CONCEPT NOTE

THE SEED INDUSTRY AND THE FUTURE OF AGRICULTURE

SOME KEY ISSUES THAT NEED TO BE INVESTIGATED

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Executive Summary

Agricultural production is fundamental to human life, and is a particularly strategic issue for LAC countries, given that the sector supports both the external economy and the livelihoods of a large proportion of the continent's population. Seeds are fundamental to the production and improvement of agricultural crops. The ways in which plant breeding and seed production activities are organized and perform over the years and decades to come will be pivotal in influencing the future of agriculture.

The extension of patent rights to cover methods and innovations in the seed sector from the 1980s onwards has been associated with enormous concentration over the last 30 years. In the mid 1980s, the largest nine seed firms accounted for about 13% of global seed sales, but by 2012, the largest ten seed firms had a 76% share of the global seed market, and this share reaches 95% of the genetically engineered (GM) segment of the seed business.

Multiple and significant concerns have been highlighted with respect to the effects of this growing concentration and oligopolization of the seed market. They include *static economic problems* of increasing prices, reduction in varieties and the diffusion of anticompetitive practices; *dynamic problems* related to slowing rates of innovation and the focusing of innovative efforts on fewer varieties, and on those crop species that have large markets;*; developmental problems* related to the global distribution of plant breeding capabilities; and *sustainability challenges* related to access and declining agricultural biodiversity.

The initiatives that have been proposed to address these challenges are also multiple. Some propose higher public investment in the sector in order to conduct research in areas that are not covered by the large firms and/or to preserve agricultural biodiversity, in facilities such as seed banks. Others emphasize the need to restrict the use of patents, or any form of strict property rights in this sector and, to provide serious support for small-scale farming, as a way to guarantee both access to seeds and biodiversity. We have identified the possibility of also supporting an alternative trajectory in the sector, led by private companies, but that works with a different innovation strategy and business model as a possible initiative and pathway of change.

Our proposal is based on the observation that some seed firms in developing countries, where IPR regulations are less strict than in the USA, have been following this alternative trajectory and have become very successful in their regions. This is a 'high tech' trajectory, but one based not on genetic engineering, which is expensive, but on other non-proprietary modern biotechnologies. It has become very successful because it provides solutions to diversity, rather than standardised products, by developing seed varieties in smaller volumes specific to locally variable agro-ecological conditions, and by responding quickly to changes in those conditions with new adapted varieties. This is an alternative that has several of the advantages of other proposed responses, but it is knowledge intensive, and in principle can co-exist with other initiatives. We analyse this possibility a bit further since it has been neglected in existing scientific and policy discourse.

In this document we first discuss in more in detail the main changes experienced in the seed industry over recent years, the multiple concerns that these changes have raised, and some of the possible pathways proposed to address these challenges. We then sketch out a set of research and policy questions that should be explored to improve our understanding of the possibilities to address the multiples challenges of structural change in the seed sector in LAC.

1. Context

Agricultural production is fundamental to human life, and is a particularly strategic issue for LAC countries, given that the sector supports both the external economy and the livelihoods of a large proportion of the continent's population. Seeds are fundamental to the production and improvement of agricultural crops. The ways in which plant breeding and seed production activities are organized and perform over the years and decades to come will be pivotal in influencing the future of agriculture, and how this most basic of human activities can best support and sustain human societies and the ecosystem services upon which we all depend.

Over the last 30 years, plant breeding and seed production have been radically transformed. Those activities have shifted from being conducted by a heterogeneous mixture of public sector breeding institutions, a few large firms, and hundreds of medium and small sized companies, with the active involvement by farmers, to activities overwhelmingly dominated by a handful of multinational agro-chemical firms, with far fewer small and medium sized firms, much diminished public-sector participation, and the gradual exclusion of farmers from participation in breeding activities.

In the mid 1980s, the largest nine seed firms accounted for about 13% of global seed sales,[1] but by 2012, the largest ten seed firms had a 76% share of the global commercial seeds market, with the top three seed companies, all now owned by multinational chemical/biotechnology firms, accounting for over 50% of global seed sales.[2] Five of the largest seed companies--Syngenta, Bayer, Dow, Dupont, and Monsanto--are also market leaders in agricultural chemicals. A sixth firm, BASF, is making significant investments in crop biotechnology research but so far reports few crop seed or trait sales, although it is a market leader in agricultural chemicals. These companies currently constitute the "Big Six" integrated seed, biotechnology, and agricultural chemical 'agronomic systems' firms. In 2011 they accounted for almost 60% of global seed sales.[3]

Concentration is particularly acute in the genetically engineered (GM) segment of the seed business, which now represents nearly a third of the global value of the seed market.[4] The market share of the Big Six in GM corn, soybeans, cotton and canola worldwide in terms of trait-acres is over 95%. Those six firms are also responsible for 66% of GM field trials, 87% of GM crop approvals, and 76% of US patents in the plant biotechnology area between 1982 and 1997. (Schenkelaars et al. (2011)

Concentration is likely to continue to increase further in the coming years. For example, Monsanto (which in 2011 was responsible for 25% of the global seed market) has tried to buy one of its main rivals, Syngenta, on two occasions over the last year.

1. The reasons

This structural transformation in the seed market followed the development of plant genetic engineering techniques and the extension of intellectual property rules to cover the products and processes of plant genetic engineering. Patent protection for genetically engineered traits was pivotal to the entry of large

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[1] Schenkelaars, P., de Vriend, H., & Kalaitzandonakes, N. (2011). Drivers of consolidation in the seed industry and its consequences for innovation. Report for COGEM (Commissie Genetische Modificatie). Wageningen (NL): Schenkelaars Biotechnology Consultancy.
[2] ETC 2013
[3] ETC 2013
[4] Bonny 2013

MNCs in this industry because it creates opportunities for economies of scale and scope that are not available with conventionally bred seeds[5]. The latter cannot be patented in most jurisdictions and instead are covered by plant variety protection rules that give competitors the right to use a variety for further breeding; in effect, a form of open source innovation, and that allow farmers to save and reuse seed after one season. Seeds into which a patented GM trait have been inserted, by contrast, enable the owner of the patented GM event to claim part of the future income stream from all competing seed firms' varieties that wish to use the event, or that subsequently improve on the GM variety. They enable firms to monopolize seed markets in ways that are not possible with the plant variety protection rules that govern conventional breeding

Faced with a mature agro-chemical sector and declining pesticides sales, multinational agro-chemical firms such as Monsanto, DuPont and Bayer therefore viewed plant genetic engineering as offering potential for substantial growth.[6] They entered the sector, initially by acquiring start up biotechnology firms and investing heavily in their own biotechnology capabilities. This was followed by a wave of acquisitions of hundreds of smaller and medium sized seed firms, allowing for vertically integrated germplasm and GM/biotech assets and the acquisition of seed distribution networks, and then by a number of mergers with larger competitors.

The business model adopted by the agrochemical-biotechnology-seed firms is based on developing standardized, patented GM events, suitable for use in different varieties in different agricultural regions, and even in different crops, which can then either be backcrossed into the germplasm assets of the firms' own seed divisions, or licensed to other seed firms. The high fixed costs involved in creating GM events (of R&D, biosafety regulation and management of IPRs) require large markets and the ability to price seeds well above their short run marginal costs. Up to now these innovations, applied to a few globally very important commodity crops, namely cotton, maize soya, and canola, have been successful in the market because they have helped to substitute for labour or chemical pesticide inputs. (Bt cotton use by smaller farmers in the developing world is an unintended spillover).

2. ***Concerns*:**

A very large number of concerns have been raised about concentration and structural change in the global seed industry. These can be grouped into three types: (i) static, related to market structure and industrial organization, (ii) dynamic, related to innovation, and (iii) development and sustainability, related to the location and political power of the seed industry and to issues concerning agricultural biodiversity.

Static Concerns

[5] Not long ago (for the history of agriculture, is 80 years), the seeds were quasi-natural goods (i.e although modified by man, they were provided by nature) and quasi-public goods (because even exclusive in the beginning, were available for successive uses, without paying). Accordingly, as they done it for thousands of years, throughout the history of agriculture, farmers were able to re-use the seeds without paying for them or ask permission. The improvements, typically consisting of adaptations to changing environment (eg a new epidemic), in most cases, were done by the same farmers or agronomists of public institutions. The technology used was cross breeding, based on selection and the matching. The companies unable to prevent farmers to re-use the seeds did not participate or participate little in the activity. There was no seed market.
But in recent decades, two major changes revolutionized the scene. First, the apparition of hybrids which lose their new attributes (for example, resistance to a disease) in the second generation, and therefore helped in the way of commercialization of the seed, since forced farmers to buy new seed each season. The companies saw increased their opportunities to sell and make a profit and began to invest massively in seeds. A capitalist market for seeds begin to develop. Secondly, a number of advances occurred in areas of knowledge related to seeds (eg. in molecular biology) further increased the chances of commercialization and appropriation of seeds, but now associated to regulations, since advances in molecular biology are more easy to be proposed to be patentable. Genetic improvements can be patented, therefore, even in the case of non-hybrid varieties, companies that make improvements using genetic engineering, can claim ownership of successive generations of seeds.

[6] Herdt 2006; Wield et al 2010

First, there are three traditional problems in the economic literature that are associated with market concentration: a) higher prices, b) less variety and c) the diffusion of anticompetitive practices, which reinforces the first two effects. Analysis of these issues is mainly restricted to the US market, and different studies all point in the same direction.

Since 1997/1998, when GM crops were first commercialized in the USA, costs related to seeds have increased between 160% and 300%, depending on the specific period and items considered.[7] Transgenic traits and technology fees are the driving force behind this increase in costs. Increases in seed prices affect farmers' costs significantly, but they also mean that smaller seed companies that license the transgenic traits and introduce them into their own background germplasm, adapted to multiple contexts, are recouping a declining fraction of their costs, since much of the price goes back to the gene owners in the form of a royalty[8].

These fees vary crop by crop, but all have increased over the last few years. For example, the Roundup Ready (herbicide tolerance) trait in soybeans cost US$6.5 per bag in 2000 but by 2009 that had increased to US$17.5[9] . The result is that technology fees have become disproportionally high compared to the total value of the GM seed. As Hubbard (2009, p. 16) puts it: "the biotechnology industry tends to overvalue genetically engineered traits and undervalue the germplasm. In review of recent seed market dynamics, Bonny concurs with this point, arguing that "[h]igh-quality germplasm, as well as regionally specific varieties tailored to different climate and soil conditions are by far the most important characteristics of seeds. Biotech traits only add one or a few additional characteristics, while the agricultural value of the seeds depends on the entire genotype (Bonny, 20014; pages 530 and 531)

Studies indicate that technology fees represent between 23% of the seed costs of GM corn (insect resistant, 1st generation), 41% for soy (herbicide resistance) and 68% for cotton (double stacked)[10].Bonny, 2013 The higher proportion in cotton reflects, among other things, the increased importance of stacked traits, which now commonly combine herbicide resistance with a few insect resistance traits, and an increase in the share of technology fees.

Another consequence of declining competition, as clearly pointed by the literature, is a reduction in variety. Consumers have fewer choices. There are no comprehensive studies of this effect in the seed sector,

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[7] USDA/ERS 2009 "Farm income and Costs: 2009Farms Sector Income Forecast", Bonny, 2013; Taking stock of the genetically modified sector worldwide: market, stakeholders and prices, Food Sec. (2014), 6; 525-540.
http://www.fooddemocracynow.org/blog/2013/oct/4/the_gmo_seed_monopoly_fewer_choices_higher_prices

8 In Argentina, for instance, after the introduction of the soy Intacta (stacked event including resistance to Glyphosato and some insects) Monsanto has been trying to obtain 66% of the total price of each bag of seed leaving the remaining 33% to be divided between Argentinean companies of germplasm and multipliers. This is happens even though there is no evidence that the percentage Monsanto is appropriating reflects the value that the genetic innovations are contributing to the seed. On the contrary the evidence indicates that the contributions germplasm improvements impacted more on increases in agricultural productivity that what was achieved with insertion resistance gene glyphosate (Marin et al, 2014; Shi et al, 2013). Furthermore, when government has tried to intercede to regulate the distribution of benefits between the different types of companies, Monsanto threatened to leave the country. Marin, A., Stubrin, L. and Van Zwanenberg, P. (2014). Developing capabilities in the seed industry: which direction to follow? SPRU Working Paper Series, SWPS 2014-12, Junio 2014. Available at: https://www.sussex.ac.uk/webteam/gateway/file.php?name=developing-capabilities-in-the-seed-industry.pdf&site=25; Shi, G. Chavas, J. , Lauer J. and Nolan, E. (2013) An Analysis of Selectivity in the Productivity Evaluation of Biotechnology: An Application to Corn, American J. of Agricultural Economics Volume 95, Issue 3 Pp. 739-754

[9] Also of some interest is the price markup charged for GM seeds, relative to non-biotech varieties. Based on the aggregate data reported by the, for corn this markup has increased from about 29% in 2001 to 60% in 2008.
http://www.choicesmagazine.org/magazine/article.php?article=120

[10] Bonny 2013

perhaps because it is too soon to notice the effects, but some research and considerable anecdotal evidence[11] suggests that this is happening.

One such study, a comparison of maize seed variety availability in Spain, a country that has adopted GM crops, and in three other European countries that have not adopted the technology, found that the Spanish seed market was more concentrated, with fewer differentiated cultivars on offer.[12] Furthermore, the study found that overall numbers of maize cultivars had declined, by comparison with the other three countries, with an increasing number of non-GM cultivars being replaced by GM cultivars. The USDA has also documented that non-GM seeds are increasingly more difficult to locate, even though demand for non-GM varieties has increased.[13]

The third typical concern in the economic literature associated with market concentration is the diffusion of anticompetitive practices. There are many complains of this type in the literature.[14].A typical anticompetitive practice used by the Big Six when introducing stacked events has been to charge the single events at higher prices, to make sure that the new events are purchased. Another is the practice of requiring seed firms that wish to license their GM events to become exclusive licensees.[15]

Dynamic Concerns

Dynamic concerns are about the effects of market concentration on the rate and direction of innovation. There is not a great deal of quantitative empirical evidence on this topic, but the disappearance of small independent seed firms, declining R&D by public sector breeders, substantial mergers and acquisitions, and the domination of the seed sector by MNCs with core interests in producing and selling GM traits raises critical questions about consequences for the intensity and especially the direction of seed innovation.

The literature includes qualitative evidence and a range of anecdotal claims from academics, farmers and farming organizations that these trends are indeed resulting in declining rates of innovation in conventional seed variety creation, and that the direction of innovation is shifting, both towards the more profitable or widely cultivated crops, with species cultivated on smaller areas facing reduced investment in plant breeding, and towards commercially attractive traits and seed characteristics, i.e. have large rather than specific markets.[16] Hubbard cites a farmer from Illinois, arguing that:"[w]hen we had many regional breeding programs sharing genetic material, someone would find these niche varietal crosses and produce them for quite specific areas. This is gone today because the only varieties that large companies are interested in are ones that can be sold over a very large geographical area".

Public research institutes, which used to play a key role in providing diverse seed varieties, especially for crops and crop varieties where scale and demand implied low levels of profitability, now have a much diminished plant breeding role in many countries. In the USA, where patent law extends to plant varieties as well as GM events and key processes, public sector institutions with less and less funding, they are entering

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[11] http://www.fooddemocracynow.org/blog/2013/oct/4/the_gmo_seed_monopoly_fewer_choices_higher_prices

[12] Hilbeck et al.: Farmer's choice of seeds in four EU countries under different levels of GM crop adoption. Environmental Sciences Europe 2013 25:12.

[13] Hubbard, C. (2009) "Out of hands: farmers face the consequences of a consolidated seed industry. Stoughton, WI: Farmer to Farmer Campaign on genetic engineering.

[14] The American Antitrust Institute documents that only between 2002 and 2009 about 60 patent infringement and antitrust cases were filled in federal districts and appeals courts.

[15] Hubbard, C. (2009) "Out of hands: farmers face the consequences of a consolidated seed industry. Stoughton, WI: Farmer to Farmer Campaign on genetic engineering.

[16] C. Then and R. Tippe (2009) The future of seeds and food under the growing threat of patents and market concentration. http://www.misereor.org/fileadmin/redaktion/2009_e_report_future_of_seed.pdf; Bonny, 2013; Taking stock of the genetically modified sector worldwide: market, stakeholders and prices, Food Sec. (2014), 6; 525-540; Hubbard, C. (2009) "Out of hands: farmers face the consequences of a consolidated seed industry. Stoughton, WI: Farmer to Farmer Campaign on genetic engineering.

into agreements with MNCs, due to the high costs of patenting and deregulation[17]. Importantly, they cannot use existing varieties as a basis for improvement if these have been patented. The widespread patenting of germplasm, research technologies and breeding methods has resulted in a so called 'patent thicket' whose effects have been characterized as a "tragedy of the anti-commons" (Heller and Heisenberg, 1998).

For smaller companies too, as well as public sector breeders, negotiating the 'patent thicket' on materials and methods is now a significant transaction cost for breeders[18]. Since such costs are fixed, these discourage smaller and less resourced breeders[19]. Uncertainties as to what is patented also create an important constraint on research. Even where the intellectual property offices of US public breeding institutions agree that patent claims made by the companies are not likely to be defensible in court the advice, nonetheless when potential conflicts arise they advise not to proceed with the research, because the cost of even a successful lawsuit would be prohibitive. As Kloppenburg notes, monopoly power is thus being used to obstruct research and impede innovation, in a clear inversion of the intent of patent legislation. Public researchers and independent firms, therefore end up performing complementary instead of alternative solutions to farmers' problems.[20]

Quantitative research on the effects of market concentration on innovation exists but is so far restricted to the effects of market concentration on GM-based research in the USA. Here, the annual number of field-trial applications for GM crops increased from 9 in 1987 to 1,206 in 1998. Dividing the annual number of field-trial applications from private firms by private industry sales of seed for each major crop provides a measure of research intensity (applications per million dollars of sales) comparable across crops. Calculations for corn, soybeans, and cotton indicate that as the seed industry became more concentrated during the late 1990s, private research intensity dropped or slowed. Furthermore, ERS analysis, using econometric methods, found a simultaneous self-reinforcing relationship between the concentrating industry and the slowing intensity. Those companies that survived seed industry consolidation appeared to be sponsoring less research relative to the size of their individual markets than when more companies were involved. [21]This finding runs counter to the hypothesis that dominant firms in consolidated industries conduct more new product research than they otherwise would in order to expand the size of their markets (because of less risk of being outcompeted during the long time periods required to bring new products to market).

Development and Sustainability concerns

A final set of concerns about concentration and structural change in the seed industry are about a) the location, and political power of the seed industry, and b) the issue of agricultural biodiversity.

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[17] Kloppenburg, 2013

[18] It has to be considered that research and innovation in seed requires full access to existing genetic material since new characteristics are obtained based on existing variability.

[19] Regulatory costs to bring a GM crop to the market can vary from 15-30 million US dollars to 100-180 million US dollars. Similarly, the estimated regulatory compliance costs for GMO approvals vary from 10-30 million US dollars to 80-110 million US dollars (Schenkelaars et al 2011). This often exceed R&D costs by far. Existing estimations indicate that they can be up to 10 times higher than R&D costs.

[20] But restricted access to biotechnology tools, genes and information to public sector researchers and developing country firms, as a result of stricter IPRs does not only affect innovation, it also affects research on impact (http://www.nytimes.com/2009/02/20/business/20crop.html?_r=0)

[21] Fuglie, K. Heisey, P King, J. and Schimmelpfennig, D: Rising (2012) Concentration in Agricultural input industries influences new farm technologies; http://www.ers.usda.gov/amber-waves/2012-december/rising-concentration-in-agricultural-input-industries-influences-new-technologies.aspx#.VglHS99Vikp; Schimmelpfennig, D; Pray C., and Brennan, M (2010) The impact of seed industry concentration on innovation: A study of U.S. biotech market leaders, file:///C:/Users/anabel/Downloads/SSRN-id365600.pdf; Cornejo, J. and Schimmelpfennig, D. (2014). "Have Seed Industry Changes Affected Research Effort?". United States Department of Agriculture. Economic Research Service.

The first of these refer to a range of issues, such as for example, concerns about developing countries' loss of plant breeding capabilities in situations where foreign firms are purchasing much of the domestic seed industry, and where public sector plant breeders are less and less active in crop variety development. Related to this are anxieties about food sovereignty, given that not only plant breeding activities may be increasingly conducted by foreign owned forms, but also because those firms own plant varieties and genetic resources. The fact that the seed-biotechnology-chemical 'agronomic systems' that may own a significant part of national seed resources, and that conduct a large proportion of seed R&D within many countries, are so large and powerful, economically and politically, has also raised concerns about the difficulties of creating and securing domestic legislation and policy changes that run counter to their interests. Similarly, at international level, these large firms are able to secure favourable international rules and regulations that may limit national political autonomy on matters related to the seed and agricultural input sector (Bonny, 2013)[22].

The second issue, of agricultural biodiversity is of key importance. Over much of the last century and especially in the post war period, the trend has been one of dramatically declining agricultural biodiversity. Agricultural concentration on a few high performing crop varieties, a trend that began before the most recent period of consolidation in the seed industry, but that has been reinforced by concentration in this industrry over the last three decades, together with the further diffusion of intensive agriculture has resulted in a dramatic loss of agricultural biodiversity at three levels: a) a decrease in the range of cultivated plant species for food; b) loss of intraspecific biodiversity, i.e. a decrease in the cultivated varieties of each plant species; and c) genetic erosion of both the plant varieties excluded from cultivation, and of those varieties that are marketed and cultivated (due to modern methods of selection and subsequent inbreeding).

In a 2004 report, the United Nations Organization UN Food and Agriculture (FAOSTAT) noted that in one century the planet has lost more than 75% of its agricultural biodiversity. This is because three quarters of world food is produced from only 12 plants and five animal breeds, and because, from about 12,000 known edible plants, humans use only 150 to 200. Currently, only three species (rice, maize and wheat) account for 60% of the calories and proteins obtained from plants to meet human food needs.

The main problem is that this dramatic reduction in variability involves substantial risks. A disease or pest can wipe out large swathes of the world's food production and clearly dependence on a few staples worsens the consequences of any crop failure. Such risks are magnified by climate change, which is expected to cause higher temperatures and more frequent droughts, changing the distribution of pests and diseases. [23] Declining agricultural diversity also threatens future innovation in crop varieties, because less natural genetic variability diminishes the material upon which new traits can be discovered.

A wide range of factors contribute to the decline in agricultural biodiversity, but further concentration in seed markets, and diminishing participation by both public breeders and small and medium companies and the exclusion of famers from breeding activities it is very likely to contribute to those long run declines. Seeds, however, are not only a means of maintaining agricultural biodiversity, but also of increasing it, but

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[22] Bonny, 20013; Iden; P. Newell and D. Glover (2003) Business and biotechnology: regulation and the politics of influence, IDS Working Paper 192; Vanloqueren, G. and Baret, P. V., (2009). 'How Agricultural Research Systems Shape a Technological Regime That Develops Genetic Engineering but Locks out Agroecological Innovations', Research Policy, Vol. 38, No. 6, pp. 971-83.

[23] http://www.economist.com/news/leaders/21664144-storing-wild-seeds-will-save-harvestsand-lives-growing-pains?fsrc=scn/tw/te/pe/ed/growingpains

the latter function requires increased variability and diversity to increase. The prospects for accelerating such variability and diversity, given the disappearance of small and medium size firms and public sector, appear very slight.

3. Responses

These challenges have elicited a number of different responses and proposals. One such response, which addresses only some of these challenges, has been to propose greater public investment in seed banks. These are facilities used to store seeds from crop varieties as well as wild plants, in an effort to prevent the complete loss of existing levels of biodiversity. Seed banks, located all over the world, have been established by governments and organizations concerned with crop diversity. (Plucknett et al. 1983).

Seed variety specimens stored in seed bank are periodically used to grow plants, which are used to produce fresh seeds to ensure that the seeds will be viable if they ever need to be used. In addition, plant cultures for species that do not readily grow from seed are also stored. Seed banks are especially important for "orphan crops" such as cassava and taro, which make up a substantial part of people's diets in some part of the world. Damage to these crops could have a very serious impact, which can be averted by a seed bank. A seed bank also preserves important pieces of regional heritage, such as rare and unusual crop varieties that are not viable commercially, as well as the wild relatives of cultivated plants.

Wild relatives have been a crucial resource for dealing with agricultural challenges in the past and are likely to become more important in the face of climate change and population growth. As the Economist explained in 2015 *"Botanists can screen [wild relatives] for valuable traits, and use the genes to breed new domestic varieties. Asian paddy fields were saved from the brown planthopper 40 years ago thanks to one wild Indian rice species. This is often cheaper and less controversial than genetic modification. But success depends on having thousands of varieties to test*." (The Economist, 2015)[24]

There are examples of germplasm banks at global scale such as the Millennium Seeds Bank Project (www.bgci.org/worldwide/article/134/) and the CIMMYT (www.cimmyt.org/en/what-we-do/germplasm-and-seed) but the plant breeding community has warned that these are not sufficient. Most global seed banks were built in the 1970s and 1980s and since then there has been little effort to develop new ones. Some have disappeared in situations of wars and climate disasters and such phenomena will continue to affect seed banks in the future. According to a recent study, existing seed banks are missing more than half the wild relatives of the world's most important food crops - which potentially harbour useful traits for creating higher yields, resistance to disease and resilience to climate change.(ScieDev, 2015)[25]. -

In addition, most of the broader and most ambitious seed bank initiatives are located in, or managed by, advanced countries. For example, the largest wild-plant seed bank in the world, housing 76,000 samples from more than 36,000 species, the Millenium Seed Bank in Sussex, is part of Britain´s Royal Botanic Garden. In less developed countries, where most existing biodiversity is still preserved in situ, seed banks are scarcer

[24]http://www.economist.com/news/leaders/21664144-storing-wild-seeds-will-save-harvestsand-lives-growing-pains?fsrc=scn/tw/te/pe/ed/growingpains

[25] See more at: http://www.scidev.net/global/genomics/news/half-of-key-wild-crops-missing-from-gene-banks.html#sthash.nwSkRd8x.dpuf

and more vulnerable. A common problem is that whilst investments are made in infrastructure, there is less funding for maintaining healthy samples which requires regular propagation, not just dehydration and freezing.

Argentina is a good example in this respect. The country has several initiatives; some of which are managed by the National Institute of Agricultural Technology (INTA), such as the National Network of Germplasm Banks (inta.gob.ar/videos/red-de-bancos-de-germoplasma-1/view), and others by Universities or independent research institutions such as Conicet. However, each of these initiatives is autonomously managed, with its own objectives. The country lacks a national policy of biodiversity preservation or access to national biodiversity. Many of the seed banks, although developed using substantial public funds, can and have been sold to private companies. There is no regulation related to this issue .

A second, broader and perhaps more common reaction to the challenges associated with concentration of the seed sector in a small number of MNCs has been to challenge the legitimacy of the new IPR rules, which have been pivotal to creating the opportunity for large firms to invest in the seed business and genetically engineered seeds in particular; and to challenge the safety and social acceptability of GM crops varieties and/or the agricultural trajectories that they support and reinforce. This can be somewhat of a defensive strategy, and indeed is often coupled with calls to help reinstate and support practices that have been eroded under current trends, such as more traditional 'low tech' farmer-to-farmer seed exchange/improvement practices, or public sector investment in seed breeding. More proactive responses point to the need to combine farmer's knowledge with more specialized technological and scientific knowledge through methods such as participatory plant breeding (PPB). PPB, aligned with the idea of open innovation, is based on the idea that farmers as well as professional plant breeders have important knowledge and skills that should complement each other[26].

One of the main arguments made in favour of preserving the role of farmers in breeding is that farmers are the true guardians of agricultural biodiversity since they are the only actors that can practice *in situ* conservation. *In situ* conversation is important, even where there is *ex situ* conservation, mainly because it is dynamic, increasing diversity as well as conserving existing diversity. For example, farmer-to-farmer seed exchange/improvement practices also encourages the preservation of traditional farming knowledge, which is important for a number of reasons, including the fact that it varies from location to location, and because farmers use different criteria when evaluating seeds depending on locality, the size of their farm, their objective, tastes, and cultural differences. This is a unique means for expanding seed diversity.[27] Furthermore in situ conservation does not incur the same risks as seed banks, such as genetic drift within collections, loss of seed viability, equipment failure, security problems, or economic instability (Aoki, 2009, p. 2304)[28]

[26] The roles that farmers and trained breeders play may vary depending on the specific project and the expertise of the participants. Formally trained plant breeders can bring expertise in how to set up trials to get the best information from them and how to access varieties or other breeding material that might not be available commercially. Formal breeders also bring expertise in specific techniques such as crossing or disease evaluations. Farmers may play a role in setting the breeding goals, deciding which varieties to use as parents in new crosses, making crosses, growing and selecting the breeding populations, and releasing new varieties. In many of the best partnerships, the farmers are the experts in knowing what the production and market needs are for a given crop, what are currently the best available varieties, and where the gaps are in what's available commercially. They often know the best way to grow a breeding population to best match real farm production conditions, and know when to look for key traits.

[27] Kloppenburg, J. (2014): Re-purposing the master's tools: the open source seed initiative and the struggle for seed sovereigntyThe Journal of Peasant Studies, 2014 Vol. 41, No. 6, 1225–1246, http://dx.doi.org/10.1080/03066150.2013.875897; Shiva, V. 2012b. Defending seed freedom. Available at http://seedfreedom.in/declaration/ [Accessed 25 August 2013], Shiva, V., C. Lockhart, and R. Schroff (eds.) 2013. The law of the seed. New Delhi, India: Navdanya International.

[28] Aoki, K. 2009. 'Free seeds not free beer': Participatory plant breeding, open source seeds, and acknowledging user innovation in agriculture. Fordham Law Review, 77(5), 2275–2310.

Many commentators argue that public sector breeding is key to meeting farmers diverse needs and expanding the choice of varieties, given that the private sector focuses predominantly on crops with a large market share and on traits that are useful for commercial agriculture. This is held to be especially important in developing countries where many crops that are hugely important for small-scale farming have little commercial interest for the private sector. Responses vary between arguments for rebuilding public plant breeding programs;[29] arguments that the public sector is often unable to develop new varieties alone (e.g. because key technologies are unaffordable) and therefore public-private partnerships are required;[30] and arguments that public investment should be encouraging the develop of genetically engineered seed innovations for example through public-private partnerships, transfer of knowledge and technology from the private to public sector (and vice versa) and by increasing the incentives for the private sector to develop less commercially attractive crops and traits.[31]

Interestingly, there appears to be a third, much less widely recognized (and understudied) potential alternative response to market concentration by a few MNCs, and this is to support a distinctive seed innovation trajectory by private companies. We observe that some seed firms in developing countries, where IPR regulations are less strict than in the USA[32] have been following this alternative trajectory. It is a 'high tech' trajectory, but one based not on genetic engineering, which is expensive, inefficient and more controversial,[33] but on other non-proprietary modern biotechnologies, and molecular biological knowledge. This also involves a different business model to that adopted by the large MNC seed firms. This model is based on providing solutions to diversity, rather than standardised products, by developing seed varieties in smaller volumes specific to locally variable agro-ecological conditions, and by responding quickly to changes in those conditions with new adapted varieties[34]/. Several of the challenges identified earlier that are associated with the trajectory followed by the Big Six, namely the oligopolistic characteristic of this market (static disadvantages), the dynamic disadvantages related to innovation, and the challenges of sustainability and development may be better addressed if this alternative trajectory flourishes, and can compete successfully with the dominant business and innovation model. This is an alternative that has several of the advantages of the farmer-to-farmer seed exchange/improvement option, but it is knowledge intensive, and in principle can exist in parallel with farmer-based seed improvement practices

Some Argentinean and Brazilian firms that have been adopting this alternative business model and innovation trajectory are successfully outcompeted the larger MNC seed firms in the region, even in unfavorable regulatory environments, but we note that that evidence is largely neglected in wider

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[29] Hubbard, C. (2009) "Out of hands: farmers face the consequences of a consolidated seed industry. Stoughton, WI: Farmer to Farmer Campaign on genetic engineering.

[30] M. Lusser (2014) Workshop on public-private partnerships in plant breeding .JRC SCIENCE AND POLICY REPORTS European Commission

[31] Pray, C. E., & Naseem, A. (2007). Supplying crop biotechnology to the poor: opportunities and constraints. *Journal of Development Studies,* 43(1), 192-217.

[32] Most developing countries have in place some kind of sui generis system of protectiontipically following UPOV 1978. But they do not have patent systems that extent to plants. Actually the only countries that have such system are USA, Australia, Korea and Japan

[33] The Economist, 2015, http://www.economist.com/news/leaders/21664144-storing-wild-seeds-will-save-harvestsand-lives-growing-pains?fsrc=scn/tw/te/pe/ed/growingpains

[34] As pointed out by a key informant interviewed from one of the companies within this trajectory: "A key element of Don Mario strategy is positioning itself as a first mover (…). Don Mario´s strategy consists of possessing a wide spectrum of seed varieties that are suitable for different climate and soil conditions as well as resistant to pests. Thus, Don Mario attempts to be the first that cater to the market with the type of variety that is more suitable for the problems or agro-ecological conditions of each year and region". A TMG key informant also asserts that: "Time-to-the market and diversification are the main strategies to compete in the seed market". Marin, A., Stubrin, L. and da Silva Jr., J. J. (2015). KIBS Associated to Natural Based Industries: Seeds Innovation and Regional Providers of the Technology Services Embodied in seeds in Argentina and Brazil, 2000-2014. Discussion Paper No. IDB-DP-375. Available at http://publications.iadb.org/handle/11319/6955

discussions about the evolution of the seed industry. An indication of the importance of these firms is their participation in the ownership of plant certificates that reach the market (or market share). In the case of Argentina, for example, for the four most important industrial crops (soybean, maize, sunflower and wheat), three local companies have the greatest market share. The case of Don Mario is a good example (Nidera is very similar). Don Mario is a local company dedicated to the development of new varieties of soybean. The firm has managed to gain a significant share of the domestic market not only in Argentina but also abroad. The company, with subsidiaries in Brazil, Bolivia, Uruguay, Paraguay (and more recently in the USA) had almost 50% of the Argentine soybean market in 2013 (with another 40% served by another Argentinean/Dutch company Nidera), around 25% of the total Brazilian market and 57% of the south of Brazil, where the company is named Brasmax, and an estimated 25 % market of all the Latin American soybean market.[35.]

Don Mario is deliberately not involved in the development of transgenic events, not for lack of technological capabilities, but because of the significant costs of complying with regulatory biosafety requirements and the costs of patenting – which can reach levels up to 10 times higher than those connected with developing the new event. The company, however, performs crossbreeding relying on advanced bio-technological tools (e.g. molecular markers) and on a complex network of development and experimentation that spreads all over the soy regions in Argentina, the south of Brazil, Paraguay and Uruguay.

Table 1 shows the improvements managed by the company in crucial dimensions of the process of development and innovation in seeds well adapted to different agro-ecological conditions in Latin America. These improvements have resulted in significant genetic gains. It has been estimated that the soy varieties of Don Mario have increased the average yield by 1.63% per year in the period 1998-2013. The total yield increased by 22.84%.

Table 1: Evolution of Don Mario innovation efforts (1997-2013)

	1997	**2013**
Soybean varieties	8,500	400,000
Number of experimental plots	30,000	1,100,000
Number of locations of experimentation	5	70
Breeding time (average)	12/13 years	5/6 years

Source: Own elaboration based on information provided in the interviews.

Similar evidence has been found in the case of India, in cotton, where domestic firms providing diversity have outcompeted foreign MNCs. The cotton market in India, as well as the soy market in Argentina, has adopted the transgenic innovations provided by the large Big Six, namely herbicide tolerance and insect resistance.[36] Nevertheless, as in the Argentinean case, the Indian market is dominated by domestic firms

[35]The company licenses transgenic events from MNCs, but does not develop genetic engineering. Marin, A. and Stubrin, L. (2015). Innovation in natural resources: New opportunities and new challenges. The case of the Argentinian seed industry. UNU-Merit Working Paper, Maastricht. Available at: http://www.merit.unu.edu/publications/wppdf/2015/wp2015-015.pdf

[36] Choudhary, B. and Gaur, K. (2015). “Biotech Cotton in India, 2002 to 2014”. ISAAA Series of Biotech Crop Profiles. ISAAA: Ithaca, NY. ; Iizuka, M. and Thutupalli, A. (2014). "Globalization, the rise of biotechnology and catching up in agricultural innovation: The case of Bt technology in India". UNU-MERIT. Working Paper Series. Pray, C., and Nagarajan, L. (2012). "Innovation and Research by Private Agribusiness in India". International Food Policy Research Institute. Discussion Paper 01181.; Spielman, J., Kolady, D., Cavalieri, A. and Chandraskhara Rao, N. (2014). "The seed industry and agricultural biotechnology industries in India: An analysis of

developing their own varieties. The firms Nuziveedu Seeds, Rasi, and Anker, all indigineous capture most of the final market of seeds. As early as 2000, these firms had developed a knowledge base critical for developing variaties adapted to different agronomic and agro-ecological conditions (Pray et al., 2014). In fact, Nuziveedu Seeds, a firm that currently captures 23% of the total market, enjoyed market leadership in non-Bt or conventional cotton hybrids that were developed in house before the entry of Bt technology into India. By sublicensing the Bt event from Monsanty, Nuziveedu then introduced the Bt versions of the same hybrids and utilizing its existing competences, in terms of both the in-situ knowledge base and expertise in developing conventional hybrid seed markets (Pray and Nagarajan, 2014) maintained the highest market share in the market.[37].

This is surprising with a world seed market increasingly concentrated in a few large MNCs that own and can defend internationally patented genes.

Clearly the business and innovation strategies adopted by the kinds of domestic firms we have described can work in complementary ways with those adopted by the large MNCs (i.e. GM events can be licensed from MNCs and backcrossed into new germplasm that has been developed by those firms using advanced conventional breeding) but they also represent competing ways of obtaining new characteristics and traits. In principle many of the same traits that MNCs create using genetic engineering, or that they might in the future create using genetic engineering, can also be created using advanced conventional breeding techniques[38]. At the same time important traits that cannot be obtained, or have not been obtained with GM technologies have been managed within this trajectory[39]. In other words, the alternative business strategies and associated innovation trajectories are potentially competing too.

Importantly, this alternative business model/trajectory does not require or tend towards a highly concentrated sector in the way GM-based strategies do, and so avoids most of the potential problems associated with high levels of concentration, such as the destruction of national seed industries. Furthermore, entry barriers are far lower, given less arduous regulatory biosafety and IPR demands and less

industry structure, competition, and policy options". Food Policy, Vol. 45, pp. 88-100.; The Times of India (2015). "Seeds of doubt: Monsanto may never have had Bt cotton patent". Published in June, 8th. Available in: http://timesofindia.indiatimes.com/india/Seeds-of-doubt-Monsanto-never-had-Bt-cotton-patent/articleshow/47578304.cms; Metahelix (2015). Accessed in September. http://www.meta-helix.com/; Nuziveedu Seeds (2015). Accessed in September. http://www.nuziveeduseeds.com/; Rasi Seeds (2015). Accessed in September. ; http://www.rasiseeds.com/; JK Seeds (2015). Accessed in September. http://jkseeds.net/

[37] Nuziveedu Seed Private Ltd (NSPL) has led the market in the sale of cotton seeds for more than a decade because it developed two superior cultivars, Bunny and Mallika, from its own R&D in 1995. When commercial cultivation of Bt cotton started in India in 2002, NSPL licensed Bt and released Bt Bunny and Bt Mallika in 2005. By 2007, Bt cotton was marketed by more than 25 companies in India. Because almost all 25 companies used the same Bt gene, the principal differentiating factor of NSPL hybrids to farmers was the superior attributes of background hybrids. So far, NSPL has about 142 varieties of hybrid commercial cotton seeds, approved by the Indian government's Genetic Engineering Approval Committee. The market share of NSPL hybrids has been greater than 35 percent over the last decade as a direct result of superior germplasm (NSL limited website (2010) and Indian Credit Rating Agency(ICRA) Perspective, February, 2010).

[38] Actually key traits achieved by genetic engineering - for herbicide tolerance, coleopteran pest resistance, b-carotene enrichment and delayed ripening - have all been introduced in major food crop varieties by advanced cross breeding and mutagenesis techniques (Arundel 2001; Zamir 2008; Brumlop and Finckh 2011)

[39] In the Latin American region, this domestic firm led trajectory has indeed delivered important innovations, which have revolutionized the agricultural scene. A good example is a change in the life cycle of soybeans, an achievement of domestic firms in Argentina which has enabled farmers to increase productivity significantly and improve field management. This involved altering the growth habit of soybean varieties in so called 'long maturity groups', which work well in the Pampeana North Region and the North Region, in Argentina and in the southern region of Brazil, two regions that experienced a significant increase in the cultivated area during the last decade[39]. Another example is the adaptation of varieties of short maturity groups to work well in regions where previously only long maturity groups worked well. By advancing the period of maturation, these varieties allowed double cropping of soy and corn, which in Brazil has explained the boom in production of both crops during the last recent years.

need to license knowledge. And the business model does not tend to a reduction in innovation diversity; rather niche markets and less commercially attractive crops can be attended to (see Table 2).

Table 2: Competing approaches to improve seeds: differences in regulatory, market and environment of application

Potential dimensions to consider	Transgenic	Cross breeding
Knowledge base (1)	Scientific	Traditional and Scientific
Type of knowledge (2)	Proprietary	Proprietary and free
Regulations (3)	International harmonized and ad hoc loalised Very expensive	International harmonized and ad hoc loalised Cheap
Potential applications (4)	Limited	Diverse
Main private actors (5)	Large MNCs companies	Domestic, SMEs, public agencies, farmers, ..
Role of public institutions (6)	Limited	Very important
Criteria of Success (7)	Appropriability and market power	Diversity, preserving the germoplasm
Technology markets (8)	Global and concentrated	Regional and disperse
Demand (9)	Restrictions linked to consumers' awareness	Unrestricted
Products (10)	Standarised, Private	Diversified, private and public
Health and environmental risks (11)	Uncertain	Low
Entry barriers and concentration (12)	High	Low

An important challenge that this trajectory faces, however, currently, is the disequilibrium in the IPR system protecting genetic engineering events and germplasm improvements. In LAC, as elsewhere, non-transgenic seed varieties are protected by a property rights regime for seeds based on an international protocol known, as UPOV. This gives seed breeders exclusive rights to market their own registered varieties, but allows competing plant breeders to use those registered varieties as an initial source of germplasm or the purpose of creating new plant varieties, without the need to seek permission or pay royalties to the original breeder. By contrast, the patent regime does not allow patented gene sequences to be used as a basis for further improvement to seeds without a license from their owner. This means that seed companies that have developed transgenic seed varieties have the right to a financial claim on all future seed varieties that use the transgenic gene sequence (or at least until their patent expires). By contrast firms that create a novel trait using non-transgenic techniques only have a claim on the first variety to incorporate that innovation; other firms are then free to use that non-transgenic variety (and the novel trait it incorporates) as a basis for creating their own novel seeds. This is a huge advantage for firms that choose and are able to use a transgenic approach when distributing rents and works in detriment of firms performing other types of innovations.

Several are arguing that one way to equilibrate the situation would be to use patents or plant certificate's more similar to patents – in fact UPOV 1991 proposes a systems of plant certificates more similar to patents- to provide both contributors to the innovation in seeds, the ones that contribute gen and germplasm equal tools to protect their innovations. Nevertheless, by doing so the system might end up encouraging a similar behavior by these firms as the one followed by the large MNCs. It would more profitable for them as it has been for the large MNCs to develop a few standardized innovations that can be protected for a long time and then exploit these innovations. There will be not enough incentive for innovations, of the kind they are doing now. At the same the benefits derived from the alternative trajectory they have followed, which involves lower entry barriers and free circulation of germplam, which incentive dispersed innovation, will be eliminated, and again the same costs of the patent system will emerge.

A different solution that has been proposed by some thus is to use an open source system, similar to the one used in the open software movement[40] (see explanation in Box 1).

[40] Kloppenburg, J. (2014): Re-purposing the master's tools: the open source seed initiative and the struggle for seed sovereigntyThe Journal of Peasant Studies, 2014 Vol. 41, No. 6, 1225–1246, http://dx.doi.org/10.1080/03066150.2013.875897;, Aoki, K. 2009. 'Free seeds not free beer': Participatory plant breeding, open source seeds, and acknowledging user innovation in agriculture. Fordham Law Review, 77(5), 2275–2310; Hope, J. 2008. Biobazaar: The open source revolution and biotechnology. Cambridge, MA: Harvard University Press

BOX 1: Open source in seeds

The open software movement responded to programmer´s needs for sharing source code and was premised on the General Public License (GPL), which is viral. This means that if one downloads a copy of GNU/Linufx, for instance, one is bound by its terms. These imply that any modifications one makes to the program are not proprietary but rather subject to the same terms of the GPL. Free software can be sold, and the ones that buy it can modify it, and re-sell it. What they cannot is to restrict other´s right to continue using, and modifying the program. Seeds are similar to software it is argued. Actually large companies in defending their right to use IPR to protect them claimed these similarities. Companies like Monsanto, Syngenta and Dow, in the 1990´s trying to obtain patents for their genetic improvements, redesigned the business using this metaphor. Seeds were software. Genetics were improved almost surgically, with breeders altering DNA the way programmers rewrite code. When you buy a seed what you are buying actually is the right to use its services, the services that contain the seed which have been introduced by breeders. Open access to plant genetic resources covered by open source licenses have been proposed to help to guarantee access to germplasm for future improvement, and in this way to preserve access, and socio-economic diversity, all of which seem crucial to preserve biodiversity.

This should include according to the proponents is a “copyleft” requirement that all derivatives lines and combinations of the licensed material be free for breeding. The originators of the genetic material might collect or not collect royalties, but their obligation is not restrict usage in any way. Recipients of genetic material can grow the seed, reproduce it, share the seed, sell the seed, might conduct research with the seed, might breed new varieties with the seed and farmers may save and replant the seed. So the system can incorporate the need of breeder to collect resources in association with their investments in innovation, and at the same time the requirements of farmers to save seeds and those of breeders, to be able to re-use seeds fir further research and innovation. The problem that the open source system challenges thus is not that seed companies obtain and use crop genetic resources, or even that they sell seed. The problem this system aim to address is that they are restricting access to and preventing the use of material that as a matter of reciprocity ought to be shared.

In this way, biodiversity and access to this biodiversity can be to some safeguarded.

The proponents of this system are confident that by means of a system like this a vibrant participatory plant breeding system that includes, both farmers and breeders, public and private can be developed. It works with the idea that farmers are both users and developers of different types of information technologies. An application of the model would entail creating, maintaining and growing an inclusive user community of farmers, plant breeders and researchers through which information and technology may be exchanged freely via decentralized commons-based peer production networks, ..

Under this system also smaller seed companies would be able to compete with larger companies by lowering fix costs and farmers by creating new varieties suited to local environments.

5. Policy and research questions

The challenges outlined earlier associated with the oligopolization of the seed market are huge, and of different types. They include static economic problems; dynamic problems related to innovation; developmental problems related to the global distribution of capabilities and to sustainability challenges related to agricultural biodiversity. They are interconnected, but each one represents an important challenge in itself.

We know little about the potential and feasibility of the existing responses and alternatives that have been outlined as a means to address these challenges, or how we might best encourage and support them. At the same time it seems that none of these proposals can deal with all of the challenges at the same time. The different responses and possibilities will probably need to complement each other. We also know little about how such proposals might interact with each other.

Given this context it seems appropriate to outline and reflect on a research program that addresses several questions. These can be grouped into three overarching sets of questions; first about better characterizing the implications of seed market concentration and restructuring; second about how each of the alternative proposals are currently working, the extent to which and ways in which they address existing challenges in the seed sector, and their potential to play a more important role in that sector, and third about how each of the alternatives could be better supported, in terms of public policies, invectives, capability building and so on. Under each of those sets, a more specific group of questions can be proposed as follows of

1. Further characterizing the implications of seed market concentration and restructuring

Concerns about the static, dynamic and development and sustainability challenges of seed market oligopolization are widely expressed, but empirical evidence, especially quantitative evidence, is sometimes sparse. We know far more about trends in the USA, for example, than we do in other countries. And some of the challenges, for example associated with the dynamic implications of seed market restructuring for the rate and direction of innovation, have not yet been systematically explored. Important questions include for example:

- In the USA, rapid and extensive concentration in the seed industry and few remaining small and medium independent firms are well documented, but what is the situation in other countries?
- How have funding, research intensity and research priorities changed in public sector breeding institutions, and for what reasons?
- How have seed prices changed in countries other than the USA over the last 20 years?
- How have the number and diversity of crop varieties available on the market changed in different countries, and how does this vary by crop and between jurisdictions where GM crops have been commercialised and those where the technology has not been adopted?
- How has the rate and direction of innovation in conventional plant varieties been changing, and how do those changes correlate with changes to the structure of the seed industry in different countries

2. Understanding how alternative proposals that have been advanced to address these challenges are working at present, how and to what extent they address key challenges, and the scope for expanding alternatives so that they have a more influential role in the seed sector?

In relation to seed banks important questions include:

- How can seed bank initiatives help to preserve plant species that currently exhibit low diffusion for potential future use?
- How might seed banks help address issues of food security in face of climatic change and population growth?
- Can national germplasm banks addresses challenges related to seed access, especially by small farmers, helping to reduce inequality?

In relation to an alternative trajectory of seed innovation by private firms, important questions include:

- In Argentina, and in India, alternative trajectories of seed breeding have been documented, but how widespread is this alternative trajectory in other jurisdictions?
- Where independent seed firms have adopted this alternative trajectory why have they done so? What are the policy, regulatory, institutional, economic and other incentives for pursuing, and constraints on, that business model and innovation trajectory?
- What factors threaten the survival and expansion of those alternative trajectories? Do they differ amongst different among crops?
- Under what kind of policy and legislative framework can alternative trajectories continue to or best succeed?
- How do these new emerging trajectories interact with dominant pathways followed by large MNCs (synergies/conflicts etc)
- Do the knowledge bases underlying emerging and existing trajectories overlap? Why does this matter?
- Who is creating the knowledge for the new emerging trajectories?

3. How can each of the alternatives be better supported, in terms of public policies, invectives, capability building, education knowledge resources, etc. For example:

- Which is the role of knowledge in supporting each of these alternatives? Would the knowledge necessary to support those alternatives be available if market incentives go in one direction and public interest in another?
- If knowledge advances are not independent of market incentives, but dependent on them, a variety of responses and alternatives can only exist if a variety of advances in knowledge are also assured. How can we ensure that happens?

4. How can different responses complement each other? Can we think of a public system guardian of biodiversity and access when the IPR system can restrict the access of important varieties to cope with future problems?