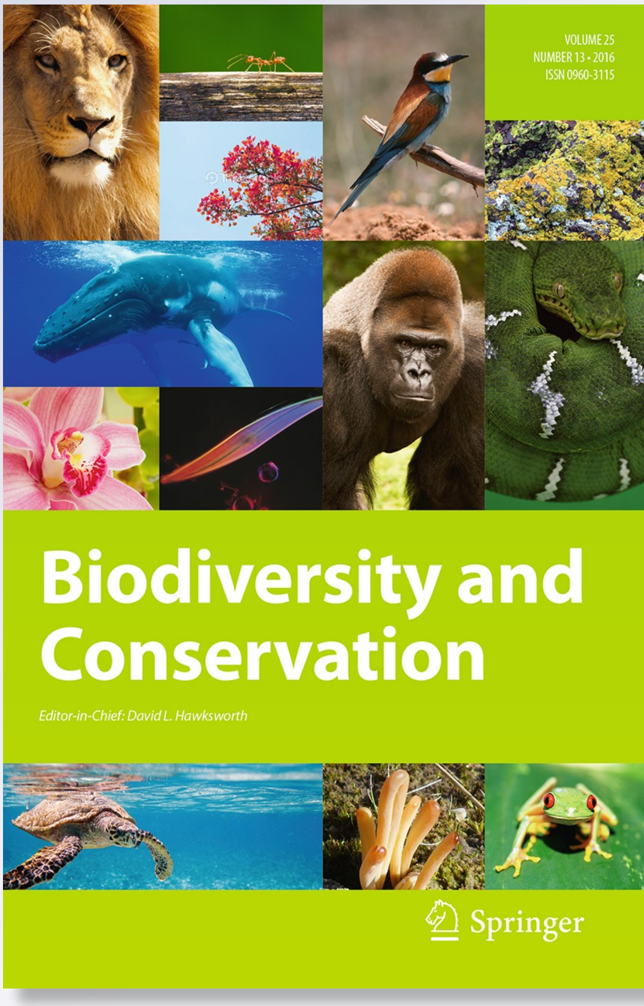
Noah's arks in the XXI century. A typology of seed banks

Pablo A. Pellegrini & Galo E. Balatti

Biodiversity and Conservation

ISSN 0960-3115
Volume 25
Number 13

Biodivers Conserv (2016) 25:2753-2769
DOI 10.1007/s10531-016-1201-z



Springer

Biodivers Conserv (2016) 25:2753–2769
DOI 10.1007/s10531-016-1201-z

ORIGINAL PAPER

Noah's arks in the XXI century. A typology of seed banks

Pablo A. Pellegrini[1] · Galo E. Balatti[2]

Received: 14 December 2015 / Revised: 9 August 2016 / Accepted: 24 August 2016 /
Published online: 12 September 2016

Abstract In recent decades, seed banks have spread out worldwide as essential institutions for biodiversity preservation, like new Noah's arks. However, little is known about the diversity of practices that are involved in them. The aim of this study is to reconstruct the dynamics of operation of the different seed banks, developing a typology of them worth providing. As sources for that aim, in-depth interviews to seed banks referents, documents and other materials related to seed banks have been used. First, we describe three stages which seed conservation has undergone until it became modern seed banks. The impact of the Convention on Biological Diversity and its debate context are considered. We analyze the knowledge involved in seed banks which turn them into more than just seeds reservoirs. Afterwards, we study how seed banks are used. From the functioning of seed banks and their objectives, we have identified three bank profiles: assistentialist, productivist and preservationist profiles. Finally, we analyze a series of cases that allow us to show the type of seed banks we have proposed. Policy implications are discussed.

Keywords Seed banks · Typology · Biodiversity · Natural resources · Conservation

Introduction

A seed bank in the United States sent a Chinese research center around 67 varieties of tomatoes that had been collected between 1932 and 1974 in Argentina (Hu et al. 2012). Thanks to this material, Chinese researchers are able to expand their genetic variability and

This article belongs to the Topical Collection: Ex-situ conservation.

✉ Pablo A. Pellegrini
ppellegrini@unq.edu.ar

[1] CONICET and Instituto de Estudios sobre la Ciencia y la Tecnología, Universidad Nacional de Quilmes, Roque Sáenz Peña 352, 1876 Bernal, Argentina

[2] Instituto de Estudios sobre la Ciencia y la Tecnología, Universidad Nacional de Quilmes, Roque Sáenz Peña 352, 1876 Bernal, Argentina

increase the productivity of their tomato crops. On the other hand, those seeds have not been preserved in Argentina. The situation accounts for a globalized, yet asymmetrical flow of natural resources. Does the exchange of seeds benefit all parties equally? Who is the owner of these resources? Such questions can be transferred to many other examples related to the use of plant varieties in recent years: researchers at the University of Colorado tried to patent some varieties of quinoa that Bolivian farmers had been using for a long time; in other example, some chickpea varieties from an Australian seed bank which, in turn, had been obtained from India were intended to be patented (Mgbeoji 2006; Powledge 2001). In some cases, the appropriation of resources or traditional knowledge has been denounced as a form of 'bio-piracy', especially concerning plants (Choudhury and Khanna 2014; Hammond 2011; Mgbeoji 2006; Shiva 1997).

While these events take place, the preservation of natural resources -particularly in seeds- has been established as a measure to protect biodiversity from the destruction of natural habitats (Schoen and Brown 2001).

In an era of globalization and commercialization of knowledge, where plants have become a highly valuable object, seed banks emerge as a key actor in each of the situations described above: both seed conservation and obtaining knowledge about them merge there.

Seed banks are relatively new institutions, since they have arisen in the twentieth century and developed a legal framework after the Convention on Biological Diversity of 1992. They are scattered throughout the world, assuming the mandate to become reservoirs of seeds.[1] Thus, they represent the protection of biodiversity. Embedded in a discourse about the concern for environmental damage, seed banks appear as guardians of biodiversity for the benefit of mankind. Social sciences have not paid much attention to these institutions, perhaps because social problems were not perceived as having a central role in them. However, in this paper we analyze seed banks showing that there are a number of social tensions linked to the production and use of knowledge related to them.

The approach of this study is a qualitative analysis using as its source in-depth interviews to seed banks referents, documents as well as other primary and secondary sources related to seed banks. Our aim is to reconstruct the dynamics of operation of different seed banks, being able to provide a typology of them.

First of all, we will begin this work by noting that seed banks are not just reservoirs of natural resources, but they involve specific knowledge which makes those seeds worth of an additional value which turns them into highly coveted objects. Then, we discuss how seed banks are used, noting that only some actors are actually able to get an important benefit from these institutions. Finally, we also show that it is possible to distinguish different kinds of seed banks, depending on the way they are used.

Seed banks origin

The beginning of agriculture about 10,000 years ago, involved the use, storage and transfer of seeds. Thus, preservation of seeds, in abstract terms, can be something as archaic as agriculture itself. However, we can distinguish three stages in the evolution of seed conservation.

[1] According to FAO, there are over 1750 banks of plants in the world (FAO 2014). The largest seed banks are in the USA, China and Russia, but they are largely based on collections from sites around the world (Murphy 2007).

Primitive conservation

Agriculture had a gradual origin, which involved the domestication of crops along many years (domestication which in turn led to a decrease in the genetic variability of plants), and expanded the possibilities of social development (Garrison Wilkes 1988; Hancock 2012). Indeed, the establishment of agricultural practices marked the transition from hunting and gathering to agriculture, and thus, to modern societies (Barker 2009). Farmers must have seeds, and before there was a seed industry in the twentieth century they had to basically furnish the seeds themselves. To do this, farmers conserved seeds to be used in a future harvest. In that sense, seed conservation intertwines with the origin of agriculture itself. But it was a conservation—with modes and duration—very different from that of current seed banks.

Imperial conservation

A second stage in seed preservation can be traced back to the seventeenth century, within the imperial dynamics of modern European states. At this moment, together with seed conservation, seed transfer becomes important. In the sixteenth century travelers to exotic countries who gathered plants to be transferred to the European metropolis proliferated. Indeed, the imperial powers were interested in obtaining crops of commercial value from their expeditions, and eventually scatter these crops along the territories under their control. Plant materials moved along with mineral wealth from empire's peripheries to enrich its core (Aoki 2008). Within this framework Botanic Gardens are born: plants and seeds collected in exotic countries were kept there, which then could be taken to a colony to try to grow them on a large scale. The first botanic gardens were created in Europe by the sixteenth century with the aim of providing medicinal plants. However, during the seventeenth and eighteenth century the interest of the botanic gardens focused on plants of agricultural interest (Hill 1915). Among the first botanic gardens is that of Leiden in the Netherlands (1587), the Jardin des Plantes in Paris (1626) and the one in Edinburgh created in 1670 (Plucknett et al. 1987). In the eighteenth century, the imperial powers created botanic gardens in their colonies, in order to have plants that could grow there and then feed the metropolis (Plucknett et al. 1987). The New World supplied new plants of enormous culinary, medicinal and industrial significance to the central powers (Kloppenburg 2004). In the nineteenth century, the British botanic garden network promoted the prosperity of the British Empire through the use of its plants (Brockway 1988).

Biodiversity conservation

A third stage begins with the creation of modern seed banks, whose origin is usually located in the twentieth century and focuses on the figure of Vavilov. What we might think of as a feature of this third stage is the interest in avoiding the loss of variability of seeds, that is to say, the conservation of germplasm (set of genes that feature certain plant diversity). Consequently, this is a stage that is part of the deployment of knowledge in genetics, as well as a greater development of agricultural production.

Genetic erosion implies irreversible loss of genes in a population of individuals, in this case, plants. Domestication of crops involves a loss of diversity, the increase in agricultural modernization in the twentieth century has left only few high performance plant species in the land. This globalization of the agricultural sector has clear advantages for the economic development but it also displaces thousands of varieties of plants, whose unique characteristics could be lost (FAO 1997).

Already in the 1920s, the Russian botanist Nikolai Vavilov warned about such issues through his theory of *centers of origin*, which would be crucial for biodiversity. This theory studies plant diversity from the geographic origins of crop varieties, emphasizing the need to conserve germplasm in the form of seeds. To develop his theory, Vavilov traveled around the world collecting seeds of wheat, potatoes, barley and other grains (Vavilov 1992). The Soviet botanist explicitly stressed the need to collect and study germplasm from around the world, in order to optimize production in a framework of "socialist agriculture" (Vavilov 1931). Vavilov theoretically framed the study of the evolutionary history of plants in Marxist historical materialism, stressing the need to "control the historical process of the evolution of cultivated plants" (ibid.) in order to optimize agricultural production.

Vavilov traveled much of Eurasia and several countries in Africa and America, collecting seeds and typifying plant species. These seeds were studied and stored in research centers throughout the former USSR. His work was interrupted because Vavilov was arrested, tried and convicted by the Stalinist regime for claiming Mendelian inheritance which was considered a bourgeois theory in those times. He died in Sratov prison from dystrophy (Loskutov 1999).

In short, Vavilov stated the importance of biodiversity as a source of variations for crop development. This led to the establishment of modern gene banks which are conceived as collections of seeds linked to the crops used in agriculture (Sachs 2009).

Standardization of seed banks

In the creation and consolidation of seed banks, international agencies also played a key role since they set standards and promote policies on plant genetic resources.

Procedures for seed treatment are established by FAO and by the *International Seed Testing Association*, an organization created in 1924 which accredits laboratories working with seeds and certifies that they meet their standards (ISTA 2015; FAO/IPGRI 1994; FAO 2014).

The *Consultative Group on International Agricultural Research* (CGIAR), a group established in 1971 by 18 countries and organizations whose common goal was to fight against famine, created several centers who perfected the ex situ techniques and set up a model of plant gene bank (CTA 1992).

In 1983 an important international legal instrument was issued: the *International Undertaking on Plant Genetic Resources* of the FAO claiming the need to conserve genetic variability in order to achieve improvements in crops, while establishing genetic resources as "heritage of mankind to be preserved and to be freely available for use" (FAO 1983).

Finally, the 1990s would bring a new legal framework for these initiatives. In 1991, FAO acknowledges the full sovereign rights of countries over their own plant genetic resources (FAO 1991). The following year the United Nations would ratify the latter and other initiatives,[2] through the *Convention on Biological Diversity (CBD)* (UN 1992).

Sovereignty is acknowledged to countries to exploit their own natural resources, but always under the legal responsibility of conserving its diversity and using it sustainably; assuming that while the right to exploit is sovereign, the conservation of biological

[2] Such as World Conservation Strategy (1980), Caring for the Earth (1991) and Global Biodiversity Strategy (1992), among others.

diversity is of common interest (UN 1992, Preamble). The exchange of information and scientific and technological cooperation between the parties is also agreed upon. This would be the legal foundations for the construction of public policies and specialized laws on plant gene conservation (UN 1992, Art. 15).

Thus, both FAO 1991 resolution and 1992 CBD gives way to national appropriation of biological resources (particularly of genetic resources), shifting the notion of *heritage of mankind* to *heritage of nations*. Nevertheless, a relevant precedent can be founded in 1958 and 1962 United Nations General Assembly resolutions, where UN recognizes "The right of peoples and nations to permanent sovereignty over their natural wealth and resources" (UN 1958, 1962).

At the same time, in the CBD the attribution of another sense to biodiversity is now categorically expressed: as an end in itself that must be preserved from human activities. Indeed, "the intrinsic value of biodiversity" is emphasized in the agreement and the concern for "the significant reduction of biodiversity as a result of certain human activities" is stated (UN 1992).

Disputes concerning access and benefit-sharing (ABS)

The objectives of the CBD can be resumed in: the "conservation of the biological diversity", the "sustainable use of its components" and the "fair and equitable sharing of the benefits arising out of the utilization of genetic resources" (UN 1992, Art. 1).

However, the establishment of these broad objectives required enormous effort and intense negotiations among the parties, especially between the "north" and the "south" countries (Beyerlin 2006). While "north" highly industrialized countries with low biodiversity were mainly interested in the conservation of the biological diversity aim, the "south" biodiversity-rich and developing nations pushed for the inclusion of the benefit-sharing objective. Finally, the "south" parties agreed to support the biodiversity objective under the condition that the ABS guidelines be included in the framework of the agreement (Buck and Hamilton 2011; Greiber et al. 2012; Rosendal 2006). The biggest concern of the "south" countries was to avoid "biopiracy", as in the case of the rosy periwinkle plant in Madagascar (Karasov 2001).[3]

Nevertheless, the addition of the "third aim" to the CBD as a tool against biopiracy was not enough. Although the CBD seeks to guarantee monetary and other benefits to the source countries, it lacks legal precisions on the implementation of public policies, rights and obligations related to the ABS objective (Greiber et al. 2012). That's why the following meetings of the Conference of the Parties (COP), governing body of the convention, focused on the ABS issues, conforming the Ad Hoc Open-ended Working Group on Access and Benefit-Sharing in 2000. Then, during the 7th reunion in 2004, the COP urged the parties to "elaborate and negotiate an international regime on access to genetic resources and benefit-sharing with the aim of adopting an instrument/instruments to effectively implement the provisions in Article 15 and Article 8(j) of the Convention and the three objectives of the Convention" (COP 7 2004). While the Article 15 of the CBD is related to the general ABS issues, the Article 8(j) recognizes the indigenous and local communities ABS rights in the framework of in situ conservation policies (UN 1992). In

[3] This plant, originally from Madagascar, was used in the 1980s by the pharmaceutical company Eli Lilly to develop two drugs, generating an estimative of 100 million dollars annually in profits. Although the rosy periwinkle plant has been used in traditional medicine for centuries, Madagascar never received any economic benefit for the products obtained from bioprospecting on their lands.

the case of seed banks, there was a strong dispute in relation to the material recollected before the adoption of CBD. In this case, should be the benefits shared with the source country? And the seeds obtained from indigenous sources, were under the regime of article 8(j)?

In the subsequent COP meetings these topics were discussed, but they didn't achieve many clear definitions. Nonetheless, during the COP 9 the first articles of a new global agreement focused on ABS were discussed and approved. Finally, in the following meeting (COP 10) in Japan, the "Nagoya Protocol" was adopted. The aim of Nagoya is the "fair and equitable sharing of the benefits arising from the utilization of genetic resources" (COP 2010, Art. 1).

In fact, CBD has also promoted the development of a multilateral system materialized through the adoption in 2006 of Standard Material Transfer Agreement (SMTA) as a legal tool for genetic material transference. Despite the fact that they are legally private law contracts between the donor of the material and the recipient, SMTA contracts provide a framework with terms and conditions standardized and pre-negotiated in the context of CBD (Tvedt 2015).

The Nagoya Protocol reaffirms the CBD and reinforce the position of the source nations. It also provides an explicit definition of "utilization of genetic resources", establishes new obligations on the parties and emphasizes the need to protect indigenous and local communities rights to benefit-sharing and adherence with access standards. Although Nagoya Protocol represents a major political progress in the transparency of genetic resources flux, it still does not provide an univocal legal framework for ABS. According to Coolsaet et al. (2013), Nagoya needs to go beyond the "simple facilitation of a market of genetic resources" to achieve its goals. Seed banks developed, hence, without a simple linear frame regarding the benefits of the use of natural resources.

Seed banks: natural resources or intellectual resources?

International standards that promote and regulate the functioning of seed banks, conceive their existence mainly on the need to preserve biodiversity.[4] Seeds are considered a fundamental biological resource to be preserved for the benefit of mankind.[5] But, are seed banks mere reservoirs of biological resources? To what extent is there knowledge that the seed banks themselves incorporate to this resource?

In fact, every natural resource is inextricably linked to knowledge about it, in terms of that the appeal to this natural resource will necessarily be done from a certain way of understanding what it is, how to use it, etc. But in seed banks, this knowledge takes on a key role, to the extent that we could even doubt about the concept of conservation that intervenes there because when incorporating certain knowledge to them, a transformation of those resources also operates.

[4] So states the FAO for example: "The need to conserve and sustainably use the world's plant genetic diversity is more critical than ever. It is the basis of food security, in a world facing many challenges (…) The continuing loss of plant genetic diversity for food and agriculture greatly reduces our options, and the options of future generations, for adapting to these changes and ensuring food security, economic development, and world peace" (FAO 2011).

[5] According to UN's definition: "The term 'biological resources' is understood as genetic resources, organisms or parts of then, populations, or any other biotic component of ecosystems with actual or potential value or use for mankind" (UN 1992).

To put it plainly: not only do seed banks retain a piece of nature, but also they arrange and classify in a certain way that piece of nature and, in doing so, they add a value to that natural resource that turns it more coveted.

Let us see what kind of knowledge is linked to biological resources in seed banks.

Knowledge and seeds

Once collected in their wild environment, the seeds must go through a fairly standardized process of treatment in the seed bank. On the one hand, the seed goes through a drying process, seeking to reduce its moisture content, since it has been shown that the drier the seed and the lower the temperature it is stored, the longer it will live.[6]

Once the seeds are dry, their ability to regenerate a plant is checked, which is called *germination power*. To evaluate this, some seeds are put to germinate and the amount of which do germinate is registered. It is generally considered acceptable if at least 85 % of the seeds germinate, that is, 85 % germination power. If these values are reached, the dried seeds are placed in waterproof bags in chambers at temperatures below zero.

After 10 years, it is checked that the stored seeds are alive, again with the germination power. If the value results less than 85 % new samples of those seeds are sought to integrate the bank.

But throughout the process of seed collection and conservation, the bank produces a number of valuable information. That information is stored along with the seeds, being it accessible through the bank database. There is a number of data produced in relation to the origin of the seeds: where they were collected, the location conditions (soil type, climate information, surrounding vegetation), number of individuals at the time of collection and amount of fruits per plant. As mentioned above, there are international rules that establish how to collect seeds; therefore it is quite a standard procedure.

Each crop has a number of descriptors, that is to say, statements which describe the plant. FAO has several manuals on genetic resources which account for these descriptors. A frequent class of descriptor is composed by morphological descriptors (for example, the average height of the material, the shape of the leaf, the amount of seed produced, the seed size, weight and color). Before molecular biology, descriptions were morphological and agronomic: descriptions included what was seen as well as characteristics of the performance, tolerance and abilities to respond under certain situations. Today, with the advancement of molecular biology, genetic mapping is made: each crop is described genetically.

In short, seeds stored in banks usually undergo morphological, agronomic and molecular characterization.

If banks kept a seed of wheat, for example, without more information than to be a seed of wheat, it would have a quite limited usefulness. But what happens is quite different: banks hold hundreds of different wheat varieties, each with information ranging from their genetic constitution to their agricultural yield. Thus, seed banks are much more than just a seed hopper. The knowledge generated by the banks is used in various ways by different social actors. Moreover, seed banks can be thought of as part of a broader process of

[6] Not all seeds tolerate that. Those which do it are called orthodox seeds; those which do not are called recalcitrant. Recalcitrant are those seeds that cannot be dried, neither can they be stored at low temperature then, because the water inside the seed forms crystals when it freezes, so those plant organisms must be stored in vivo to fields or as seeds but for a short time (a few months).

"databasing the world", necessary for the development of a knowledge economy which needs huge amounts of standardized and classified data (Bowker 2000, 2005).

Biodiversity for whom?

In the first stage characterized in relation to the development of germplasm conservation, we said that the main concern was simply to save seeds to have material to grow in coming harvests. In a second stage, conservation of germplasm concentrated more on the diversity of species, conserving different types of plants in order to aim at broadening the own imperial powers crop basis. In a third stage, the modern seed banks arise trying to preserve the largest possible biodiversity. In the first two stages of germplasm conservation, the goal was to contribute to a larger agricultural productivity. With modern seed banks that goal is also present, but in some other way.

The changes in agriculture which took place in the twentieth century led to a new way of using and appraising seeds: the continuous search for agricultural productivity led to a decrease in the variety of seeds used, because the traits and crops selected were those contributing to an increased productivity. But, at the same time, to generate new and more productive varieties, occasionally requires different features to be combined with the standards and, in this way, achieve a new competitive variety. All this requires the availability of different varieties, which in turn raises the need for having unused seeds and eventually combine them with the most productive varieties to generate new commercial crops. Biodiversity decrease in seeds in a highly globalized and competitive agriculture would need, at the same time, maintaining some biodiversity to ensure an ongoing increase in agricultural productivity.

However, that is not the only meaning assigned to biodiversity in seed banks. While Vavilov and other pioneers in seed conservation highlighted the importance of variability as an input to improve agriculture, there is another sense which was added to the notion of biodiversity.

The term biodiversity (or biological diversity), would have been first used in 1968 by Raymond Dasmann, who in his book *A Different Kind of Country* advocated the preservation of the environment. In 1986, with the aim of attracting the attention of politicians, educators and the society in general, the *National Forum on Biodiversity* focusing on the rapid destruction of natural habitats of the Earth and the subsequent loss of plants and animals was held in Washington (Carrera Zamanillo 2011). Since then, the term would gain great popularity, and in 1992 biological diversity was defined by the United Nations Earth Summit in Rio de Janeiro as "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems". The same Agreement on Biodiversity starts by setting the "conservation of biodiversity" as one of its primary goals.

The origin and development of this concept is explained in relation to certain wider social processes. Indeed, in the 1960s the first environmental movements began to take shape, and would consolidate in later decades. By the late 1970s it was clear that there had been a change in the prevailing paradigm among public opinion. This change would be that the "dominant social paradigm" (characterized by the belief in progress and development brought about by science and technology) would have been displaced by the "new environmental paradigm" that emphasizes environmental protection and preservation of natural resources (Dunlap et al. 2000). Thus, an anthropocentric vision which placed the man with the ability and need to use nature to his advantage, had been displaced (at least in part of society) by an ecocentric vision in which nature is seen as something alien to man which must even be protected from him (Berenguer 2000; Pellegrini 2013, pp. 29–33).

In short, biodiversity is often a notion embedded in the idea that we must preserve nature from human beings threats. The focus on the preservation of biodiversity can partly be explained by the large public call "to protect nature from man" (Pistorius 1997, p. 116).

Since seed banks play a central role in the preservation of biodiversity, the idea of preservation of seeds as a good in itself (or a future benefit for mankind, where the availability of seeds has perhaps diminished) is a meaning added to the banks. This would not intend, from that point of view, to conserve a large diversity of seeds in order to increase agricultural productivity but, above all, to protect a natural asset for the future.[7]

While we have previously characterized various historical stages in the development of germplasm banks and associated their aims to each of these stages, it does not mean that, at the present stage, the abovementioned objectives have disappeared. Not only did we notice some diversity of objectives set by the seed banks, but above all, different functioning of these banks can be observed.

Seed banks are usually presented in terms of their origin as private, public or community seed banks. In fact, only community seed banks have gained some attention as initiatives from small communities that may improve their local farming activities (Lewis and Mulvany 1997; Shrestha et al. 2013; Vernooy et al. 2015). Nevertheless, as our aim is to analyze the global diversity of seed banks through the link between the objectives stated and the actual functioning seed banks carry out, we can build a new typology of different profiles.

Consequently, in this paper, we show that seed banks can adopt different profiles in relation to the main objectives stated and their operation, as shown in Table 1.

In this way, the biological diversity of seeds a bank contains can be used for various purposes. We will describe the operation of different seed banks, in order to show how this scheme works in practice and which actors benefit from the biodiversity seed banks contain.

Case studies: profiles of seed banks in the world

Here we will discuss a series of cases that will allow us to account for the diversity of seed banks profiles previously mentioned.

Assistentialist profile

Some initiatives regarding seed banks focuse on the needs of farmers or small cooperatives. Community seed banks have been slowly developing in the last 30 years with the core function of maintaining seeds for local use (Vernooy et al. 2015). Here we will explore a recent case in Argentina.

---

[7] How useful may the preserved seeds be in a long future is uncertain. But the central idea in this perspective is not usefulness but preservation: "Seeds are placed in gene banks not so much to preserve seeds as to preserve diversity", argues Fowler and Mooney by adding that "Because extinction is forever, conservation must be forever" (Fowler and Mooney 1990).

Table 1 Profiles that can be adopted by seed banks

Profile	Assistentialist	Productivist	Preservationist
Objective	Conserve varieties of seeds in case they need to be used in coming harvests	Conserve varieties of seeds to contribute to the improvement of current crops by crossing them with those seeds	Preserve varieties of seeds to preserve nature in case man destroys natural diversity
Functioning	The bank provides seeds to farmers who lack them	The bank makes its seeds available to produce new crops of agricultural interest from these seeds	The bank does not offer its seeds but it safeguards them

La Plata's outskirts, in the province of Buenos Aires, it is the most important horticultural production area in Argentina. There, family farming of vegetable crops is particularly strong (Garat et al. 2009). In this context, during 2013 a group of students and graduates of the Faculty of Sciences from the National University of La Plata decided to create an active germplasm bank, intended to assist those small producers. The bank, therefore, seeks to conserve agricultural biodiversity of family farmers in the region. The motivation of the bank creators responded to two issues: the first one was to provide seeds to small farmers in the area in case they lost theirs (for example, due to flooding); and also to avoid that in the future a company seeks ownership of seeds used by farmers in the area. As regards the second issue, the bank intends to keep track of the varieties used by producers in the area. There is a research project associated with the bank, which seeks precisely to identify whether the crops that are used in the area correspond to different varieties from those used in other regions. Thus, if a company tried to patent these crops, the bank could show that it already has them registered. Stored crops are mostly varieties of tomatoes, squash and peppers.[8]

While the bank is young and does not yet have regulations regarding exchanges of material, it is defined as an assistentialist bank, since it aims to address the needs of small farmers in the area, most of who rely on subsistence agriculture.

Productivist profile

In the province of La Rioja, located in the northwest of Argentina, a seed bank is emerging with different features. Agrogenética Riojana SAPEM is a majority state-owned public limited company[9] devoted to provide plants and advice to the local agricultural sector through its network of nurseries. While providing subsidized services and products to small farmers, it also offers these services and products to medium and large customers at market prices.[10]

Shortly after starting its operation, the company typified a series of farmers' problems and needs which could not be met by conventional nurseries:

> "We have identified critical issues such as: the presence of diseases affecting the different crops of the province in terms of productivity, quality problems and market

[8] Interview to bank coordinator, March 2015.

[9] La Rioja province has 99 % of the limited society market share, founded in 2009.

[10] Interview to the manager of the Agrogenética Riojana SAPEM Commercial Department, April 2015.

access, the introduction of foreign varieties with inappropriate behavior, lack of and wrong management of water availability, the existence of a large number of old plants with low performance levels, the lack of certified genetics and traceability of plants, and the inadequacy of the varieties to new national and international demands".[11]

These problems prompted the company to submit a draft to the Government of La Rioja Province for the construction and implementation of the Laboratory of Biotechnology and Germplasm Bank BIOVIDA, with the aim of increasing the quality and performance of the genetic material provided. The main objective of the project was to offer a wide range of products and services for agriculture, seeking to increase the competitiveness of producers through the provision of high quality plant specimens. As part of this initiative, the creation of a gene bank was also considered and taken as a key element for increasing the quality of the material. Therefore, in this case the bank is acting as a systematic genetic reservoir that provides the necessary material for the improvement and propagation of seedlings, task which is carried out by the laboratory itself. While this gene bank is not yet fully operational, it is a bank with a productivist profile since the motivation for storing genetic material is simply to have the best genetics for the agricultural sector. The seedlings provided by this bank will directly cater to the producer to provide specimens with special features such as resistance to disease, higher yields and adaptation to local conditions.

Another feature that turns it into a productivist bank is the genetic material stored there. Unlike other cases described here, it does not look for storing high biodiversity, but it seeks to conserve the best genetic selection of the region. Along these lines, one objective is the improvement of tomato through traditional crossing. The project involves the collection of seeds used by farmers in the area. This can be done even without transfer contracts (for both reception and delivery of material), since, according to the Commercial Department of the company, the seeds in question are neither registered nor there is a specific duty on them. The bank also provides a storage system for in vitro[12] crops of regional interest such as vines, olive and walnut. Thus, the bank seeks to accelerate the process of improvement and production of plant varieties used in the area, making a product of greater value available for the producers of the region.

Preservationist profile

As a paradigm of the third profile analyzed in this paper, which refers to the preservation of seeds as ideological expression of the search for nature preservation, is the *Global Seed Vault*, located in a remote Norwegian archipelago called Svalbard. According to the international organization *Crop Trust* (GCDT), established by *Biodiversity International* and main contributor to the maintenance of Svalbard global bank, its purpose is to preserve duplicates of seeds from other banks around the world (GCDT 2015).

The construction containing the reservoir is housed inside a mountain covered by snow (Chaskey 2014; Fowler 2008). These particular characteristics protect the collections living there from the passing of time even without electricity, because low temperatures in the venue can preserve germplasm for long periods of time, while the rock acts as a barrier against possible disasters. For these reasons the press has called it "*doomsday vault*"

[11] Interview to the head of the company laboratory, carried out in March 2015.

[12] It implies conservation of buds, apices and meristems by limiting growth through low temperatures (between 4 and 10 °C) and other factors.

(Kinver 2008; The Economist 2010). The reason the bank is deployed in such extreme conditions, is because it was sought to have a seed reservoir that could be used in case the humanity suffered a global catastrophe such as a nuclear war (Andersen 2012).

The initiative arose from the FAO's *International Treaty on Plant Genetic Resources for Food and Agriculture*, which entered into force in 2004 (FAO 2009; Qvenild 2008). This agreement facilitates the exchange of genetic resources among countries and, in this context, the Norwegian Ministry of Foreign Affairs and the Norwegian Ministry of Agriculture and Food created a group of experts under the direction of the *Norwegian University of Life Scientists* (UMB) to make a preliminary study for finding venues for the construction of a global reserve of seeds. The venue chosen was the archipelago of Svalbard (Noragric 2004). The construction of the bank was in charge of the state-owned company Statsbygg, it cost 50 million Norwegian Crowns (equivalent to about 6.5 million dollars) and was financed by the Norwegian Ministry of Environment, Food and Agriculture and Foreign Affairs. Maintenance costs are funded by the Ministry of Agriculture and the *Global Found for Crop Diversity* (through GCDT), funded by various actors such as governments, companies, foundations, organizations and individuals (Statsbygg 2008).[13]

Its operation is different from other traditional seed banks because it works as a *back-up* for seeds stored in national and international gene banks around the world, such as those above mentioned centers of CGIAR.[14] Therefore, the incoming seeds cannot be either removed -with the exception of those who donated them- nor studied or distributed. The preserved material in there is accessed only if the "original" seed is lost (Statsbygg 2008). Thus, the repository acts exclusively as support to both natural and manmade disasters. This system is called "black box", since only the depository institution of the material can access and open the box containing the seeds that it facilitates (Fowler 2008). Likewise, and unlike other seed banks, the legal instrument used to deposit seeds (*Standard Deposit Agreement*) does not imply any legal property rights or similar transfer in favor of the host institution.[15]

It currently has about 830,000 samples of the most varied crops from around the world (GCDT 2015).

Mixed profile

Although we have described three paradigmatic profiles of seed banks, it does not imply that all banks must correspond to only one of those profiles. In fact, most seed banks show a mixed profile combining different operating strategies and where, at most, one profile stands outs over the other.[16]

[13] Complete list at https://www.croptrust.org/about-crop-trust/donors/.

[14] Complete list at http://www.nordgen.org/sgsv/index.php?page=sgsv_depositor_list.

[15] This is clearly stated in Art. 2, part 2 from SDA: "The act of deposit shall not act in any way to convey any property rights over the Deposited Materials to the Nordic Gene Bank or the Royal Norwegian Ministry of Agriculture and Food" (NMFA 2012).

[16] In fact, in the case described as productivist profile, the seed bank belonging to a company in La Rioja, there is also a preservationist line. The company committed to store in vitro tissue samples of national historic trees, in agreement to the National Commission of Monuments, Historical Sites and Properties. It also stored carob seeds native of the region, in agreement with the Ministry of Environment of the Province. To do this, it receives funding from national and provincial government. The aim is to preserve the biodiversity of these species in the region, which is a characteristic feature of a preservationist profile.

The *World Vegetable Center* (AVRDC) can be analyzed as a mixed bank. With 60,899 samples from 156 different countries, the AVRDC has the largest germplasm collection of vegetables of the planet (AVRDC 2014). It was founded in 1971 by a conglomeration of Asian nations together with the US government, and while it is committed to ensuring long-term preservation of its vegetable germplasm collection, it also aims at "fighting poverty and malnutrition in developing countries" (AVRDC 2010).

The team, distributed throughout numerous institutes based in Taiwan, is responsible for the collection, preservation, phenotypic and genotypic study, and distribution of seeds of species for food coming from around the world. For this it works in 4 lines: *Germplasm conservation, evaluation, and gene discovery,* in order to preserve biodiversity and make the most of it; *Genetic enhancement and varietal development of vegetables*, in order to obtain advantageous varieties for farmers; *Safe and sustainable vegetable production systems*; and *Balanced diets through increased access to and utilization of nutritious vegetable* (AVRDC 2013, p.6).

The AVRDC offers its seeds to various types of actors. The seed samples go to AVRDC scientists (37 %), national agricultural research and extension systems (26 %), private sector, seed companies (22 %), universities (10 %), nongovernmental organizations (3 %) and others (2 %) (Schreinemachers et al. 2014). When an interested actor asks for seeds, he must sign an agreement. In those agreements, the AVRDC states that any transfer of materials resulting in a marketable product, that is, products incorporating the transferred material or a gene derived from it must pay AVRDC a fixed percentage on sales derived from marketing such product. Thus, if a company manages to improve certain food crop by traditional or modern improvement with seeds obtained in the AVRDC and achieves a patent as well as placing this product into the market, it must pay a fee to the AVRDC.

On the other hand, the same institution performs research and development on their own samples. The institute research groups have developed tomato lines with beta-carotene high content and various lines of plants resistant to *stress* and diseases (Palada et al. 2006).

Clearly, the AVRDC does not distribute seeds freely, but the signing of transfer agreements involve control and even a possible economic return on the genetic resources it hosts and, more importantly, on its potential derivatives. This makes it part of a productivist profile.

However, there is also an assistentialist profile in their work. The institute seeks to make samples and techniques available to farmers that allow the increase in productivity of their crops. More than 466 improved vegetable varieties developed from this germplasm have been released to farmers around the world (Mecozzi and Ebert 2012).

Discussion

Seed banks have become key institutions for the production and use of knowledge on seeds in the world. Great varieties of seeds which can be useful for agriculture are gathered, recorded, characterized and preserved in them.

The importance that social actors can give to either sense of seeds preservation can have significant impacts. Nikolai Vavilov, father of modern seed banks, gained recognition over the importance of having a wide biodiversity available in order to increase agricultural productivity. Thereafter, seed banks were established as an increasingly coveted object. In the 1920s, Vavilov gathered the largest collection of seeds of the time. During World War II, a Nazi secret service command, the *Sammelkommando*, was created to seize that seed collection (Esquinas Alcázar 2013). During the blockade of Leningrad by the German army, the largest seed bank in the world was preserved at the Institute of Plant Industry with samples from every continent, collected by Vavilov and his collaborators during his expeditions to different regions of the planet. Although much of the preserved material was edible, the curators of this immense patrimony preferred to die of starvation before damaging the collection of genetic material (Esquinas Alcázar 2013; Plucknett et al. 1987; Pruna Goodgall 2012).

The meaning given to the conservation of seeds has changed over time, and this diversity is still evident today. On the one hand, the seeds can be conserved in order to be available to small farmers as fundamental input for their food and substance. But seeds can also be conserved to broaden the genetic variability of crops and thus, allow having more useful genes for the generation of new crop varieties, thereby increasing the productivity of agricultural production. Finally, seeds can be stored for an indefinite future; for fear that biological diversity is destroyed and aiming at its preservation.

The Convention on Biological Diversity of 1992 propelled the development of seed banks, although it didn't provide a unique legal frame regarding the benefits of the use of natural resources. The tensions that were present among countries that ratified the CBD may be reflected in the diversity of seed banks, as there were interests oriented towards preserving natural resources in a general sense, while there were also other interests in obtaining local benefits from natural resources.

From the functioning presented by seed banks and their objectives, we have identified three banks profiles: assistentialist, productivist and preservationist. Assistentialist seed banks are devoted to provide seeds for farmers who might need them. Thus, they represent a role of safeguarding the production of small farmers. They are institutions which are generally financed by states or non-profit organizations. Productivist seed banks, by contrast, seek to increase agricultural productivity, using stored seeds to create new varieties of crops. Seed banks associated with companies usually have this productivist profile. Finally, preservationist banks seek to protect the seeds of their eventual destruction in the environment, and are not intended to be used at present. The case of Svalbard is the only bank with a purely preservationist profile, it is funded by the Norwegian state, and responds to a concern for the future of biodiversity.

Some seed banks can combine different profiles, they may present a preservationist discourse, a largely productivist functioning, and also provide assistentialist aid. These are complex institutions that have multiplied in the world in recent decades. The typology presented in this paper aims to contribute to the analysis of the heterogeneity of practices, interests and discourses that intersect in seed banks.

One implication of this study could be towards seed banks legislation. Although such legislations are mostly recent or still in the process of being implemented, they conceive seed banks as a black box institution, concerned with the preservation of natural resources and without differentiating profiles among them. But this differentiation we have shown could be translated into specific normatives, enhancing thereby the seed bank purpose. For instance, an assistentialist seed bank do not need the same transfer material agreement as productivist seed banks do; and preservationist profiles could benefit of a more permissive requisites for germplasm collect, but stricter in regard of its utilization.

A deeper implication for public policies is related to the debates concerning funding and benefits of seed banks. As seed banks usually appeal to a preservationist discourse regarding natural resources (but not always function in such a way), public funding seems reasonable because preserving nature for the future of mankind looks like a general benefit. But do all societies -and all social sectors within- have the same needs of natural resources?

To explain this question we could use science policy as an analogy. In the mid of the twentieth century, science policy spread in Western societies with the conception of the 'linear model of innovation'. This policy considered that states should invest in basic science because that would trigger an innovation process that would ultimately benefit all society (Bush 1945; Godin 2006). But although every knowledge may be valuable in itself, what happens with the specific knowledge that a society needs in a certain moment? Why a country should invest its limited resources in all kind of basic science, when it may need a certain kind of scientific innovations with urgency? Those kind of criticisms began to open the way to a more complex and oriented science policy.

In a similar sense, to invest in preserving natural resources for an undefined future may be worthwhile, but not all social actors today has the same need of natural resources. Local farmers may need to use seed banks to obtain samples for immediate farming. On the other hand, enterprises may need other kind of seeds to produce new commercial varieties. As we have shown in this article, seed banks in practice have already developed different profiles. But there are no debates about the sort of seed bank needed in each region, as all of them tend to legitimize under the naturalized discourse of biodiversity preservation for the future.

Acknowledgments This research was supported by the Agencia Nacional de Promoción Científica y Tecnológica through funding PICT-2011-1713.

References

Andersen R (2012) After 4 years, checking up on the svalbard global seed vault. The Atlantic, 28 Feb 2012

Aoki K (2008) Seed wars: controversies and cases on plant genetic resources and intellectual property. Carolina Academic Press, Durham

AVRDC (2010) Prosperity for the poor and health for all: strategic plan 2011–2025. The World Vegetable Center, Shanhua

AVRDC (2013) 2013–2015 Medium-term plan. The World Vegetable Center, Shanhua

AVRDC (2014) 2014–2016 Medium-term Plan. AVRDC—The World Vegetable Center, Shanhua

Barker G (2009) The agricultural revolution in prehistory: why did foragers become farmers?. Oxford University Press, Oxford

Berenguer J (2000) Actitudes y creencias ambientales: una aplicación psicosocial del comportamiento ecológico. Ediciones de la Universidad de Castilla-La Mancha, Cuenca

Beyerlin U (2006) Bridging the north-south divide in international environmental law. ZaöRV 66:259–296

Bowker GC (2000) Biodiversity Datadiversity. Soc Stud Sci 30(5):643–683

Bowker GC (2005) Memory practices in the sciences. MIT Press, Cambridge

Brockway LH (1988) Plant science and colonial expansion: the botanical chess game. In: Kloppenburg JR (ed) Seeds and sovereignty: the use and control of plant genetic resources. Duke University Press, Durham, pp 49–66

Buck M, Hamilton C (2011) The nagoya protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization to the convention on biological diversity. RECIEL 20(1):47–61

Bush V (1945) Science the endless frontier. A report to the president by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945. United States Government Printing Office, Washington

Carrera Zamanillo MI (2011) La construcción del paradigma de biodiversidad: Una nueva figura de bio-poder en el siglo XXI. III Coloquio Latinoamericano de Historia y Estudios Sociales sobre la Ciencia y la Tecnología, México, 15–19 Nov 2011

Chaskey S (2014) Seedtime: on the history, husbandry, politics, and promise of seeds. Rodale, New York

Choudhury P, and Khanna T (2014) Bio-piracy or prospering together? Fuzzy set and qualitative analysis of herbal patenting by firms. Harvard Business School, Cambridge. Working Paper 14-081, 28 Feb 2014. http://www.hbs.edu/faculty/Publication%20Files/14-081_6cfa4f81-d5cb-44f6-9a0c-1fe7c91f61ef.pdf. Accessed 1 Jun 2015

Coolsaet B, Dedeurwaerdere T, Pitseys J (2013) The challenges for implementing the nagoya protocol in a multi-level governance context: lessons from the Belgian case. Resources 2:555–580
COP (2004) COP 7 Decision VII/19. https://www.cbd.int/decision/cop/default.shtml?id=7756. Accessed 25 May 2015
COP (2010) COP 10 Decision X/01. https://www.cbd.int/decision/cop/default.shtml?id=12267. Accessed 25 May 2015
CTA (1992) IBPGR: International Board for Plant Genetic Resources. Technical Centre for Agricultural and Rural Cooperation (CTA): SPORE Bulletin N°38. http://collections.infocollections.org/ukedu/en/d/Jcta38e/9.1.html. Accessed 1 Jun 2015
Dunlap RE, Van Liere KD, Meeting AG, Jones RE (2000) Measuring endorsement of the new ecological paradigm: a revised NEP scale. J Soc Issues 3(56):425–442
Esquinas Alcázar J (2013) Biodiversity and Security. In food security and global security, 98–140. Strategic Dossier 161-B. Madrid: Spanish Ministry of Defence
FAO (1983) Resolution 8/1983. 23rd November 1983. http://www.fao.org/fileadmin/templates/nr/documents/CGRFA/Resolution8-83_s.pdf. Accessed 4 Jun 2015
FAO (1991) Resolution 3/1991. 25th November 1991. http://www.fao.org/fileadmin/templates/nr/documents/CGRFA/Rightsofnations_s.pdf. Accessed 4 Jun 2015
FAO (1997) The state of the world's plant genetic resources for food and agriculture. Food and Agriculture Organization of the United Nations, Rome
FAO (2009) International treaty on plant genetic resources for food and agriculture. Food and Agriculture Organization of the United Nations, Rome
FAO (2011) Second global plan of action for plant genetic resources for food and agriculture. Food and Agriculture Organization of the United Nations, Rome
FAO (2014) Genebank standards for plant genetic resources for food and agriculture, Revised edn. Food and Agriculture Organization of the United Nations, Rome
FAO/IPGRI (1994) Genebank standards. Food and Agriculture Organization of the United Nations, International Plant Genetic Resources Institute, Rome
Fowler C (2008) The svalbard seed vault and crop security. Bioscience 58(3):190–191
Fowler C, Mooney P (1990) Shattering: food, politics, and the loss of genetic diversity. The University of Arizona Press, Arizona
Garat JJ, Ahumada A, Otero J, Terminiello L, Bello G, Ciampagna ML (2009) Las hortalizas típicas locales en el cinturón verde de La Plata: su localización, preservación y valorización. Hortic Argent 28(66):32–39
Garrison Wilkes H (1988) Plant genetic resources over ten thousand years: from a handful of seed to the crop-specific mega-gene banks. In: Kloppenburg JR (ed) Seeds and sovereignty: the use and control of plant genetic resources. Duke University Press, Durham, pp 67–89
GCDT (2015) Svalbard Global Seed Vault. What we do? https://www.croptrust.org/what-we-do/svalbard-global-seed-vault/. Accessed 20 May 2015
Godin B (2006) The linear model of innovation: the historical construction of an analytical framework. Sci Technol Human Values 31(6):639–667
Greiber T, Peña Moreno S, Åhrén M, Nieto Carrasco J, Chege Kamau E, Cabrera Medaglia J, Oliva MJ, and Perron-Welch F, in cooperation with Ali N, and Williams C (2012) An Explanatory Guide to the Nagoya Protocol on Access and Benefit-sharing. IUCN Environmental Policy and Law Paper No. 83, Gland
Hammond E (2011) Marker-assisted biopiracy. Ex situ wild tomato collections, genetic breeding techniques and patent claims. Briefing Paper 2. Third World Network, New Delhi
Hancock JF (2012) Plant evolution and the origin of crop species, 3rd edn. CABI, Cambridge
Hill AW (1915) The history and functions of botanic gardens. Ann Mo Bot Gard 2(1/2):185–240
Hu X, Wang H, Chen J, Yang W (2012) Genetic diversity of Argentina tomato varieties revealed by morphological traits, simple sequence repeat, and single nucleotide polymorphism markers. Pak J Bot 44(2):485–492
ISTA (2015) International Rules for Seed Testing. Vol. 2015, N° 1. International Seed Testing Association, Bassersdorf
Karasov C (2001) Who reaps the benefits of biodiversity? Environ Health Perspect 109(12):582–587
Kinver M (2008) 'Doomsday' seeds arrive in Norway. BBC News. http://news.bbc.co.uk/2/hi/science/nature/7217821.stm. Accessed 20 May 2015
Kloppenburg JR (2004) First the seed: the political economy of plant biotechnology, 2nd edn. The University of Wisconsin Press, Madison
Lewis V, Mulvany PM (1997) A typology of community seed banks. Natural Resources Institute, University of Greenwich, Chatham

Loskutov IG (1999) Vavilov and his institute. A history of the world collection of plant genetic resources in Russia. International Plant Genetic Resources Institute, Rome
Mecozzi M, Ebert AW (2012) At this bank for vegetables, withdrawals produce interest. DFID case study on AVRDC Genebank. The World Vegetable Center, Shanhua, Taiwan
Mgbeoji I (2006) Global biopiracy: patents, plants, and indigenous knowledge. UBC, Vancouver
Murphy DJ (2007) Plant breeding and biotechnology: societal context and the future of agriculture. Cambridge University Press, New York
Noragric (2004) Study to assess the feasibility of establishing a Svalbard Arctic seed depository for the international community. Center for International Environment and Development Studies (Noragric), Agricultural University of Norway & Nordic Gene Bank. https://www.regjeringen.no/globalassets/upload/lmd/kampanjesvalbard/vedlegg/frohvelv_study_to_assess.pdf. Accessed 6 Jun 2015
Palada MC, Kalb TJ, Lumpkin TA (2006) The role of AVRDC—the world vegetable center in enhancing and promoting vegetable production in the tropics. HortScience 41(3):556–560
Pellegrini PA (2013) Transgénicos: ciencia, agricultura y controversias en la Argentina. UNQ Editorial, Bernal
Pistorius R (1997) Scientists, plants and politics: a history of the plant genetic resources movement. International Plant Genetic Resources Institute, Rome
Plucknett DL, Smith NJH, Williams JT, Anishetty NM (1987) Gene banks and the world's food. Princeton University Press, Princeton
Powledge F (2001) Patenting, piracy, and the global commons. Bioscience 51(4):273–277
Pruna Goodgall PM (2012) N. I. Vavílov a los 125 años de su nacimiento: la obra y el contexto. In: 13th congress of the Sociedad Mexicana de Historia de la Ciencia y la Tecnología, México, 14 Nov 2012
Qvenild M (2008) Svalbard global seed vault: a 'noah's ark' for the world's seeds. Dev Pract 18(1):110–116
Rosendal GK (2006) Regulating the use of genetic resources—between international authorities. Eur Environ 16(5):265–277
Sachs MM (2009) Cereal germplasm resources. Plant Physiol 149(1):148–151
Schoen DJ, Brown AHD (2001) The conservation of wild plant species in seed banks. Bioscience 51(11):960–966
Schreinemachers P, Ebert AW, Wu M-H (2014) Costing the ex situ conservation of plant genetic resources at AVRDC——The World Vegetable Center. Genet Resour Crop Evol 61(4):757–773
Shiva V (1997) Biopiracy: the plunder of nature and knowledge. South End Press, Cambridge
Shrestha P, Gezu G, Swain S, de Boef WS (2013) Community seed banks: a common driver building social capital for community biodiversity management. In: de Boef WS, Subedi A, Peroni N, Thijssen M, O'Keeffe E (eds) Community biodiversity management: promoting resilience and the conservation of plant genetic resources. Routledge, London, pp 109–118
Statsbygg (2008) Svalbard global seed vault. Norway: Statsbygg. http://www.statsbygg.no/files/publikasjoner/ferdigmeldinger/671_SvalbardFrohvelv.pdf. Accessed 10 Jun 2015
The Economist (2010). Banking against Doomsday. The Economist print edition, 10 Mar 2010
Tvedt MW (2015) Changes in the plant treaty—how can benefit sharing happen and the link to intellectual property rights—assessing the mutually supportiveness. Law Environ Dev J 11(1):3–16
UN (1958) General assembly resolution 1314 (XIII) of 12 December 1958
UN (1962) General assembly resolution 1803 (XVII) of 14 December 1962
UN (1992) Convention on Biological Diversity. Rio de Janeiro, Brazil: United Nations
Vavilov NI (1931) The problem of the origin of the world's agriculture in the light of the latest investigations. In: Bukharin NI (ed) In Science at the cross roads. International Congress of the History of Science and Technology, London http://www.marxistsfr.org/subject/science/essays/vavilov.htm. Accessed 20 May 2015
Vavilov NI (1992) Origin and geography of cultivated plants. Cambridge University Press, Cambridge
Vernooy R, Shrestha P, Sthapit B (2015) The rich but little known chronicles of community seed banks. In: Vernooy R, Shrestha P, Sthapit B (eds) Community seed banks: origins, evolution and prospects. Routledge, New York, pp 1–8