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Benign or detrimental institutional environments

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Abstract:

This paper explores whether GM crops are a feasible option in the light of social conditions that determine a successful and satisfying deployment of such crops. We use the new institutional economics framework of Williamson to structure four main institutions that we consider crucial for the societal acceptance of GM crops. To create broad support and a proper basis for the use of GM, food safety and environmental regulations, intellectual property rights, entrepreneurship and public debate should all be in place. These four institutions should be seen as four legs of a chair: they are all related and if one or more leg fails the chair will be very unstable. Too much food safety and environmental regulations may however prevent companies from trying to get new seed varieties approved. Also on the degree of IPR protection a delicate balance needs to be struck to encourage R&D yet avoid an undesirable degree of market concentration. Public debate and participatory engagement are important for increasing consumers' and citizens' trust but very heated debates can lead to a stalemate that blocks further progress.

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1. Introduction

The rise of botanical gardens in the 17th century has been an important development in plant breeding. This progress in plant breeding control could however be called futile in comparison to the level of control made possible in the modern biotechnology era, which started in the 1950s when Watson and Crick presented the double helix model for DNA (deoxyribonucleic acid). It took some decades before molecular genetics and plant breeding began to interact with each other but in the 1980s it became clear that the tools of genetic engineering could be used in the process of plant breeding on a level of control that eclipsed all previous scientific efforts. Biotechnology is a major improvement because it truncates both time and space and introduces a much greater precision in the breeding process (Busch et al., 1991).

Since then genetically modified (GM) crops have been presented as a technological promise for realizing food and nutrition security (Tonukari and Omotor 2010; Halford 2012) but have also functioned as a lightning rod for visceral debate on questions of ethics, biosafety, biodiversity, intellectual property rights and the position of developing countries (Serageldin, 1999; McAfee, 2003; Kropiwnicka, 2005; Azadi and Ho, 2010; Charles et al., 2010; Shiva, 2010; Bovenkerk 2012). On a fundamental level new biotechnologies are a milestone in the reductionist world view that sees nature in a mechanistic way: by studying the properties of the smallest pieces (atoms and molecules) we can understand how the whole machine (life) fits together and might also be controlled (Busch et al., 1991; Busch, 2010). This idea of reducing life to the laws of physics and chemistry and trying to steer life can be seen as hubris and in breach of religious beliefs. It can thereby provoke strong and intrinsic objections: we should not be playing God. Here we enter fundamental debates about the instrumentalisation of nature and the boundaries of scientific endeavour and our relations to non-humans (Bovenkerk, 2012).[1]

[1] Besides religious also secular grounds can be a basis of fundamental criticism. McAfee (2003), for instance, identifies a combination of molecular-genetic and economic reductionism that in her view falsely justifies the development and commercialization of agricultural biotechnology.

In this paper we will not go into such fundamental debates in which (new) biotechnology is rejected a priori. We start from the practical assumption that in modern societies it is generally accepted that we modify nature on the basis of scientific knowledge and that biotechnology can contribute to future food and nutrition security if certain social conditions are fulfilled (guarantee of biosafety and biodiversity, recognition of the interests of poor people, etc.). This does not mean that we consider objections of principle as irrelevant but the goal of our argument is to show that even when there is a general broad consensus on the technological possibilities and use of GM crops to secure food and nutrition security, this still leaves the question open whether GM crops are a feasible option in the light of social conditions that determine a successful and satisfying deployment of such crops. The main question of this paper is thus:

> *Assuming that GM crops can be beneficial for realizing food and nutrition security, what will be further institutionally needed to realize these benefits?*

Although a substantial number of experts advocate biotechnology as a chance to solve the world food problem, many others think that it is a peril to this rather than a solution. Therefore, the societal acceptance of GM crops cannot be taken for granted, opportunities and threats must be recognized to assess the chances of biotechnology as part of a solution for food and nutrition security.

To get a clearer view of the institutional conditions that should be fulfilled for GM crops to make a genuine difference for food and nutrition security, we will use the four level framework of Williamson (2000: 597), a well-known scholar in the field of New Institutional Economics, to structure four main institutions that we consider crucial for the societal acceptance of GM crops. An institutional perspective on this subject is in our view not only helpful but also a priority for understanding the dynamics of the policies and debates concerning GM crops. Institutions are pivotal for the structuring (or shaping) of both the micro-world of individual attitudes and free action and the wider landscape of macro-developments that are often felt as unchangeable historical facts (Giddens, 1999).

We are aware that limited data are a problem (Frewer et al., 2013) but our concern here is not the availability of data but formulating a set of institutional variables and criteria that could guide data mining on this topic. In the next two sections we will explain our use of Williamson's framework and argue which four institutions we consider to be crucial for the feasibility of GM crops being part of the solution for food and nutritional security. The subsequent sections will discuss these four institutions separately. In the final section we will summarize our findings, including some reflection on the institutional variables (and a set of indicators) that in our view should be acknowledged to assess the feasibility of GM crops in developing countries.

2. Four levels of social analysis

Taking stock of New Institutional Economics (NIE) Williamson (2000: 597) considers four levels of social analysis that in his view have different time scales. The first level of embeddedness encompasses norms, customs, mores, traditions, etc., and are linked to a very slow pace of change – in the order of centuries or millennia – whereas the fourth level of resource allocation and employment can be seen as the continuous field of neoclassical economics that deals with the law like functioning of prices and quantities in a market situation that shapes incentive alignment and efficient risk bearing. According to Williamson NIE has been concerned principally with levels 2 and 3, institutional environment and governance, which are related to a time scale of respectively 10 to 100 and 1 to 10 years.

Table 1: Four levels of social analysis

1. Embeddedness	Informal institutions	Customs, traditions, norms, religion
2. Institutional environment	Formal rules of the game	Property, polity, judiciary, bureaucracy
3. Governance	Play of the game	Contract, aligning structures with transactions
4. Resource allocation and employment	Prices and quantities	Incentive alignment

(Source: Williamson, 2000: 597)

Although we can agree with Williamson that the informal institutions of customs, traditions, norms, and religion have a pervasive influence upon the long-run character of economies, (levels 2 and 3), we believe that the time scales that are linked to these different levels of social analysis are subject for further discussion. Intuitively one will not disagree with Williamson that traditions, norms and religious ways of life are shaped by social mechanisms that often outlive certain polity, judiciary or property arrangement but by classifying them as historical events that have mainly spontaneous origins such informal institutions are too easily set apart from the other levels that Williamson considers more appropriate for economic analysis because they involve a higher level of *"deliberative choice of a calculative kind"* (2000: 597). It misses the point made by Granovetter (1985) that economic action and social structure are basically interconnected. In his classical paper on this issue Granovetter argued amongst other things that the problem of embeddedness deserves more attention in NIE to avoid the mistake of crude functionalism:

> *"The general story told by members of this school is that social institutions and arrangements previously thought to be the adventitious result of legal, historical, social, or political forces are better viewed as the efficient solution to certain economic problems" (Granovetter, 1985: 488; see also Swedberg and Granovetter, 1992: 14-16).*

This reproach was probably taken up by Williamson looking at his wording 15 years later that informal institutions have a lasting grip on the way a society conducts itself and can be functional, take on symbolic value or be pervasively linked with complementary institutions (2000: 597). However, by strictly delineating NIE to the levels of institutional environment and governance the disciplinary gap between (organisation) sociology and NIE is sustained. As a consequence, an institutional perspective containing all four levels is taken further away instead of coming more into view. This is unfortunate because Williamson's levels of social analysis offer an interesting framework to look at the institutional environment in a more broad way. Instead of demarcating the territory of sociologists and economists, it could also be taken up as an invitation to combine sociological and economic insights. Without entering into a deeper theoretical debate on the (historical) relations between sociology and economics, we take up this invitation believing that it was (and still is) *"unwise to make such a sharp separation between what is 'economic' and what is 'social'"* (Swedberg and Granovetter, 1992: 1). In the following section we will illustrate how the four levels can be useful to structure four main institutions that we consider crucial for the societal acceptance of GM crops

3. The four legged chair of crucial institutions

Although innovation is often associated with technological innovation and economic processes, it also includes social, political and cultural processes. It should be acknowledged that the societal embedding, or the lack of this, is shaped by a complex constellation of interrelated institutions. Taking the case of GM crops we identify four main institutions that determine or strongly influence the acceptance of such crops:

(i) food safety and environmental regulation;
(ii) intellectual property rights;
(iii) entrepreneurship; and
(iv) public debate.

These institutions can be considered as intermediate variables between the levels of individual behaviour and broader societal developments (including the impact of globalization) that are crucial for the acceptance of biotechnology by both farmers and citizens-consumers. The first two can be characterized as legal institutions (the first one more general, the second one of a more specific nature), whereas the third and fourth one as socio-technical and societal institution respectively.

3.1 Description of the four institutions

An obvious and very basic institution for a successful implementation of GM crops is formed by the legal arrangements on food safety and environmental regulations. Without the existence and proper functioning of such legal institutions the introduction of GM crops would be highly problematic: consumers would not be protected against irresponsible innovators and an uncontrolled commercialization of GM crops could cause damage to our natural resources and biodiversity. The many uncertainties featuring the long term effects of GM crops make regulation far from easy, and an incremental process of adjustments and changes based on new insights and progressing scientific knowledge, but legal frameworks are indispensable for taking care of both public health values and the possible impact of GM crops on our environment. The quality of these legal frameworks and their practical application (sound administration) are decisive for the societal acceptance of GM crops.

Another legal institution, of a more specific nature, that is highly important for both the implementation and the public support of GM crops is the system of intellectual property rights (IPR). In the last decades IPR in the domain of agriculture, particularly the seed industry sector that is occupied with the further improvement and development of GM crops, have been pushed forward by the patent-system. As Bovenkerk (2012: 280) succinctly summarizes, this legal institution has a threefold aim:

> *"*[F]*irstly, it rewards inventors, who have invested time and money in order to develop their invention, secondly, it is meant to encourage further innovation by making investments worthwhile financially, and thirdly, it aims at stimulating further inventions by requiring disclosure of knowledge".*

However, as we will see, the patent system forms not only an important institutional factor for (particularly larger) seed companies who want to introduce new plant varieties based on GM, it also has a substantial impact on agricultural practices and the (dependent) position of farmers (Mascarenhas and Busch, 2006; Lemmens, 2014) and, thereby, on the public perception on GM crops. The current debate on GM crops in developing countries cannot be fully understood without taking discussions on the patent system into account (Bastos de Morais and Stückelberger, 2014).

The third leg of the four legged chair concerns the level and quality of entrepreneurship of farmers in developing countries. Following Tonukari (2004) we argue that the entrepreneurial farmer should be at the forefront discussing the implementation of biotechnology in developing countries. Entrepreneurship, in our conception, cannot be solely understood as an individual endeavour but depends on the environment within which a farmer operates and lives. Through division of labour in agriculture and the externalization of tasks and procedures a network of new commercial and technological-administrative relationships has arisen extending both the supply and the demand side of farms. In the process of agricultural modernization farmers have become increasingly coordinated by the

regulations, guidance, advice and knowledge of external relations. As a consequence, when farmers are confronted with new ideas or other ways of doing business their entrepreneurial decisions will be influenced by these relations that shape their socio-technic environment. The use of and proper handling of GM crops by farmers in developing countries will be much more likely if this environment enables them to deal with genetic modification.

The fourth and last institutional condition is the public debate, including public opinion, on GM crops. Without public support and consumer acceptance of GM crops the three other institutions will still be of no avail when they perform well. For a successful introduction of GM crops in developing countries (and to decrease global inequality when it comes to food) it is important that agro-food applications of genetic modification can count on positive and benevolent attitudes of consumers and the wider public (Frewer et al., 2013). Public debate can be considered as a societal institution shaped by constitutional rights, facilitating policies and political traditions of engagement, including protest movements and NGOs, that is highly dependent on the national context and history of a specific country.

3.2 Four institutional dimensions

The four institutions outlined above show affiliation with the levels of social analysis as described by Williamson. When we blank out the time scales we discussed previously and take these levels as institutional dimensions that should be analysed by taking an interdisciplinary approach, the different institutions can be related to the analytical levels of Williamson as shown in Table 2.

Table 2: Four institutional dimensions

Embeddedness	Public debate
Institutional environment (‘rules of the game’)	Food safety and environmental regulation; intellectual property rights
Governance (‘play of the game’)	Food safety and environmental regulation; intellectual property rights
Resource allocation and employment	Entrepreneurship farmers

The societal institution of the public debate represents the norms, customs, mores and traditions that Williamson interprets as informal institutions that are part of embeddedness. The legal institutions of food safety, environmental regulation and intellectual property rights (IPR) can be seen in a formal way (how rules are written down in

legislation) but also how they function in practice (implementation and compliance). This has its parallel in rules of the game and play of the game. Finally, the entrepreneurship of farmers can be related to resource allocation and employment. Markets are to a certain extent efficiently ruled by economic mechanisms of prices and quantities but it should not be forgotten that the functioning of markets is highly dependent of economic actors (entrepreneurs) that are able to use technologies and know how to run their business. Particularly the introduction of GM crops requires a certain level of technological knowledge and management qualities among the rural population, and these capabilities are dependent on knowledge infrastructures and other facilitating organizations that stimulate entrepreneurship.

In the following sections we will take a more specific look at each of these institutions and formulate some indicators that can be useful to estimate their influence on the implementation and societal acceptance of GM crops. However, it must be kept in mind that these institutions are all interconnected and have overlaps. The metaphor here could be a four legged chair; if one or two legs are missing or badly constructed, the chair is ill-balanced and there is a very good chance that the implementation of GM crops in a certain country or region will fail and fall down.

4. Food safety and environmental regulations

The first leg of the four legged chair comprises both food safety regulations and environmental policies concerning GM crops. Besides policies aimed at safeguarding public health there are also policies aimed at protecting the environment. Due to the use of very few different seed varieties there are concerns that GM crops may mix in with indigenous plant varieties, which could increase the risk of diseases spreading (Qaim, 2009). This contamination could furthermore make weeds harder to exterminate. Another issue is that the growing tendency of monocultures, intentionally enhanced by the bigger seed firms by standardizing certain products and overpricing less bought seeds, can result in in a loss of biodiversity. Creating monocultures in practice also often means, as some argue, that seeds are not as well equipped to local circumstances as when there is a broad selection of seeds to choose from. Differences in climate, soil and weather conditions require different types of seeds, which is hard to come by when all the seeds being sold are standardized for mass production (De La Perriere and Seuret, 2000; Garcia and Altieri, 2005).

However, in spite of legitimate goals of taking care for public health and protecting the environment, environmental and food safety policies can derail to a certain extent the competition o the GM market. Too much bureaucracy or too stringent rules can create entry barriers into the market that favour large companies over smaller companies, because only they have the means to cross these barriers. The role and function of legislation can be ambivalent: a lack of proper regulation of GM and a lack of the means to establish proper

regulation may cause long-term market concentration. An example can be found on the European GM market. According to some the pressure of NGOs has led to such stringent food safety and environmental regulations that small businesses cannot get past all the red tape, while big companies do have the time and resources necessary to do that. One could pose that by their successful opposition NGOs are inadvertently helping big business to control the GM market (Versluis, 2008; Qaim, 2009). India can count as an example of how a very strict regulation regarding safety and the environment, along with heavy resistance of farmers and pressure groups against GM crops (Qaim et al., 2006; Subramanian and Qaim, 2009), has led to the use of the same seed varieties all over the country. Only a few genetically modified types of seeds have been approved for use in India, which raises some critical questions on how this might harm biodiversity.

On a very fundamental level it should be acknowledged that administrations in developing countries can be in such a bad condition that they are not able to function as reliable and trustworthy state machinery, which amongst others takes care for a responsible introduction and adequate monitoring of GM crops. A well-known example is the many states in Sub-Saharan Africa that have been characterized as 'predatory' or 'vampire' states:

> *"a state entirely patrimonalized by political elites for their own personal profit"* (Castells, 2000: 96).

Without entering into a full debate on the exact (historical) causes of such predatory states, it is clear that the last decades of the 20th century have given a stimulus to states that are instrumentalized by elites to reap the riches of their countries. While a dynamic global economy, propelled by the information technology revolution, was constituted in the rest of the world, many countries in Africa collapsed and were by and large switched off the global networks that were shaping the new world economy (Castells, 2000). Many African states are still trying to recover from this era when their economies broke down and were marginalized. However, hardship continues and the continent is not spared from new tragedies, such as more recently the outbreak of the Ebola virus disrupting societies and economies in several West African countries. In such situations food safety and environmental regulation concerning GM crops can easily vanish into thin air because of other urgent problems. Even in the case when there is a legal framework that addresses food safety and environmental issues in an adequate manner, the lack of a well-equipped administration with sufficient resources and capacities can make every GM crop regulation toothless.[2]

To stimulate the production of GM crops, the art of public policy is finding a middle way between extremely restrictive regulation and having barely any regulation at all to

[2] The large economic gap with the richer part of the world can also explain why knowledge and R&D institutions are often poorly developed in developing countries. Indirectly this can impact the quality of the governmental apparatus, because a lack of skilled experts may impede the formulation of policy and regulations on GM.

safeguard public health and decrease the associated environmental risks. The precondition of a reliable and trustworthy governmental apparatus should not be forgotten here. What are normal expectations in richer nations with respect to administrators and the state system, many people in poorer countries can only dream of. This brings us to the following indicators for food safety and environmental regulation that should be fulfilled.

Institutional indicators for benign food safety and environmental regulations

1. Legal framework for GM crops addressing food safety and environmental issues in a balanced way, i.e. avoiding regulation that is either too strict or too lenient.

2. Sound administrative apparatus effectuating the functioning of this legal framework.

3. Perception that private interests and common goals are well-balanced regarding food safety and the environment

5. Intellectual property rights

The second leg of the four legged chair is the system of intellectual property rights (IPR). Nowadays there are two arrangements of IPR that are relevant for GM crops: patent rights and plant breeder's rights:

> *"Plant breeder's rights give the developer of a new variety the right to exclude others from commercialization. The breeder's exemption ensures that other breeders may in sort of 'open innovation' use such a protected variety in their own breeding programme, making the best 7 properties of these varieties available to the breeding programmes of competitors"* (Louwaars et al., 2009: 2).

Patent rights, not having the breeder's exemption clause, make the access to genetic material more restrictive and have created many disputes whether this is good or bad for realizing food and nutrition security in the coming decades. The patent system has been pushing IPR in the domain of agriculture. In particular supporters of free markets consider the patent system as an important institution for the further improvement of seeds and the further development GM crops.

However, both the assumptions underlying the patent system and institutional factors that determine the effects and steep growth of patent claims in the last decades in the seed industry have been the subject of heated debates. The assumption that inventions can be ascribed to certain owners could be contested, because in complex societies with modern labour divisions there are so many actors who contribute (or have contributed) to innovations that there is no clear answer to the question of who could be identified as the

rightful claimant of the invention. Understanding innovation as a co-creative and co-productive effort in modern knowledge economies that thrive on the exchange of knowledge, Stiglitz (2008) openly questions whether the patent system is effective for stimulating innovations that address public needs. In his view IPR protection may in fact harm innovation in practice because it facilitates the creation of monopolies.[3]

In the case of GM crops the current implementation of the patent system has been criticized because it advantages western firms with much more financial resources and legal expertise and neglects the traditional knowledge of indigenous cultures that builds on thousands years of collective innovation (McAfee, 2003; Kropiwnicka, 2005; Shiva, 2007; Korthals and Timmermann, 2012). Moreover, the development of intellectual property protection for genes and organisms has led to a further concentration of the seed industry, resulting in big firms with global power that seem more interested in investigating and prosecuting farmers than sharing or distributing knowledge (Kinchy, 2012). In 2009, the top three seed companies owned a combined market share of 44.8% on the global seed market (Hubbard, 2009).[4] Particularly the development of genetic use restriction technologies (GURT, also known as terminator technology), which makes crops infertile so that farmers are no longer able to save seeds for next year's sowing (Bovenkerk, 2012), confirmed for many critics the mainly profit driven motives of the major seed companies. In other words, according to such criticism what is often claimed to be an invention that can be patented, is not a true invention but a lucrative legal construction played by powerful enterprises that does not encourage but rather slows down further innovation.

The important role that knowledge plays in the case of GM is evident, and strong IPR protection is increasing the power of large usually Western multinational companies. In an incontestable seed monopoly, there may be some negative externalities (Mussa and Rosen, 1978). The most important ones in the case of GM are the possibly higher price for seed, quality of seeds and diversity of products, the possible reduction of the quality of products and the possible reduction of the diversity of products by overpricing products for which there is a lower demand. The last two points – the potential lower quality and lower diversity of products – are related to each other in the case of GM. The reduction of product diversity may lead to loss of biodiversity. The lower quality of products – especially in the economic South – becomes apparent when talking about technological bias of GM seeds;

[3] Information is non-rival: if one person shares information with a second person, the ability of the first person to use that information is not diminished. Freely sharing information increases efficiency because innovators can build on previous innovations. By completely removing IPR protection, however, researchers are discouraged to innovate. Therefore, in order to spur innovation, it is important to find an equilibrium between the two extremes that has strong enough IPR protection to motivate innovation but also enough open sharing of information to facilitate new innovations (Stiglitz, 2008).

[4] The six biggest pesticide and GM corporations worldwide are known as the 'Big Six'. They are: Monsanto, Syngenta, BASF, Bayer, Dow and Dupont Pioneer. In 2009 they had a combined market share of 58% of the global seed market and 71% of worldwide agrochemical sales (http://www.seedsavers.org/ [accessed on 05-06-2014]).

seeds become less equipped for the specific area it is being used in. This technological bias is also related to the biodiversity issue, because there is a more limited amount of seed varieties (that are usually aimed at Western climates) available due to market concentration.

Too strong IPR protection may also harm competition and lead to market concentration or even monopolization within the field of innovation, because large companies own most of the patents and can charge money for the use of these patented innovations by other companies for their own innovations. In other words, with strong IPR other companies cannot always easily use existing knowledge to build upon but often have to start from the same basic genetic plant information each time. This creates a competitive asymmetry between companies. Another important question on this front could be whether research is being financed by the public or private sector. Researchers funded by the public sector may be more inclined to share information than researchers funded by the private sector.

Looking more closely at the institutional developments surrounding IPR, it becomes clear that a neutral view on genetic modification (in which a clear cut is made between the technology itself and how it is used) is hard to maintain. When these new technologies went through a faster pace of development in the late 20th century, they also triggered the development of new international arrangements of property rights concerning plant genetic resources (Raustiala and Victor, 2004). Taking a critical stance, Kinchy (2012) argues that the current state of affairs with respect to GM crops is the result of the interconnected processes of neo-liberalization and scientification, and that a neutral technocratic focus on (scientific) risk assessment fails to recognize the political and moral topics related to the transformed agro-food systems worldwide.

The developments of GM crops and economic and political institutions that deal with IPR are interconnected. In the 1990s the common heritage system of plant genetic resources moved towards propertizing such resources. Raustiala and Victor (2004: 279) speak of:

> *"*[a] *regime complex for plant genetic resources* [marked by] *the existence of several legal agreements that are created and maintained with participation of different sets of actors".*

This regime complex (e.g. the amended International convention for the Protection of New Varieties of Plants (UPOV), the UN Convention on Biological Diversity (CBD) and the World Trade Organization's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS)) has shaped the space and constraints of political and societal debates about GM crops. The fairness of this new regime complex of (international) regulations, institutions and agreements has been contested (e.g. the dependent position of farmers and indigenous people in developing countries because of a lack of legal expertise and financial resources) but, whether one likes it or not, this regime complex for plant genetic resources is the

institutional context of IPR and the (implementation of the) patent system that cannot be ignored if one considers the influence of IPR on the societal acceptance of GM crops.

Also advocates of GM crops can be very well aware of the legal and social infrastructures that determine the development, use and chances of these crops. Tonkari and Omotor (2010) point to good governance and an enabling policy environment, including amongst other things secure property rights, as part of a set of incentives for the sustainable management of natural resources. Biotechnology can only play a role in the struggle to reduce poverty and improve food and nutrition security if the entire framework for supporting agricultural development is put into place. Recording that there is very little commercial utilization from modern biotechnology research in developing countries, they call for activities in the public sector to marshal the strength of the private sector through public-private partnerships based upon mutual trust and common goals. Developing countries should be provided with hands-on experience in intellectual property management; also no-cost or low-cost licensing of inventions should be facilitated.

The major objective in the application of biotechnology is then not the transfer of technology but empowerment of the farmer to improve production. It is noticed by Tonkari and Omotor (2010) that the models from developed countries for applying biotechnology will probably not be applicable to the problems of the poor elsewhere in the world. In their approach agricultural research for the crops and problems of the poor has to proceed from the bottom up, not from the top down and public investment is of particular importance for achieving food and nutrition security in developing countries.

If it is believed that private interests and common goals are combined or mixed in a fair manner, and the treatment of IPR is crucial here, the chances of societal acceptance of GM crops would increase. This leads us to the following conclusions. Firstly, assuming that the patent system is crucial for IPR and the use and further development of GM crops, an administrative system that effectuates the functioning of the patent system in practice is a precondition. If this is not the case, for instance in poorer countries that lack a reliable administration, the chances are less that the benefits of GM crops will be realized. Secondly, in case that there is an effective administrative system that also covers the functioning of the patent-system, the perception of how private interests and common goals are dealt with will be crucial for the chances that GM crops are accepted. If this perception is that private interests and common goals are ill-balanced, the chances are less that GM crops will be accepted.

Institutional indicators for benign intellectual property rights

1. Legal IPR framework addressing technological development and innovations in a balanced way, i.e. avoiding regulation that is either too strict or too lenient.

2. Administrative system effectuating the functioning of the (international) patent system.

3. Perception that private interests and common goals are well-balanced regarding IPR.

6. Entrepreneurship

The third leg of the four legged chair concerns entrepreneurship of farmers in developing countries. By analogy with the entrepreneurial scientist (Tonukari, 2004) we argue that to exploit plant biotechnology in developing countries (also) the entrepreneurial farmer should be at the forefront.

A farmer-entrepreneur is someone who is willing to take calculated risks to make the farm profitable and its business grow. To be a successful entrepreneur a farmer must be technically competent, innovative and plan ahead. It mainly depends on the farmers' managerial capacity to cope with risks and changes. According to Rudmann (2008) entrepreneurship can be seen as a competence that can be learned. In that case entrepreneurial skills are a requirement for entrepreneurial behaviour. To be able to create and develop a profitable business, the following categories of skills are considered to be proper entrepreneurial skills:

- Opportunity skills (recognising and realising business opportunities);
- Strategy skills (developing and evaluating a business strategy); and
- Co-operation or networking skills (networking and utilising contacts).

The development of these skills is a learning process, and not so much learning through formal education but in particular learning by doing and trial-and-error. Learning happens when farmers are confronted with new ideas or different ways of doing things, which broaden their own perspectives. Many factors support or hinder that change of perspectives: internal factors relating to the farmers themselves (e.g. personality traits), external factors (such as new market requirements or provision of education), and networks and contacts that are linking the internal and external factors (Rudmann, 2008).

Entrepreneurship is not only an individual trait but also depends on the environment within which a farmer operates and lives. Practicing agriculture is intertwined with external institutions through both economic and technical-administrative relations (Van der Ploeg, 1987). Some farmers are heavily interrelated with their environment, e.g. the breeding material they use is being developed in laboratories and on experimental farms of cooperatives and fertilizer and pesticide treatments are performed by specialists according

to procedures based on scientific research. Through division of labour in agriculture and the externalization of tasks and procedures, a network of new commercial and technological-administrative relations is created at both the supply side and the selling side of farms. Those relations become more important as the farm is increasingly coordinated by regulations, guidance, advice and knowledge of external relations. Whether a farmer uses the information, advice and knowledge of its suppliers, marketing cooperatives and food processing industry depends on the inclination of the farmer to consider that advice and knowledge as adequate (Van der Ploeg, 1987).

More institutionalization will cause farms to adapt more to external developments. Farmers can be confronted with new ideas or other ways of doing business (in the biotechnology field) in their relation with their environment. Thus the entrepreneurial decisions taken by farmers are influenced by commercial relations (labour market, machine suppliers, financial market, land market, feed market, and market for genetic material) and technical-administrative relations (food industry, suppliers, marketing cooperatives). In the case of GM crops in developing countries a well-functioning scientific community and educational system is a key condition. An educated workforce may open up the market for foreign companies that can than build a facilitation system for farmers that are interested in innovative GM crops.[5]

Entrepreneurs are innovators, always looking for better and more efficient and profitable ways to do things. So, being innovative is an important quality for a farmer-entrepreneur (Kahan, 2012). For small-scale farmers to become more entrepreneurial assistance from supporting institutions is needed. Smallholder farmers may be entrepreneurial in spirit but they often lack the security to take risks. In order to create and maintain a favourable environment for entrepreneurship a range of barriers outside the control of the farmer must be addressed (Kahan, 2012):

- Poor or absent infrastructure;
- Unsupportive laws and regulations (ability to buy, sell and hire land, legal status of women, complexity of business regulations, bureaucracy);
- Lack of financial support (investment capital);
- Social barriers (i.e. entrepreneurship is not common to the culture or society, social systems that create dependence and hopelessness, women in business are not supported);
- Lack of training facilities for farmers, support services and extension staff; and
- Constrained access to markets (poor communications, marketing facilities, lack of reliable and timely market information).

[5] When GMOs were first introduced in the United States, there was a serious shortage of scientists trained in the field of biotechnology, which for a while slowed progress in developing GM (Kenney, 1986). According to Cooper (2013) it is important to have proper and accessible higher education, good R&D institutions and companies able to use and innovate knowledge when one wants to be competitive in the field of GM.

Entrepreneurship is also relevant among groups of farmers who want to form a business together. This is particularly attractive for the poorest farmers in the community or the farmers with the weakest links to the economy. They can pool their resources and share the risks. To be successful group enterprises must have the same entrepreneurial skills and spirit as individual entrepreneurs (Kahan, 2012: 9).

Studies of African agriculture illustrate that barriers for entrepreneurship are currently present. With respect to the state of entrepreneurship in agribusiness in South Africa, according to the FNB Business Banking (2010) South Africa has a large, uneducated rural population that does not have the skills to modernise agriculture. Therefore, satellite academies in rural areas are necessary to foster the development of an entrepreneurial agribusiness culture and community. A recent study of Adenie et al. (2014), assessing the perception of farmers about the potential acceptance of GM technology in the African countries Ghana and Nigeria, emphasizes the need to recognize challenges such as lack of awareness, inadequate training, low level of education and poor extension services among other things in introducing new technology (including GM technology) to resource-poor farmers in African countries like Ghana and Nigeria. The study concludes that failure to address these challenges will impede the adoption of GM technology.

According to Agriculture for Impact (2014) entrepreneurs in African agriculture may not have been trained formally but they all have an instinct for innovation and business opportunity. Turning entrepreneurial spirit into a business primarily requires access to micro finance, the provision of relevant higher education or vocational training together with business management training, and better links to markets for individuals and groups. The report also states that highly successful entrepreneurial development is more likely to occur in a country that is economically stable with well-developed institutions, infrastructure, health and education systems. Innovation, a pre-condition for successful entrepreneurship, is usually positively related to an entrepreneur's level of education in most developed and emerging countries. However, the lack of access to educational opportunities, especially for women, disadvantages the pursuit of an entrepreneurial career. So, to increase Africa's competitiveness, productivity and growth, high quality school and university programs, particularly in areas such as the applied sciences, technology and engineering, are necessary. Currently in Africa, in general, human resources, infrastructure, financial resources and policy and legal climate are insufficient to innovate, create, adapt, apply and transform its agriculture sector using the new tools of biotechnology (Chambers et al., 2014).

Discussions about new technologies such as biotechnology and GM crops in Africa also need a gender focus because the ongoing gender gap is likely to affect Africa's ability to innovate and use biotechnology at all levels (from laboratory to farm to politics). The majority of farmers in Africa are women. They provide 70–80 % of the labour for food crops grown in Africa, and their importance to African agriculture and household-level food and nutrition security cannot be underestimated. GM technology is considered highly technical.

Women, especially women farmers and other women stakeholders along the value chain, lack familiarity with it. According to Chambers et al. (2014) the technology has had mostly favourable responses from women farmers.

Institutional indicators for benign entrepreneurship

1. Level of access to and participation in higher education and training courses (especially for women).

2. The availability of and access to the financial market (investment capital, credit) for small farmers.

3. The presence (number) of successful adaptation of GM technology by farmers in the country.

7. Public debate

The last leg of the four legged chair concerns the public debate on GM crops that can differ a lot between different countries or regions and might also be absent. This last institution to estimate the chances of successful implementation of GM crops is also most difficult to distinguish analytically from the other institutions that we discussed. Public debates often directly react on and interfere with developments in the other institutional fields. A good example is the very sensitive issue of power asymmetries in the case of the patent system and genetic use restriction technologies that can lead to a loss of control of the production process for farmers. In agriculture farmers have traditionally saved and traded their seeds to be used in years to come. This created independence because they did not have to rely on outside help for resources, which in turn hindered capital accumulation in this sector (Mascarenhas and Busch, 2006). With the innovations in biotechnology, however, farmers often have to use patented seeds to keep up and that can only be bought from a few seed firms. This means that the farmer is now dependent on often very large seed companies for resources, which can cause further capital accumulation. It has been argued that there is a power shift leading to the expropriation of farmers by destroying their way of life and by alienating them from the traditional system of care associated with farming (Lemmens, 2014).

A basic understanding of what genetic modification entails is seen as important for having a more nuanced debate on agro-food applications of genetic modification. There are cases where the public rejected the use of GM technology on a large scale without having a good idea what biotechnology is (Bánáti and Lakner, 2006). Frewer et al. (2004) point to the importance of establishing participatory processes, where policy-makers, scientists and companies engage in a dialogue with NGOs and consumers before developing these

products in order to create trust in regulatory institutions and to create a consensus on policy. By engaging in a participatory process, consumers will get a chance to be informed, and a consensus on policy and regulations can be reached between policy makers, NGOs, consumers and the business sector.

In order to do this, a well-organized scientific community can play a relevant role to inform policy-makers, farmers and consumers. According to Cooke and Downie (2010) the relatively vibrant scientific community in South Africa is an important reason why this country is a leader in GM production on the African continent. What seems particularly important for the social acceptance of GM crops is the public trust in regulatory and scientific institutions that are responsible for a safe introduction and development of these crops. A high trust in these institutions reduces the perceived risk of GM. In countries with a flourishing civic culture and openness of government banning unsafe GM and thereby safeguarding public health will normally increase societal acceptance (Frewer et al. 2004; Pray et al., 2005).

Eventually, risk perception and trust are decisive for the public acceptance of GMOs. If consumers trust their government (and the government is pro-GM), the perceived risk of GM will be smaller (Qiu and Huang 2006). Looking more specifically at developing countries Curtis et al. (2004: 74) stated a decade ago that discussed benefits such as increased crop yields and dietary supplements (that are beneficial in terms of food availability and nutritional intake), along with consumers' perceived risks, have contributed to generally more positive attitudes towards GM foods in developing countries. According to Curtis et al. (2004: 71) the probability that the consumer assigns to each potential cost or risk stems from three sources:

- The level of trust in government regulators regarding food supply safety;
- Attitudes towards scientific discovery; and
- The influence of media coverage.

However, the experience is also that heated debates on GM can block or disturb a successful introduction of GM crops, as we have seen in Europe in the 1990s. To some the European debate on GM has resulted in very little progress, because policy-makers are afraid to make a controversial move:

> *"The basic problem is the need or the failure to recognize that, while proposed actions may have consequences, inaction may also have outcomes, seen or felt by other parties, affecting other variables: the negotiation of precautionary restrictions has led to some simplistic and damaging legislation, whose implications are initially clear only to limited professional circles"* (Cantley, 2012: 42).

Another example of a public debate hindering the further development of GM crops is the case of India. Although GM crops are being produced on a large scale in India, there is heavy opposition against GM. This resistance has been led by NGOs and, in particular by Shiva. This

has hindered the quick introduction of new GM crops after Bt cotton was first introduced in India in the late 1990s (Scoones, 2008; Kaur et al., 2013).

Public debate can be considered as a societal institution that is highly dependent on the national context, political traditions and history of a specific country. More specifically, it is strongly dependent on how freedom of speech, openness, access to media and free press are arranged and institutionalized in society. Countries in which the public debate is almost non-existent or poorly developed are a hard case for estimating the probability of a successful implementation of GM crops. The (acquiescing) support of citizens can appear to be false because protests or critical opinions are directly supressed or cannot be expressed because of other reasons (lack of resources, media monopolies).[6] In these cases a policy of active GM promotion and innovation, which seemingly has societal legitimacy, can suffer from a setback when in the future such debates do arise because of societal changes that lead to more political openness for criticism and public protests. In other words, public debate can be a hassle for policy-makers and innovators that are in favour of GM crops but when this debate is taken up successfully and leads to a certain public consensus on how to deal with genetic modification a more robust and stable basis of legitimacy for GM crops has been laid. In summary, we can say that three indicators can be useful to estimate and qualify the public debate that is relevant for the societal acceptance of GM crops.

Institutional indicators for benign public debate

1. News media that are allowed to voice alternative opinions on GM crops.

2. Trustworthy administrators and scientists that deal with problematic aspects of GM crops.

3. Facilitation of public dialogue and participatory engagement that transcends a polarized discussion on GM crops.

[6] China is an interesting case in this respect of how trust can compensate for an administrative system featured by poor quality arrangements of food safety and environmental regulation. In China there is lacking regulation, with unsafe research facilities and situations hazardous to human health as a result, but the Chinese GM acceptance is relatively high (Qiu and Huang, 2006; Hong et al., 2011). This is related to the state controlled media, which rarely allow adverse policy effects to come to light, decreasing the perceived risks in the case of GM (Curtis et al. 2004; Shirk, 2007; Jacques 2012).

8. Summary and conclusion

In Table 3 we summarized the indicators that we identified for the four institutions that we consider being crucial for the implementation and societal acceptance of GM crops. An important element in several indicators is social trust. When, for instance, the perception of stakeholders or a wider audience is that the rules of the game concerning food safety or IPR are not just or that the play of the game is unfair, even when these legal institutions could be said to be just and function well in practice, the potential benign effect of these institutions for GM crops can easily vanish.

Table 3: The four legged institutional chair for societal acceptance of GM crops

Food safety and environmental regulations Rules of the game	Legal framework for GM crops addressing food safety and environmental issues in a balanced way, i.e. avoiding regulation that is either too strict or too lenient.
Play of the game	Sound administrative apparatus effectuating the functioning of this legal framework.
Perception of the game	Perception that private interests and common goals are well-balanced regarding food safety and the environment.
Intellectual property rights Rules of the game	Legal IPR framework addressing technological development and innovations in a balanced way, i.e. avoiding regulation that is either too strict or too lenient.
Play of the game	Administrative system effectuating the functioning of the (international) patent system.
Perception of the game	Perception that private interests and common goals are well-balanced regarding IPR.
Entrepreneurship	Level of access to and participation in higher education and training courses (especially for women).
	The availability of and access to the financial market (investment capital, credit) for small farmers.
	The presence (number) of successful adaptation of GM technology by farmers in the country.
Public debate	News media that are allowed to voice alternative opinions on GM crops.
	Trustworthy administrators and scientists that deal with problematic aspects of GM crops.
	Facilitation of public dialogue and participatory engagement that transcends a polarized discussion on GM crops.

To create broad support and a proper basis for the use of GM, food safety and environmental regulations, intellectual property rights, entrepreneurship and public debate should all be in place. Too much food safety and environmental regulations may in practice turn out to be a barrier for companies trying to get new seed varieties approved. This may, just like too much IPR protection, lead to market concentration. However, also too little IPR protection can harm progress by discouraging R&D. Public debate and participatory engagement are important for increasing consumers' and citizens' trust and increase the legitimacy of related institutions but very heated debates can lead to a stalemate that can block further progress. Without educational and financial infrastructures that enable farmers in developing countries to work with GM crops in an effective manner, all legal efforts to safeguard safety and intellectual property will be of not much avail to stimulate the production of GM crops in these countries. There is a role for governments in creating the right institutions to facilitate innovation without harming competition, as well as there is a role for governments (and scientists) to inform the public in a transparent manner and facilitate public debate about GM.

These four institutions should be seen as four legs of a chair: they are all related and if one or more leg fails the chair will be very unstable. A few examples of how the different institutions are interconnected and influence the balance of the whole:

- If a country has balanced and well-founded food safety and environmental policies as well as a well-balanced IPR system, it may still witness low societal acceptance of GM crops if it does not have a (non-polarized) societal debate on the issue;
- A public debate that can provide consensus and societal legitimacy in combination with a well-balanced IPR system may not do the trick, if there are lacking or too stringent regulations;
- Good regulations in combination with a (good) public debate may also be insufficient, if the IPR system clearly results in monopolies.

A final word about Table 3: our qualitative analysis suggests this set of variables and indicators to get a more clear view on the institutional environment that can be more or less benign (or detrimental) for GM crops. However, for a more precise assessment it will be necessary to perform quantitative analyses and elaborate much more on the operationalization of our set of indicators. These steps should be taken if one has the ambition to do an institutional assessment that can provide a multidimensional answer to what extent the institutional environments for GM crops in different regions are benign or detrimental.

References

Adenie, A.A., W.S. Alhassan and B.O. Solomon (2014) "Potential benefits of genetic modification technology for food security and health improvement in West Africa: Assessing the perception of farmers in Ghana and Nigeria", *African Journal of Biotechnology* 13/2: 245-56.

Agriculture for impact (2014) *Small and growing: Entrepreneurship in African agriculture*. A Montpellier Panel Report.

Azadi, H. and P. Ho (2010) "Genetically modified and organic crops in developing countries: A review of options for food security", *Biotechnology Advances* 28/1: 160-68.

Bánáti, D. and Z. Lakner (2006) "Knowledge and acceptance of genetically modified foodstuffs in Hungary", *Journal of Food and Nutrition Research*, 45/2: 62-68.

Bastos de Morais and Stückelberger (eds.) (2014) *Innovation ethics. African and global perspectives*. Geneva: Globalethics.net and African Innovation Foundation.

Bovenkerk, B. (2012) *The biotechnology debate. Democracy in the face of intractable disagreement.* Dordrecht/Heidelberg/London/New York: Springer.

Busch, L. (2010) "Can fairy tales come true? The surprising story of neoliberalism and world agriculture", *Sociologica Ruralis* 50/4: 331-51.

Busch, L., W.B. Lacy, J. Burkhardt and L.R. Lacy (1991) *Plants, power, profit. Social, economic, and ethical consequences of the new biotechnologies*. Cambridge, Massachusetts: Basil Blackwell.

Cantley, M. (2012) "European attitudes on the regulation of modern biotechnology and their consequences", *GM crops and food: Biotechnology in agriculture and the food chain* 3/1: 40-47.

Castells, M. (2000) *End of millennium. Volume III of The information age: Economy, society and Culture [2nd edition]*. Oxford: Blackwell.

Chambers, J.A., P. Zambrano, J. Falck-Zepeda, G. Gruere, D. Sengupta and K. Hokanson (2014) *GM agricultural technologies for Africa. A state of sffairs*. Report of a Study Commissioned by the African Development Bank: International Food Policy Research Institute.

Charles, H., J. Godfray, J.R. Beddington, I.R. Crute, L. Haddad, D. Lawrence, J.F. Muir, J. Pretty, S. Robinson, S.M. Thomas and C. Toulmin (2010) "Food security: The challenge of feeding 9 billion people", *Science* (12 February): 812-18.

Cooke, J.G. and R. Downie (2010) *African perspectives on genetically modified crops: Assessing the debate in Zambia, Kenya, and South Africa. A report of the CSIS Global Food Security Project.* Washington: Centre for Strategic & International Studies.

Curits, K.R., J.J. McCluskey and T.I. Wahl (2004) "Consumer acceptance of genetically modified food products in the developing world", *AgBioForum* 7/1&2: 70-75.

FNB Business Banking (2010) *The state of entrepreneurship in South Africa*. White Paper.

Frewer, L.J., I. A. van der Lans, A.R.H. Fischer, M.J. Reinders, D. Menozzi, X. Zhang, I. van den Berg and K. Zimmerman (2013) "Public perceptions of agri-food applications of genetic modification. A systematic review and meta-analysis", *Trends in Food Science & Technology* 30: 142-53.

Frewer, L.J., J. Lassen, B. Kettlitz, J. Scholderer, V. Beekman and K.G. Berdal (2004) „Societal aspects of genetically modified foods", *Food and Chemical Toxicology* 42: 1181-93.

Garcia, M.A. and M.A. Altieri (2005) "Transgenic crops: Implications for biodiversity and sustainable agriculture", *Bulletin of Science Technology* 25/4: 335-53.

Giddens, A. (1999) *The constitution of society. Outline of the theory of structuration. [first published 1984]* Oxford: Polity Press.

Halford, N. (2012) *Genetically modified crops [2nd edition]*. London: Imperial College Press.

Hubbard, K. (2009) *Out of hand: Farmers face the consequences of a consolidated seed industry. Farmer to farmer campaign on genetic engineering*. http://farmertofarmercampaign.com/ (Accessed on 25-03-2014).

Jacques, M. (2012). *When China rules the world: The end of the western world and the birth of a new global order [first edition in 2009]*. London: Penguin Books.

Kahan, D. (2012) *Entrepreneurship in farming*. *Farm management extension guide*. Rome: Food and Agriculture Organization of the United Nations.

Kaur, A., R.K. Kohli and P.S. Jaswal (2012) "Genetically modified organisms: An Indian ethical dilemma", *Journal Of Agricultural And Environmental Ethics* 26: 621-28.

Kenney, M. (1986) "Schumpeterian innovation and entrepreneurs in capitalism: A case study of the U.S. biotechnology industry", *Research Policy* 15: 21-31.

Kinchy, A. (2012) *Seeds, science and struggle. The global politics of transgenic crops.* Cambridge, MA: MIT Press.

Korthals, M. and C. Timmermann (2012) "Reflections on the international networking conference 'Ethical and social aspects of intellectual property rights – Agrifood and health', Brussels, September 2011", *Synesis: A Journal of Science, Technology, Ethics and Policy*.

Kropiwnicka, M. (2005) “Biotechnology and food security in developing countries. The case for strengthening international environmental regimes”, *ISYP Journal on Science and World Affairs* 1/1: 45-60.

Lemmens, P. (2014) “Re-taking care: Open source biotech in light of the need to deproletarianize agricultural innovation”, *Journal of Agricultural and Environmental Ethics* 27: 127-52.

Mascarenhas, M. and L. Busch (2006) “Seeds of change: Intellectual property rights, genetically modified soybeans and seed saving in the United States”, *Sociologia Ruralis* 46/2: 122-38.

McAfee, K. (2003) “Neoliberalism on the molecular scale. Economic and genetic reductionism in biotechnology battles”, *Geoforum* 34/2: 203-19.

Perriere, R.A.B. de la and F. Seuret (2000) *Brave new seeds: The threat of GM crops to farmers.* London & New York: Zed Books.

Ploeg, J.D. van der (1987) *De verwetenschappelijking van de landbouwoefening*. Wageningen: Landbouwuniversiteit.

Pray, C.E., P. Bengali and B. Ramaswami (2005) “The cost of biosafety regulations: The Indian experience”, *Quarterly Journal of International Agriculture* 44: 267-89.

Rudmann, C. (2008) *Entrepreneurial skills and their role in enhancing the relative independence of farmers*. *Results and recommendations from the research project developing entrepreneurial skills of farmers*. Frick: Research Institute of Organic Agriculture.

Qaim, M. (2009) “The economics of genetically modified crops”, *Annual Review of Resource Economics:* 665-93.

Raustiala, K. and D.G. Victor (2004) “The regime complex for plant genetic resources”, *International Organization* 58/2: 277-309.

Scoones, I. (2008) “Mobilizing against GM crops in India, South Africa and Brazil”, *Journal of Agrarian Change* 8/2&3: 315-44.

Serageldin, I. (1999) “Biotechnology and food security in the 21st century”, *Science* 285 (16 July): 387-89.

Shirk, S.L. (2007) *China: Fragile superpower? How China’s internal politics could derail its peaceful rise.* New York: Oxford University Press.

Shiva, V. (2007) “Bioprospecting as sophisticated biopiracy”, *Signs* 32/2: 307-13.

Shiva, V. (2010) “Earth democracy: Beyond dead democracy and killing economies”, *Capitalism Nature Socialism* 21/1: 83-95.

Stiglitz, J.E. (2008) “Economic foundations of intellectual property rights”, *Duke Law Journal* 57/6: 1693-1724.

Swedberg, R. and M. Granovetter (1992) “Introduction”, in: M. Granovetter and R. Swedberg, *The sociology of economic life.* Boulder/San Franciso/Oxford: Westview Press: 1-26.

Tonukari, N.J. (2004) “Fostering biotechnology entrepreneurship in developing countries”, *African Journal of Biotechnology* 3/6: 299-301.

Tonukari, N.J. and D. G. Omotor (2010) “Biotechnology and food security in developing countries”, *Biotechnology and Molecular Biology Reviews* 5/1: 13-23.

Torres, C.S., R.A. Daya, T.B. Osalla and J.N. Gopela (2013) *Adoption and uptake pathways of GM/biotech crops by small-scale, resource-poor Filipino farmers*. Los Baños, Laguna: International Service for the Acquisition of Agri-biotech Applications, SEAsiaCenter and SEAMEO Southeast Asian Regional Center for Graduate Study and Research in Agriculture.

Versluis, K. (2008) “Gentech: Hoe Greenpeace Monsanto helpt”, *Resource* (10 januari 2008): 8-9.

Williamson, O.E. (2000) “The new institutional economics: Taking stock, looking ahead”, *Journal of Economic Literature* 38/3: 595-613.

FOODSECURE
FOR POLICIES THAT MATTER

The FOODSECURE project in a nutshell

Title	FOODSECURE – Exploring the future of global food and nutrition security
Funding scheme	7th framework program, theme Socioeconomic sciences and the humanities
Type of project	Large-scale collaborative research project
Project Coordinator	Hans van Meijl (LEI Wageningen UR)
Scientific Coordinator	Joachim von Braun (ZEF, Center for Development Research, University of Bonn)
Duration	2012 - 2017 (60 months)

Short description

In the future, excessively high food prices may frequently reoccur, with severe impact on the poor and vulnerable. Given the long lead time of the social and technological solutions for a more stable food system, a long-term policy framework on global food and nutrition security is urgently needed.

The general objective of the FOODSECURE project is to design effective and sustainable strategies for assessing and addressing the challenges of food and nutrition security.

FOODSECURE provides a set of analytical instruments to experiment, analyse, and coordinate the effects of short and long term policies related to achieving food security.

FOODSECURE impact lies in the knowledge base to support EU policy makers and other stakeholders in the design of consistent, coherent, long-term policy strategies for improving food and nutrition security.

EU Contribution	€ 8 million
Research team	19 partners from 13 countries

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