universal. Genesys was set up to develop the worldwide use and dissemination of data (and ultimately of material). In order to achieve this goal, a division of labour is envisaged between data generators, data providers, data integrators and users. In addition, a hierarchical Russian doll-type system is established to encourage the vertical integration of data, from local to global with a pivotal role given to national (public) deposit systems. Genesys, the global central database and portal, aggregates data from different national or regional primary providers who very often act as data depositors.

Conversely, Pl@ntnet is based on a highly decentralised system of data providers that takes into account the great diversity of the quality of data and media. A combination of various IT applications provides the infrastructure for establishing, maintaining and increasing interactions in communities and hence intensifies social capital among partners. The development of various software packages is carried out collaboratively. This involves either developers from different teams or strong interactions between development teams and thematic user groups, such as botanists, ecologists, agronomists, etc. Four different software packages are being developed: 1) Pl@ntNet-Community, a social network management software that aims to enable its users to have community workspaces to exchange and share knowledge and/or data; 2) Pl@ntNet-NameIt!, an identification and collaborative annotation software that allows users to discuss the determination of plants and to annotate pictures of plants according to the different needs and possible utilisation; 3) Pl@ntNet-DataManager, a decentralised data management software package that allows users to collectively manage data (encouraging group work) and/or facilitates the exchange of data (encouraging the flow of data by individuals or groups of individuals); 4) Pl@ntNet-Identify tool, an image-based identification software that automatically compares a given photo to large image databases. In addition, Mediawiki has been mobilised as part of a collaborative project that can be used by all groups interested in useful plants and plant uses. The content will depend on what each group,
institution and contributor wants to share. This combination of different tools — whose developments are in turn shared among communities — increases collaboration between a wide range of actors. The legal status of and contribution made by the different stakeholders, in terms of quantity and quality, may vary enormously between the stakeholders and over time.

b) Cognitive ability to share knowledge: what knowledge is shared? {info-structure}

The three projects differ with regard to the type of knowledge shared. Scholars often make the key distinction between tacit and explicit knowledge. Here, we refer to the matrix proposed by Spender (1996) who has combined the tacit/explicit distinction with the individual/collective (social) distinction to create a matrix of four elements: individual explicit knowledge, individual tacit knowledge, social explicit knowledge and social tacit knowledge.

Genesys focuses exclusively on individual and social explicit knowledge. The concept of “accession” as the common smallest unit in ex situ conservation, to which a set of standardised passport data (universally agreed worldwide) is attached. This constitutes the shared common entity to which various data can be integrated, independently of its provenance and type. However, while the concept of accession may be satisfactory for serving the needs of the curator community for conservation purposes, it is of limited relevance to breeders or farmers. Curators might be satisfied with a fairly simple representation of passport data: one row for each accession and a set of columns to describe the donor and origin of each. In contrast, breeders or researchers use samples of genetic resources that are created and managed in different ways. Therefore, their requirements exceed the simple accessions found in ex situ genebanks. In addition, they use their samples in diverse ways: combinations of crosses, selection, commercialisation, growing in situ. The parent(s) of every sample constitute(s) another sample(s). Consequently, for accession data to be useful for the purposes of breeders and other users, information on the donor and origin of an accession have to be stored: a record for the donor’s sample and a record for the original sample have to be created. Information
on the date, place and method of creation is stored with their own records and not with the record for the accession itself.

Pl@ntnet also covers individual and social explicit knowledge, but not exclusively. The implementation of social network IT tools and collaborative spaces for software development and the establishment of shared standards and codes for plant identification make it possible to share individual tacit knowledge. The opportunities provided by these IT tools as a basis for discussions on the design and evolution of shared tools and material are central and integral to the project.

The ARCAD project’s most important objective is to put together a shared corpus of objectified knowledge (i.e. social explicit knowledge), classically associated with scientific communities’ endeavours. Diverse scientific approaches are combined to serve shared scientific objectives and develop new ideas that can be tested and applied to various crops. The considerable inter-disciplinarity within each work-package and the involvement of bio-informatic specialists encourage the circulation of information and increase the knowledge base and analytical capacities at the same time. Interestingly, the ARCAD project’s club and elite structure, where much importance is given to human interaction, encourages the building and sharing of collective tacit knowledge. This combination of tacit and explicit social knowledge makes it possible to transfer conceptual and operational knowledge for the study of neglected species, such as fonio (*Digitaria exilis*). For instance, this knowledge can be used to compare fonio’s historical evolution to that of other African crops and then to determine scenarios for fonio domestication. When combined with ethno-botanical approaches and methodologies, it can be applied to the development of innovative and precise sampling strategies. Lastly, it has benefited from common protocols, sequencing techniques and analytical pipelines, which means that genomic data can be acquired more efficiently and intelligently.

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1 Ruaraidh Sackville Hamilton, 2012, personal communication.
c) Relation-based motivation to share knowledge {infoculture}

Through its club approach, ARCAD has developed a strong identification strategy that forms the basis for trust and shared values. ARCAD is developing collective research tools and material. In this way, it can offer more than what each individual researcher could obtain from his/her own affiliated institution. This has generated a sense of common interest, which is crucial for shaping individual behaviour towards increased cooperation, particularly for data sharing among participating researchers. Pressure for publication, which tends to reduce the incentive to share data and information, can be neutralised more easily. In addition, pressure that may arise from proprietary concerns is minimised. In particular, the existence of long-established scientific partnerships with several African countries ensures the smooth sharing of material, information and knowledge with countries that are usually depicted as provider countries. Here it is worth noting the importance of training activities, which act as a mechanism for capitalisation. In addition, they constitute a non-monetary benefit-sharing component essential for the long-term sustainability of partnerships.

In the context of Pl@ntnet, relation-based motivation to share knowledge and data is based on generalised reciprocity principles that are an integral part of the architecture and design of the information-technology system. Indeed, the distributed data management system favours collaborative production by i) facilitating access to databases that fit their users’ expectations, since every user can customise the management system to his/her own needs, ii) data exchange between various types of database. The new knowledge generated by these systems acts as an incentive to contribute to them.

The genebank managers that constituted the basis for the Genesys project have a long history of transnational collaboration. They share common values and during the eighties they jointly developed common characterisation and evaluation standards for the accessions they hold to facilitate exchange between them, the Multi Crop Passport Descriptors. However, the politically sensitive intergovernmental environment in which Genesys operates has a major influence on the
relational dimension established. ABS discussions have generated some risk-adverse strategies and undermined trust between curators. Consequently, it is not surprising that was only possible to set up a project like this after the International Treaty on Plant Genetic Resources for Food and Agriculture had been enforced. The treaty provided the framework for facilitating international collaboration on PGRFA. Although the framework mainly deals with the material component of exchanges, it nevertheless contains some obligations with regard to information and data sharing attached to this material. Genesys very much relies on these common norms and obligations to foster data sharing. One major incentive for using and contributing to this system is the fact that it constitutes an easy-to-use treaty compliant system of exchange that provides users around the world with the required legal certainty.

**III. Discussion and conclusion**

The three case studies show different coping strategies in biodiversity-based projects for knowledge commons management in a context where access is becoming increasingly problematic.

Table 1 summarises the main findings using the IAD framework and social capital parameters. We focus the discussion in this conclusion on one aspect that has important policy implications: the combination of formal and informal rules regulating knowledge commons as the consequence of the mixed nature of research actors’ motivations for sharing data and knowledge.

Broadly speaking, with the exception of Genesys, informal rules play a big part in the regulation of knowledge commons in life-science research projects.

This fact is endorsed by the institutional characteristics of the research sector, as well as the attributes of the community involved in these projects. Even if some formal institutional policies are established between the partnering organisations within the ARCAD project through a consortium
agreement, it is the community norms and shared intrinsic values that mainly govern knowledge and data sharing between participating members. This is facilitated by the homogeneous structure of the community and the club rationale of the ARCAD project. Regular meetings and direct human interactions facilitate exchange practices and neutralise free riding behaviour. This is accentuated by the fact that the project is anchored in a larger and long-established cooperation between participating research organisations.

Given the wide range of actors brought together within the Pl@ntnet project and the dispersed nature of data production and management, various social network IT tools have been established to encourage interactions and collective learning processes. Access to these collective workspaces could be differentiated: open, community-driven, topic-driven, etc. Documents and data could easily be shared through these workspaces in order to optimise the data open management system established under Pl@ntnet. However, Pl@ntnet’s designers had to formalise the open-access rules through open-access-like licenses for software and databases originating from the project.

Consequently, tension can be observed between informal rules — which ensure smooth and unencumbered data and knowledge exchange practices — and formalised rules — which encourage wider participation of various actors and greater sharing of output and outcome from the projects. The benefits of the ARCAD project remain limited to a small number of actors: new knowledge and data are still concentrated in the hands of the scientists involved. However, this is compensated for by a combination of research, conservation and training activities for geographical areas (tropical and Mediterranean countries) and some minor crops that are not usually the focus of mainstream research. Despite its narrow membership and club approach, ARCAD consequently allows 1) recreating a space where genetic diversity-based research on various species could exist and be developed; 2) recreating linkages and collective actions in increasingly entropic research systems. Nonetheless, the enterprise remains very fragile because of the absence of solid knowledge capitalisation tools and a legal framework to guarantee wide diffusion. For the time being, ARCAD is
the result of the combined motivation of scientists and their affiliated institutions keen to provide
the necessary support and enabling framework so that a project like this can exist. As a result, the
project is subject to external institutional support that potentially threatens its long-term
sustainability. The wider distribution of benefits and increased functional linkages between the
physical infrastructure and the transfer of knowledge (as a non-monetary component that ensures
the sharing of benefits with a wide range of actual and potential providers of genetic resources)
should limit this risk in the long term.

In the case of Pl@ntnet, the info-structure itself constitutes a benefit widely shared among and
across various communities. The open structure of the data information management system is
based on the principle of the active participation of a wide range of contributors who could also be
involved in its implementation and design evolution. In this case, the knowledge commons becomes
more valuable as information circulates and is validated by different actors. This dynamic and
inclusive conception of the data management system increases the degree of accuracy and
completeness of plant knowledge commons. The technical dimension of crosschecking and
improving descriptive standards is further complemented by knowledge integration activities linked
to the data collected. This occurs, for instance, with the possibility offered for various stakeholder
communities to use and combine the different data collected for problem-solving purposes. For
example, in the Kruger National Park in South Africa, there is collaboration to improve the
management of different sets of data, particularly those collected by the people in charge of
controlling invasive plants in the park and the South African Environmental Observations Network
(SAEON). In summary, the combination of mixed basic scientific and applied knowledge motivations
(i.e. research & use motivations) ensures the continuous provision of new data and information. In
addition, an ever-increasing number of actors (contrary to the club logic) with various capacities and
potentially different objectives could contribute to and benefit from Pl@ntnet in a customised way.
These different communities could be connected and could share their expertise for specific
thematic and/or geographic areas.
As a gateway to access the world’s significant collections, the Genesys project provides a universal framework to collect and display data from all around the world. By combining and integrating this information to various sets of data, more relevant and accurate information can be generated for use and conservation purposes. For example, the combination of passport data with geo-referenced data using Geographical Information Systems improves the assessment of the distribution of diversity compared to environmental, climatic and demographic data. Furthermore, Genesys, which is based on the international legal framework provided by the ITPGRFA, makes it possible to request accessions from providers in compliance with the multilateral system of access and benefit sharing and its standard material transfer agreement. Genesys consequently establishes linkages between the biological samples (the material component), the information attached to it (the immaterial component), and the legal conditions for the use of the sample/information. In a context where sovereign rights over genetic resources apply (and particularly for national ex situ genebanks), this result was achieved thanks to the key role given to national institutions, which act as broker or checkpoints. On the other hand, the lack of international standards over and above the accessions’ Multi-Crop Passport Descriptor means that this global information system is only relevant to the curator community.
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<td>Ideas, database, research tools</td>
<td>Database</td>
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<td>Formalised in very broad terms through institutional framework agreement between partnering institutions but, practically speaking, very informal procedures amongst researchers</td>
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<td>University researchers, ARIs for development, NARS, teachers/trainers, genebank managers, farmers</td>
<td>University researchers, ARIs for development, NARS; Breeders, genebank managers, decision-makers/administrative representatives, regional professional networks, NGOs</td>
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<td>Cognitive ability to share knowledge</td>
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