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Genetic engineering in agriculture: New approaches for risk management through sustainability reporting

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Abstract

Genetically modified crops and foodstuff have been highly controversial for environmental, health, and ethical reasons. The controversies have been worldwide, but most prominent in the European Union, for reasons that include distrust of the regulatory authorities, scientists and technocratic decision making. An informal moratorium in the EU came recently to an end, without solving the underlying problems. In response to the criticisms, the European governments have attempted to improve the risk assessment methods and their scientific basis, and to tailor public policies to the growing demand for transparency, accountability, and public participation.

This paper proposes a novel approach to including the public in evaluating the impacts of food and agricultural biotechnology and present and future applications modeled after the growing practice of sustainability reporting by companies. The most visible among those, Global Reporting Initiative (GRI), when implemented properly, includes a wide range of stakeholders, including the financial institutions, companies, NGOs and the civil society, in an interactive multi-stakeholder discourse and collaboration. The reporting exercise would open the discussion about the R&D around new GMO products, and could mitigate potential adverse effects in an early stage (Constructive Technology Assessment). We specifically propose initiating a broadly based societal initiative aimed at developing of a new sectoral supplement of GRI Guidelines, specifically designed for the food and agricultural biotechnology sector.

This approach can be conceptualized as experimentation on a small scale with a multitude of stakeholders involved (Bounded Socio-Technical Experiment or BSTE) which is an effective venue for higher-order learning among participants. Sustainability reports and BSTEs have been so far applied in limited cases, none of which included highly controversial technologies such as biotechnology; they need further elaboration and testing to

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become possibly highly effective concepts and tools for mitigating conflicts on the societal implications of emerging technologies, and to lead to better public policies and greater social trust.

Keywords: Genetically Modified Organisms, GMOs; Global Reporting Initiative, GRI; Constructive Technology Assessment, CTA

1. Introduction

Genetically modified organisms (GMOs) have been introduced in the agricultural system and on the market of consumer goods in the last 10–20 years, initially in the USA but also increasingly in developing countries. Since the discovery of genetic engineering, with its potential to modify DNA of living organisms, discussion and controversy have been abundant [1,2] both cited in [3]. Europe has witnessed a particularly strong resistance to the introduction of GMOs in agriculture and for consumer food products, both from consumers, national governments and from the EU. The public objections had numerous causes, including the concerns about the risk assessment, the ethics and equity issues, power relations and the mistrust of technocrats and public authorities. The resistance in Asia, Latin America and North America has been generally weaker than in Europe, although some authors have voiced scathing criticism of the US governments and the industrial lobby for abusing famine in Africa to foster the spread of GM food to developing countries [4].

In response to the criticism, the European governments have attempted to improve the risk assessment methods and its scientific basis, and to tailor public policies to the growing demand for transparency, accountability, and public participation. Much less progress has occurred to date in the actual articulation of these ideas: the form which such public participation might take; how it would contribute to greater transparency and accountability; and how it would contribute to more effective and legitimate public policies.

In this paper, we contribute to clarifying these poorly elaborated concepts. Starting with the assumption that discourse and public engagement are indeed positive and necessary for solving the GMO controversy, we argue that the growing practice of voluntary sustainability reporting by companies can serve to enhance a discourse, including the widest possible range of participants, some of whom have been until now kept outside the debate; and that a multi-stakeholder discourse so created enhances societal participation in the strategic corporate decisions regarding the research and development trajectories for agricultural GMOs – constructive technology assessment – and elevates the idea of social accountability and social responsibility of producers of GMOs.

2. GMOs in agriculture and food: risks, public perceptions and regulation

In food biotechnology, genetic modification techniques have been most extensively applied to enhance enzyme production by microorganisms used in food manufacture [5]. In agriculture, the focus has been mostly on producing genetically modified crops that are resistant to insects, viral pathogens, and commonly used herbicides, such as Monsanto's Roundup [5,6,7]. Experiments are also under way to produce crops with enhanced nutritional and health benefits ('functional foods' and 'nutriceuticals'), and with the capacity to produce pharmaceuticals ("pharming"). The metaphor of 'crops becoming factories, producing vaccines, plastics, industrial starches, and feed supplements and enzymes' captures the trajectory of this type of research.

2.1. Major issues

Concerns about the introduction of GMOs in crops and in food concentrate on four mutually overlapping areas: environmental concerns; public health concerns; ethical concerns about "tampering with nature" and individual choice; and a combination of ethical and socio-economic concerns related to the issues of patenting.

The environmental risks include the possibility of a transfer of the introduced genes to wild plants and non-target insects, and the subsequent emergence of resistant or highly invasive insects and weeds. There is also the possibility of harmful changes in the nutritional status of foods, and decline of the biodiversity of wildlife as a result of changes in the availability of food [5,7,8].

Among the health concerns, allergenicity and antibiotic resistance are most often mentioned [5,9]. Kuiper et al. [10] also discusses the possibility of horizontal gene transfer (HGT) of recombinant DNA from GM crop-derived foods to human gut microflora or the human or animal genome, as gene transfer between different organisms is quite common in nature and a driving force in evolution. (However, transfer from food upon ingestion is a rare event and only consequential if the trait is expressed and confers selective advantage.)

In relation to the ethical concerns about 'tampering with nature' [11], Burkhardt [12] discerns three ethical paradigms: consequentialism (acceptable outcomes for most people), ethics of autonomy/consent (everybody should have a choice), and ethics of virtue/tradition (based on traditions of the community). In the *consequentionalist ethics*, the first generation of GM technology is acceptable because it generally focuses on improving efficiency, if applied with enough foresight about possible adverse consequences. It is unclear if the same holds for second generation GMO products, because they add new properties and thus goes beyond efficiency.

In the ethics of *autonomy/consent*, each person should have the right to avoid GMO products. The policy implication is the need to separate GMO from non-GMO food, to label them accordingly, and to create rules for optimal traceability. The *ethics of virtue/tradition* can take different forms, depending on the tradition. In the '*agrarian*' tradition, agriculture is a 'way of life' and its adherents oppose GMOs as part of the broader resistance to modern biotechnology-based agriculture. In the '*nature-ism*' tradition, trans-species of genetic material can upset the operations of ecosystems, with unknown consequences, and thus are ethically unacceptable. The *consequentionalist ethics* have dominated the early years of the GMO debate, focusing on risks, costs and benefits, while the other perspectives have been marginalized. During the 90s, the other ethical perspectives have been elevated by consumer activists and environmental groups.

The issue of patenting on living organisms has been hotly debated since the 1980s. The controversial Supreme Court ruling (Diamond vs. Chakrabarty, 1980), which upheld the companies' claim to patent life forms, gave it an additional visibility. In an extensive review, Krimsky et al. [13] summarize the arguments against patenting life forms as follows: it does not 'promote the progress of science and useful arts' [14], and often even interferes with the development of new technologies [15]; the knowledge of crop and food production, which underlies the development of GMOs, has accumulated over thousands of years of human development and is taken for free to enrich the GMO manufacturers, and thus is '….little more than blatant piracy from cultures whose history has long demonstrated the "utility" of such plants.'; the clash of values between those who consider life as another form of property ("genes are basically chemicals") and those who consider the knowledge about the functioning of a genome as something that fundamentally should be shared by everyone is unresolved; plants and genes represent cultural artifacts that cannot be claimed as inventions or discoveries; life forms are simply part of nature, and no ownership can be claimed over them [14]. King et al. [15] also highlight the rich debate about the impacts of patenting on the livelihood of small farmers, who lose the free access to an essential public good: crop seed. They cite hundreds of cases where the seed manufacturer Monsanto took farmers to court for planting seed obtained from genetically engineered plants (p. 53).

The above concerns regarding GMOs in food production and agriculture are further magnified by the uncertainty associated with the high-speed and large-scale adoption of GMOs around the world (what Brooks [16] referred to, two decades ago, as the hazards of technological monocultures), as well as with the rapid developments in the science and technology of GMOs.

2.2. Public resistance to GMOs

While the introduction of GMOs in food and agriculture engendered debate around the world, the European public has been most active in resisting the new technology. The difference between the US and Europe is especially striking because it is quite the opposite to the acceptance of cigarette smoking on the two sides of the Atlantic. Kurzer [17] attributes the greater US acceptance to the fact that "Americans perceive farming as yet another industry "…on par with cars or steel". They do not harbor the same sentimental ties and ethical concerns for the preservation of rural life" as the Europeans do [18]. Others explain the difference by the Americans' trust in the government agencies with oversight of the GMOs: EPA, FDA and USDA. The Europeans, on the other hand, are said to doubt the competence of regulatory agencies, especially after the recent mad cow disease fiasco [19,20,21]. Lieberman et al. [22] characterize the differences as being caused by opposing dominant principles of "substantial equivalence" (USA) and "precaution" (EU); or, even more succinctly, as "innocent until proven guilty" vs. "guilty until proven innocent".

The reaction of the European public to GMOs has been characterized by a mistrust of the regulatory institutions and the technocratic approach to the risk assessment and management. While the Eurobarometer surveys conducted between 1991 and 2002, and other sources [11] register the familiar concerns about "tampering with nature" and environmental and health consequences (allergens, out-crossing, super-weeds), the public appears to recognize and accept the scientific uncertainty with which regulatory agencies must deal [21]. Rather, the public questions the ability of scientists to serve the public good, as well as the ability of government agencies to produce wise policies. Pellizoni [21] used focus groups to elicit public opinions about risks, experts and regulations in five European countries. This author discovered that there is little knowledge of regulatory institutions and a lot of skepticism about them, often related to the mad cow disease incident. There is also a widespread feeling that the bureaucracies favor formal procedures over actual safety, and favor big corporations over small firms. There are also complaints about the extreme specialization of scientific research, and the strong connections between science and industry. Overarching is mistrust of ambition-driven scientists, experts, regulators, and policy management of risk and uncertainty. Unfortunately, Pellizoni does not describe in his article the positions of focus groups on specific aspects of risk and uncertainty in the GMO debate.

Pellizoni's results are consistent with the results of other focus groups, which uncovered a resentment of decision-making procedures and unease about the prevalent direction of the agro-food system [23]. Frewer et al. [11] and Barling et al. [5] also mention the perception of an institutional failure to address public concerns, mistrust in these institutions, and specific concerns about the balance of power between producers and consumers, and between the industrialized and developing worlds. Notably, the public appears to favor the idea of 'societal usefulness' as the criterion for judging the acceptability of GMO technologies over the economic efficiency criterion. Frewer et al. [11] also note the increased demands for public participation and the rise of the 'consumer citizen' movement since the mid 1990s (through purchasing decisions and consumer boycotts), and the attendant need for labeling foodstuffs and traceability of food components.

2.3. Public policies

Regulation of GMOs in agriculture and food in Europe has been difficult, owing to the legislative and regulatory complexity of the EU, the technical complexity of the issue, its economic and industrial importance, and the inherent uncertainties [24]. The initial wave or regulation during the 1980s engendered so much criticism from the member states and various stakeholder groups that it resulted in imposing in 1998 a *de facto* moratorium on all GMOs, first adopted by France and Greece, then Italy, Denmark, and Luxembourg, and finally by the EU Commission [25,22]. The proximate trigger of the decision was the highly publicized shipment of GMO maize by Monsanto to a European harbor.

Since then the EU has been tackling the issue along three lines: developing specific GMO regulations, re-interpreting the precautionary principle, and creating an EU Food Safety Agency. In 2003 more and stringent regulations were adopted concerning authorization procedures, but also concerning labeling and traceability of the sources of food components. The precautionary principle was extended from environmental protection to consumer and health protection. The most important innovations in the 2003 regulations include: explicit inclusion of the principle of 'consumer choice', by making the labeling and traceability requirements mandatory; formalizing the distinction between risk assessment, risk management, and risk communication; and recognizing that risk communication means a two-way dialogue with a goal of making the general public an active participant in both the technical and policy discourse [24]. These innovations have been reached after extensive informal consultations with numerous stakeholder groups.

Another approach sought to create an effective barrier between GM and non-GM crops by creating GMO-free zones. Schermer et al. [26] propose a GMO-free zone in the Alps region of Upper Austria, Biosphere Reserve, for the following reasons:

- The active promotion of alternative technologies, as opposed to following a single direction of technological innovation (like in the case of nuclear energy)
- The creation of a protected space (a 'niche') for experimentation and learning about alternatives
- 'Endogenous response' to globalization by 'less favored regions', meaning the mobilization of local knowledge and solutions to ensure sustainable development

In 2003, the EU Commission rejected this request, and the decision is being contested in the courts [27].

Greenpeace has generally supported the 2003 EU regulations, warning, however, against the attempts by the US to undermine these regulations through the World Trade Organization (WTO) [28]. Indeed, in 2003, the USA, Canada and Argentina challenged the EU over its *de facto* moratorium on GMOs at the WTO [27]. The ruling of the WTO in 2006 is that that the USA claim is largely rejected; however, it is ruled to be illegal that individual countries ban specific GMOs; strict laws are still possible [29].

One of the key features of the European policy with regard to GMOs – the labeling and traceability requirements – has proved to be difficult to implement. For one thing, there is no consensus about the definition of non-GMO-containing foodstuffs. (Greenpeace has been campaigning against companies that lobbied the EU to allow increasing amounts of 'contamination' by GM food). Second, incidents of mixing during storage, transport, and processing are bound to occur, as exemplified by the widely publicized case of Starlink corn in the US, where GMO corn, strictly limited to the use for animal fodder, found its way into supermarket cereals and other grain products. In 2005, there was the highly publicized case of Syngenta misleading the public and regulators and withholding information about GM maize contamination. Recently Greenpeace has created a Contamination Index describing 113 incidents; Greenpeace has consistently argued that 'coexistence' of fields with GM and non-GM crops is impossible without contamination.

The third problem is that once cross-contamination is detected, traceability to the source of GMOs is difficult, opening to questions the capacity for enforcement of the labeling policies. Finally, not all foods are covered; for instance, there are no procedures to label meat and dairy.

With regard to improving transparency, accountability, and public trust and participation, the establishment of the European Food Safety Agency (EFSA) has been a step in the right direction [23]. However, according to Borras [24], the consultation and participation in the present risk policy remains inadequate. The informal process of consultation and contestation creates problems of unequal access and influence, largely related to the inequality or the stakeholders' resources. Also, the EU parliament and the national parliaments have no involvement in the authorization process. Thus, it is unclear if the new GMO rules will gain social acceptance. Now that the moratorium on GM foods is effectively lifted in most countries of the EU, it remains to be seen how consumers will respond to the appearance of GM products on the supermarket shelves.

One way in which the technical and policy communities responded to the public concerns about the GMOs and the institutional ability to control the attendant risks and uncertainties has been to develop increasingly sophisticated methods for testing, monitoring, early problem detection, and risk assessment [7]. Other ways were to modify and refine existing expert-based assessments. One of those proposed by the Food and Agriculture Organization and World Health Organization is the concept of "substantial equivalence" [9,22]. Substantial equivalence embodies the concept that "… if a new food or food component is found to be substantially equivalent to an existing food or food component, it can be treated in the same manner with respect to safety" [22]. This concept has been criticized by Millstone et al. [30], who note: "…the degree of difference between a natural food and its GM alternative before its "substance" ceases to be "equivalent" is not defined anywhere, nor has an exact definition been agreed by legislators". Moreover, it is ironic that the same actors who endorse the concept of "substantial equivalence" also endorse the present right to patent new GMO life forms.

Kuiper et al. [10] propose in an EU-funded project a more elaborate method for the safety assessment of foods derived from GM crops: ENTRANSFOOD. Using the substantial equivalence approach, this procedure amounts to a thorough description of all aspects of the products and the process, including study of unintended side effects. According to the authors, this method is applicable to both the first and second generation GMO crops, the latter including nutritionally enhanced crops, those with improved performance under environmental stress conditions (salt tolerance, heat resistance), and others.

While these proposals may be steps in the right direction, they are still in essence expert-based, technocratic approaches, limited by scientific uncertainties and technocratic judgment. As such, they do not go far enough in addressing many of the public concerns. Perhaps for that reason Kuiper et al. [10] call for "research on new ways of public participation in the risk analysis process for foods and new food producing technologies" as well as the establishment of a Permanent Evaluation and Discussion Platform for the scientific and societal assessment of the development and introduction of future foods in Europe, without however, clarifying how such participation would contribute to either the risk assessment or risk management of GMOs. Recently, Noteborn et al. [31] have described an Office of Risk Assessment of the Dutch Food Safety Authority (VWA) as a "front office" to 'facilitate the pooling for early warning signals for trouble, novel innovations and developing knowledge, to screen potential threats on significance for human and animal health; to analyze public perceptions and to commission supportive research and technical assessments…'. However, the effectiveness of this approach is not yet known.

2.4. The unresolved question of public participation

One of the prominent themes in the voluminous literature on science and policy of agricultural GMOs is the recognition of the central role for a broadly based, inclusive societal discourse on risk assessment, risk management and policy development [3,10,11,24]. There is much less clarity in the literature on how to create an effective discourse and participation, or what exactly its objectives would be. With regard to the objectives of public participation, the open questions include: Would it seek to reduce the public mistrust of the public institutions, and thus empower these institutions to act in the public interest? Would it seek to educate the public about the benefits and risks of GMOs, and thus help them make individual choices as consumers? Would it help the regulatory agencies to understand public concerns, and thus make more informed and possibly more effective public policies? Or perhaps other objectives should be chosen?

Several studies have in fact shown that better education and outreach to the general public does not necessarily reduce controversy or increase public trust in regulatory agencies. For example, Frewer et al. [11] showed that more information polarizes the existing attitudes rather than open peoples' minds to reconsidering their views; consumers with initially negative values become even more negative, while consumers with initially positive values become even more positive. In another study by Scholderer et al. [32], it appeared that more information had no effect on the attitude towards GMOs, either positive or negative, but it lead both the proponents and opponents to recommend reducing the use of GMOs. Barling [5] also showed that the perception of high risk was greater amongst the individuals with greater 'objective' knowledge of the GMO technology and those who recently discussed biotechnology.

This paper aims to contribute to clarifying the poorly elaborated concepts of inclusive societal discourse and public participation. Starting with the assumption that a discourse and a public engagement are indeed good things and necessary for solving the GMO controversy, we advance three propositions:

- The concept of sustainability offers a helpful framing of the debate about the multiple controversial aspects of GMOs in food and agriculture.
- The rapidly growing practice of voluntary sustainability reporting by companies provides a powerful instrument for serving the goal of creating a discourse that includes the widest possible range of participants, some of whom have been until now kept outside the debate.
- (Following from the previous one), a multi-stakeholder discourse so created opens an opportunity for increasing societal participation in the strategic corporate decisions regarding the research and development (R&D) trajectories for agricultural GMOs (Constructive Technology Assessment, CTA [33]), and elevates the idea of social accountability and social responsibility of producers of GMOs.

Taken together, this approach – sustainability reporting – advances social learning about the agricultural GMO technology.

3. The role for sustainability reporting

During the past decade two ideas have taken root in the discourse on corporate social responsibility: the need for regulatory institutions with a global reach [34,35,36,37], and the need for incorporating accountability and transparency into standard business practice. In the area of environmental and social sustainability, companies around the world have rapidly responded by adopting the practice of voluntary reporting of performance in the environmental and social domains. Various standardized performance disclosure systems have emerged, both in the US and globally[1] [38,39,40,41,42]. According to a recent survey [43], 52% of the Top Global 250 companies issue separate corporate responsibility reports. As the so-called non-financial reporting has moved swiftly "from extraordinary to exceptional to expected" [44], regular disclosure of environmental and social performance has become *de rigueur* in large global companies seeking to maintain legitimacy as socially responsible actors.

At its most explicit, the social argument in favor of reporting is that it empowers all stakeholders to hold companies accountable for their actions, and to exert pressures for changing behaviors (a phenomenon known as *civil regulation*), either through political action, or market mechanisms, or through more collaborative mechanisms. A less often discussed, but crucial, argument for reporting is that it forces the reporting companies to gather and critically examine data about themselves, and, in the cases of serious commitment to producing a high level report, to engage with their most important stakeholders: those who experience, and have an interest in, the impacts of the company's activities. This, in turn, may lead to considerable organizational learning and may create dialogue between the company and the rest of society.

One recent example is a sustainability report released by Nike Company. Apart from the skeptics' gripes that it was an exercise in reputation management (which it was, following the embarrassing disclosures of sweatshop practices of Nike vendors in developing countries), all agreed that the report was of high quality and based on a genuine engagement with the relevant stakeholders. There is evidence that Nike management truly learned from the experience and that its reports raised the bar on other such reports within the apparel sector.

A third key benefit of reporting is that the collective process of reaching a consensus on what and how to report creates a platform for a discourse among many different types of societal actors while providing a common language for conducting it. It is these two aspects of reporting – its potential to create a platform for a multi-stakeholder engagement and a broader societal discourse on many dimensions of agricultural GMOs – that we address in this section.

Among the many voluntary reporting schemes in current practice, Global Reporting Initiative, GRI, has emerged since the late 1990s as the best known and most widely used across countries, cultures and economies (www.globalreporting.org). With the official endorsement from the United Nations, close working relations with the International Standards Organization, ISO, and links to many influential organizations in the area of corporate social responsibility, GRI aspires to define the global standard for accountability through information disclosure and stakeholder engagement. For that reason, and because of some of GRI's unique features, we use GRI as a case in point for discussing the role that non-financial sustainability reporting might play in the debate over agricultural GMOs.

Three features of GRI are of particular interest here: its inclusiveness and interactive character, its focus on social impacts, and its global scope. The inclusiveness and participatory character are structurally built

[1] The mandatory EPA Toxic Release Inventory, TRI, was one of the earliest (www.tri.gov).

into the GRI system in the following manner: the framework for reporting (Reporting Guidelines) is developed through a collaborative effort of the widest possible range of international actors, including the manufacturing and service sectors, institutional investors, financial rating sector, banks and insurance industry, accountancy organizations, religious organizations, social activists, environmental and labor organizations, governments, communities, and others. Since the birth of the idea of GRI within the Boston-based Ceres organization in 1997, over three thousand individuals and organizations worked together (through many interacting working groups and over time) on figuring out what to report, how to report, and how to account for the individual sectoral and regional activities, needs and interests. This collaboration has produced three generations of generally applicable Reporting Guidelines (known as G1, G2 and G3), and half a dozen of supplemental guidelines tailored to specific sectors (Sectoral Supplements for automotive, telecommunications, financial services, tour operators, mining and metals, and public agencies) as well as countless discussion papers and discussion forums.

Furthermore, because the GRI Guidelines are a perpetual work in progress – the work on the subsequent version of the guidelines commences as soon as on is officially released – this is in effect a self-replicating process of social discourse over the issues that are of interest to a widely ranging constituency.

The process by which GRI Guidelines have evolved – intense interaction, wide range of views and ideas, a shared goal – was highly conducive for social learning (see [45] for a theoretical discussion on learning). Research by one of us [46] has uncovered several dimensions of that learning:

- GRI has contributed to the operationalization of the abstract concept of social impacts (within the sustainability framework), demonstrated that communicating social performance in a systematic and comparable way is in fact possible, and showed that broadly based consensus can be reached on how to do it;
- GRI illustrated how a very broad multi-stakeholder process can serve to build consensus on a difficult and possibly divisive issue such as sustainability indicators;
- The cumulative effect of the iterative revisions of the successive generations of GRI Guidelines has been to increase the sense of broad ownership of *a* system of widely applicable sustainability reporting and to acknowledge that a broadly based societal dialogue is necessary to develop, perfect and use it;
- GRI has legitimated the idea of sustainability reporting and created an expectation that such a report would be comprehensive, responsive to its stakeholders, verifiable, and based on mutual engagement with the key stakeholders; and
- GRI challenged the existing institutions and lead to innovations within them [46].

Although the GRI Guidelines do not seek to establish norms of behavior, the process they set in motion is most likely to contribute over time to the emergence of a societal consensus on what constitutes the proper use of technology or the fair treatment of employees or communities. When many participants debate so intensely the issues of which among companies' activities are important to the society, they sooner or later start discussing which, among these activities, are more or less beneficial for the society.

Here the application to the GMO problem becomes apparent: should the GRI organization (namely, its Amsterdam-based Secretariat) embark on producing a *Sectoral Supplement*[2] *for the agricultural GMO*

[2] A better term could be a "Technology Supplement" in this case, because the sector is ill-defined and the reporting issues arise from the technology.

industry, the process thus generated would automatically create a platform, a language and framing for a discourse, and a widely ranging constituency. The participants would go beyond the "usual suspects", namely regulatory agencies, industry, technical experts, environmentalists, and public health, consumer and civil society advocates. They would also include the insurance industry and various members of the financial sector who have not so far been part of the debate but who have great stakes in its outcome.

This inclusive multi-stakeholder process would certainly lead to new ideas and new perspectives on the issue of agricultural GMOs. In time, it might contribute to the emergence of a societal consensus about what constitutes acceptable norms of behavior with regard to the development of specific types of agricultural GMOs and the mode of their application into commerce. It might also contribute to the development of formal policies.

This type of participation and democratic deliberation over the trajectory of technological development is not a new idea. In the 1980s, it has received a considerable attention under the umbrella of "Constructive Technology Assessment (CTA)" [33]. CTA aimed at mitigating unforeseen and societally undesirable effects of new technologies by increased stakeholder participation in the process of technology development. What is new here is the proposal to employ the newly emerged instrument for eliciting corporate accountability – namely, sustainability reporting as defined by the GRI – to create an instrument for implementing such technology assessment.

To consider the types of questions that might be scrutinized in the process, and by whom, we take a closer look at the GRI guidelines. The system uses three categories of sustainability indicators:

1. *Social performance indicators* center on how an organization contributes to the well-being of its employees, customers, other stakeholders and the society through its labor, human rights, governance and product responsibility practices. It includes topics such as: labor and human rights; diversity and use of fair hiring practices; board members and suppliers; workplace safety; transparency; ethics; corporate governance; relationship with and social impacts on host communities; product safety; and others.
2. *Economic performance indicators* address the organization's and its host community's economic prosperity, by focusing on its economic impacts on customers, suppliers, employees, providers of capital, and the public sector. Some of the topics include: sales, profits, capital expenditures; debt and interest; wages; community donations; taxes; local purchasing; and brand strength.
3. *Environmental indicators* concern environmental performance and impacts, both now and for the future generations. They cover topics such as: resource conservation, waste prevention and management, environmental risk control and restoration, supply chain impacts, waste disposal, recycling, energy conservation, greenhouse gases, biodiversity, water and materials use; renewable energy; and wildlife conservation.

Clearly, the three categories create an opportunity to ask companies to engage in some of the most vexing questions about this technology, not only *after* it is developed and/or introduced into the market *but especially earlier in the development, at the R&D stage*. Questions such as: the type of social good that is expected to emerge from a particular new trait in the agricultural GMOs; how it will impact the socioeconomic well-being of indigenous communities; compensatory mechanisms for free access to the indigenous knowledge; and others, can be addressed at this stage.

Some of the current GRI indicators are well designed for the above questions; others could serve only as rough proxies for those. The Sector Supplement would be necessary to refine the system to serve the purpose of technology assessment.

So far, we focused largely on the process of developing Agricultural GMO Sector Supplements of GRI Guidelines as the engine of creating an interactive multi-stakeholder discourse around this technology. But the application of the Guidelines to prepare a sustainability report by GMO manufacturers would be another way of setting this process in motion. The above-mentioned example of Nike's sustainability report illustrates this phenomenon. In order to report on the impacts of its products on labor conditions and human rights, the company engaged with all its global vendors and sought their input. Stated simply: it is impossible to report on such issues as human rights, community development, labor relations, and others, without the participation of a diverse constituency affected by these matters.

In short, we see considerable benefits in taking advantage of the growing popularity of voluntary sustainability reporting to enrich and increase the effectiveness of the current discourse about agricultural GMOs. We make this point using the case of GRI system but we do not equate that with endorsing GRI specifically. Rather, this particular system, with its unique features, serves to illustrate how a reporting system that emphasizes both the *product and the process* – the inclusive multi-stakeholder engagement and the ever-evolving Guidelines – can serve that purpose.

Is there a sufficient will to create sustainability reporting guidelines for the agricultural GMOs sector, and then use them? The answer is not easy. In a recent review, White [44] cites research reports showing that in a knowledge-based economy such as ours the returns on investments into technology developments are becoming increasingly important, which creates powerful incentives for protecting intellectual property and for avoiding transparency. On the other hand, research cited by White [44] also shows that the current system of financial reporting, which does not account for the knowledge-based assets, adversely affects the functioning of markets: it creates abnormal gains to informed investors at the expense of everybody else, erodes investors' confidence, leads to high share-price volatility, and increases the cost of capital. These findings make an economic and political case for greater transparency with regard to technological developments within the companies such as GMO producers. The difficulty with resolving these competing objectives is a key argument that the *financial sector* and other hitherto neglected stakeholders must *participate* in the social discourse about the science, policy and economics of agricultural GMOs.

There are also signs of mounting social expectations for companies to engage with the society through meaningful and verifiable sustainability reporting. Over the past decade, this practice has taken on the characteristics of an *institution*. The term denotes a self-sustaining and highly resilient systems of shared values, norms and taken for granted behavioral patters and assumptions that actors hold about 'how the game is played' [47,48,49,50]. As Offe noted, 'good institutions' inculcate responsibilities, provide societal actors with validated standards for desirable and expected behaviors, and produce outcomes that are beneficial to society [51].

Our recent research on GRI and similar reporting frameworks discloses that they possess numerous characteristics of a global institution [46]. Some illustrations of this phenomenon include: the increasing consensus about what constitutes a high-quality sustainability report and what process should underlie its preparation, the incorporation of the concept of reporting into the discussions of corporate accountability and social responsibility, the emergence of new professions (such as social investment financial analyst) and new enterprises (consultancies and think tanks) that depend on sustainability reporting and that specialize in their preparation and verification, and stabilization of a wide network of diverse stakeholders, ranging from market analysts to shareholder activists to labor, civil rights and environmental organizations, who have developed a sense of shared enterprise with regard to the expectation of sustainability reports by companies.

In short, the most salient promise of GRI as an emerging institution is that it may help create transparency in an early phase of the R&D process, where new GMO products and GMO-based production processes are still under development. Institutionalization means that powerful incentives would be created to comply with the emerging codes of conduct, viz. disclosure of information as to R&D processes that have been until now highly confidential. These issues are highly intertwined with patenting and intellectual property rights. Probably the GRI Guideline should address these issues as well if they take up sectoral guidelines for GMO-based agriculture and food.

A multi-stakeholder process as in GRI may be conceptualized as a Bounded Socio-Technical Experiment (BSTE): an experiment, bounded by scope and time, but with a wide range of inputs, which has a good chance to induce higher order learning among the participants [45]. A BSTE exhibits several characteristics: an attempt to introduce a new technology or service on a scale bounded in space and time; a collective endeavor, carried out by a coalition of diverse actors, including business, government, technical experts, educational and research institutions, NGOs and others; a cognitive process in that at least some of the participants explicitly recognize the effort to be an *experiment*, in which learning by doing, trying out new strategies and new technological solutions, and continuous course correction, are standard features. Such an experiment is driven by a long-term and large-scale vision of advancing the society's sustainability agenda, though the vision needs not to be equally shared by its participants. Its goal is to try out innovative approaches for solving larger societal problems of unsustainable technologies and services.

The concept of an 'experiment' also means that monitoring the behavior and actions of participants is an essential part of the procedure. In a BSTE, the discourse between participants may change due to learning; monitoring these learning processes by participants themselves has been labeled as "reflexive monitoring" [52,53].

Several features make small-scale experiments effective learning systems. First, the participation by a heterogeneous set of actors who represent different organizations, communities of practice and institutional affiliations assures the presence of a range of interpretive frames and belief systems. Second, the vision of sustainability, which is the driving force for at least some participants, has the potential to provide a platform, an umbrella, for re-framing the clashing interpretive frames, should conflicts arise. Third, by evolving around a specific tangible "thing" – the innovative product or service – the project provides a focus and a shared language. Other design features can be purposefully brought into the experiment in order to facilitate learning. These include: creating a sense of urgency; making deliberate efforts to encourage self-reflection and reassessment by and among the participants; and facilitating the emergence of a common language.

Our earlier empirical studies of experiments with alternative low-impact vehicles for individual mobility [54] and with designing a fossil fuel-neutral building [45] showed a considerable degree of higher order learning among the participants. The learning took place at the level of problem definition and, to a lesser extent, at the level of interpretive frame. The case of GMO presents an opportunity to apply such socio-technical experimentation to induce learning for the purpose of reducing the controversy and advancing the policy process. This is for several reasons: there are many technical and risk assessment problems to investigate, thus providing an anchor (the 'boundary') for the experiment; there is a wide range of views and interpretive frames represented; many of the parties to the controversy, not withstanding their public positions, recognize both the inevitability of diffusion of GMO technology and its considerable potential to produce social good (as well as harm); developing wise public policy necessities creating a broadly based discourse and mutual learning.

To be successful, such experiments must be organized by a relatively 'neutral' party, such as a university (without major biotechnological research enterprise) or socially engaged think tank or philanthropic organization. We recognize that in the GMO case it might be hard to find 'neutrality', but with strong leadership it is not impossible. One of the main tasks for the organizer would be to provide a vision that can unite the participants, and to countervail the self-destructive internal pressures on the process, and to frame its goals in terms of learning. The concept of *sustainability*, largely absent from the GMOs discourse so far, provides a powerful uniting theme for creating such a vision. Another task for the organizer would be to bring all the relevant parties together, including the a-typical stakeholders, such as, for example, representatives of insurance sector, and to mediate the process, again, from the learning perspective.

4. Discussion and conclusions

In this article, we have developed a framework for managing the societal controversy around GMOs in agriculture, in food and in fodder. We have argued that GMOs constitute an example of a new technology with largely unknown consequences and risks, as well as high potential benefits for society. Risk assessment in its traditional form, as proposed and practices by many actors, both scientists and regulators, appears to be inadequate and is by many actors perceived as overly technocratic. Many authors call for new and improved forms of public participation in the public debate, in decision making, and in regulation. However, these pleas are seldom specific.

Public debate has been intense, propelled by a wide range of NGOs and concerned scientists, and is magnified by cases of inadequate regulation, unwanted incidents, and sometimes fraud. However, we argue in this paper that this debate comes often too late, when the GMOs are already on the market, shipped overseas, and for sale in the supermarkets. One of the important issues we address in this paper is the need for more transparency very early in the research and development (R&D) process, where the chances of influencing companies' behavior are greatest, and the economic stakes are not yet so high. This is an example of Constructive Technology Assessment early in the R&D process. It is highly interwoven with the issue of intellectual property rights and patents on the one hand, and the emerging institution of public disclosure of information on the other hand. We argue that the Global Reporting Initiative (GRI) provides both a vehicle to engage the public and other key stakeholders at the R&D stage of GMO development. This is not easy, given the secrecy of companies and the high economic and social stakes, but it is necessary in order to alleviate the unease and unrest in the civil society.

We have argued that such a GRI process can be conceptualized as a small-scale socio-technical experiment, which offers great opportunities for higher-order learning among a wide variety of stakeholders, including those who have not been involved earlier in the process. Such an approach could and should be part of any regulatory framework, so that enough resources and time are available for a public discourse, possible course corrections, and regulation that would satisfy at least the great majority of the concerned stakeholders. BSTEs offer opportunities for experimenting and learning, for discourse and dialogue, on various levels from problem definitions on specific issues to framing the issues in different ways. Although it is highly unlikely that world views of the participants will change in such a discourse, it is very well possible that a certain level of congruence in problem definitions can be reached, meaning that different parties recognize each other's problem definitions and problem framings as legitimate, and engage in searching solutions that accommodate each parties' interests and beliefs. Mutual trust building is an important part of such an endeavor. It is to be expected that the speed of introduction of

GMOs will be greatly reduced at the very least. Given the widespread unease about technological developments that are going too fast to allow accommodation of institutions, this could be hailed as a positive development by all parties.

Of course, there will be parties who are not interested in such a discourse. On the one hand, some MNCs could prefer to continue on the present path of relatively fast introduction of new GMOs on the market, ignoring the emerging new rules of the game, and to improve their market share world-wide. (However, the characteristics of an emergent institution imply that such behavior could be increasingly labeled as unacceptable, thus damaging the reputation of such companies.) On the other hand, some NGOs may continue to battle against all forms of GMOs for reasons ranging from ethical to environmental to social and political and economical. It would be interesting to study further if and how emerging institutions such as GRI and emerging practices such as BSTEs would create enough mechanisms to accommodate divergent worldviews and interpretive frames.

Finally we might be criticized for advocating solutions that are but another form of enlightened technocratic approach. For better or for worse, emerging technologies cannot be ignored, and deserve serious attention from technologists, social scientists, politics, and representatives of the general public. It is unimaginable that this can be realized without at least employing somewhat technical approaches, together with all non-technical arguments. It depends on the specific forms of the reporting system and the socio-technical experiment whether this process will be branded as neo-technocratic or as truly democratic.

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