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Elusive publics

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Understanding Techno-Scientific Controversy and Democratic Governance in the GM Crops Debate

Andreas Mitzschke

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Understanding Techno-Scientific Controversy and Democratic Governance in the GM Crops Debate

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List of Abbreviations

AAP	Aam Aadmi Party
ABC	Agricultural Biotechnology Council (United Kingdom)
ABLE	Association of Biotech Led Enterprises
ABSP	Agriculture Biotechnology Support Project (Cornell University, USAID)
ASHA	Alliance for Sustainable and Holistic Agriculture
BAC	Biotechnology Advisory Council (Belgium)
BASF	Badische Anilin & Soda Fabrik
BfR	Bundesinstitut für Risikobewertung (German Federal Institute for Risk Assessment)
BKS	Bharat Krishak Samaj
BKU	Bhartiya Kisan Union
BSE	Bovine Spongiform Encephalopathy
Bt	Bacillus thuringiensis
CBD	Convention on Biodiversity (United Nations)
CCI	Competition Commission of India
CEE	Centre for Environment Education (Ahmedabad)
CEO	Corporate Europe Observatory (Brussels)
CIFA	Consortium of Indian Farmers Associations
CICR	Central Institute for Cotton Research (Nagpur)
COPE	Committee on Publication Ethics
CRIIGEN	Comité de Recherche et d'Information Indépendantes sur le gémnie Génétique (University of Caen)
CSA	Centre for Sustainable Agriculture (Hyderabad)
CSE	Centre for Science and Environment (New Delhi)
DNA	Deoxyribonucleic acid
DBT	Department of Biotechnology (MoST, GoI)
ECI	Expert Committee I
ECII	Expert Committee II
EFSA	European Food Safety Authority (Parma)
ENSSER	European Network of Scientists for Social and Environmental Responsibility
ERA	Environmental Risk Assessment
ESG	Environment Support Group (Bangalore)
ETC	Action Group on Erosion, Technology and Concentration (Toronto)
EU	European Union
FAO	Food and Agricultural Organisation (United Nations)
FBAE	Foundation for Biotechnology Awareness and Education (Bangalore)
FCT	Food and Chemical Toxicology (Elsevier)
FDA	Food and Drug Administration (United States)

GEAC	Genetic Engineering Appraisal Committee (previously Genetic Engineering Approval Committee, renamed in 2009)
GE	Genetically Engineered
GLP	Good Laboratory Practice
GM	Genetically Modified
GMO	Genetically Modified Organism
GoI	Government of India
H.NU	Hervorming Nederlandse Universiteiten Nu
HT	Herbicide Tolerance
IAASTD	International Assessment of Agricultural Science and Technology for Development
ICAR	Indian Council of Agricultural Research
ICCFM	Indian Coordination Committee of Famers Movements
ICRA	Institute for Cultural Research and Action (Bangalore)
IIVR	Indian Institute of Vegetable Research (Varanasi)
IPM	Integrated Pest Management
IR	Insect Resistance
IRRI	International Rice Research Institute (Philippines)
ISAAA	International Service for the Acquisition of Agri-Biotech Applications
KRRS	Karnataka Rajya Raitha Sangha
Mahyco	Maharashtra Hybrid Seeds Company (Mumbai)
MEP	Member of European Parliament
MMB	Mahyco Monsanto Biotech
MoEF	Ministry of Environment and Forests (GoI) (renamed into Ministry of Environment, Forest and Climate Change in 2014)
MoST	Ministry of Science and Technology (GoI)
NGO	Non-Governmental Organisation
NLSIU	National Law School of India University (Bangalore)
NPM	Non-Pesticidal Management
NTO	Non-Target Organism
OECD	Organisation for Economic Corporation and Development
PIL	Public Interest Litigation
PP	Precautionary Principle
RCGM	Review Committee on Genetic Engineering
rDNA	recombinant Deoxyribonucleic Acid
RTI	Right to Information Act (India)
SCOT	Social Construction of Technology
SD	Sprangue Dawley (laboratory rat used in toxicological feeding studies)
SICCFM	South Indian Coordination Committee of Famers' Movements

SiT	Science in Transition
SMC	Science Media Centre
SSK	Sociology of Scientific Knowledge
STS	Science and Technology Studies
TEC	Technical Expert Committee
TNC	Transnational Corporation
TNAU	Tamil Nadu Agricultural University (Coimbatore)
UAS	University of Agricultural Sciences (Dharwad)
UN	United Nations
UNCED	United Nations Conference on Environment and Development
USAID	United States Agency for International Development (Washington, DC)
USDA	United States Department of Agriculture
WHO	World Health Organisation
WTO	World Trade Organisation

Chapter 1

Introduction - The GM Crops Controversy

GM crops & publics

Since the first marketization of genetically modified (GM) crop technology in the mid-1990s, controversies about this agricultural biotechnology, its potential benefits and risks, as well as the implications of implementing GM crops in agricultural systems around the globe have provoked widespread and enduring scientific, political, and public debate. While the pharmaceutical use of biotechnology, such as the production of insulin with the help of genetically modified bacteria have become almost universally accepted, transgenic crops have been met with fierce and continuous public opposition in some countries. Although various GM crops have been adopted widely in the agricultural systems of the United States and many South American countries, in the European Union a de-facto moratorium on the cultivation of transgenic seed technology is in place. In emerging economies such as India, the gradual implementation of GM crops has provoked widespread public opposition and debate too.[1] GM crops and public opposition to and debate about this technology are closely intertwined.

This book is about the development of the GM crops controversy and the pervasive role of 'the public' therein. In the European Union (EU), hardly any GM crops are cultivated. Only one GM crop (MON 810, an insect-resistant maize) is commercially grown in only five member states of the EU. The 150.000 hectares on which GM maize gets grown amount to only 1,5 per cent of the total EU maize cultivation surface. However, the EU imports substantial quantities of GM-based feed. In 2013, more than 60 per cent of plant-based protein for feed use in the EU's life stock industry consisted of GM crops imported from third countries (EC, 2015). Europe's de-facto moratorium on the cultivation of transgenic crops is almost without exception explained by widespread public opposition to the technology. For instance, a special Eurobarometer survey on Biotechnology by the European Commission's Directorate of Research identified GMOs to meet "almost universal resistance from the public" (EC, 2010, p. 4), particularly for the use in food. Similarly, the European 'public's' opposition to GM crops is taken to be "a blueprint for the fear of public unease" (Torgersen & Schmidt, 2013, p. 45) that is to be avoided with other technological innovations, such as nanotechnology and synthetic biology (cf. Levidow & Carr, 2010).

The pervasive role 'the public' plays in opposition to GM crops in Europe can also be seen in India. In 2002, the introduction of insect-resistant Bt-cotton as the first commercial GM crop in India led to an intense scientific debate and public controversy about the technology's diffusion, performance, and its social and environmental appropriateness (Shah, 2005). However, more than 90 per cent of India's cotton area is planted with Bt-cotton today; farmers seem to have made the choice for this technology. Although many studies suggest the technology performs well, data raised by Non- Governmental Organisations (NGOs) contradict the success story about Bt-cotton (see Kalamkar, 2013, for an overview). Moreover, since each side of the controversy engages in its own authentication loops for generating,

[1] Stone notes that the terms biotechnology and genetic modification are commonly used synonymously, "although strictly speaking, biotechnology also includes other technologies such as tissue culture and genetic-assisted marker breeding" (Stone, 2002, p. 611). For reasons of clarity, I will refer to genetic modification (GM) or transgenes to denote the technology I study here, while I use the broader term agricultural biotechnology to refer to branches of industry and science involved with, but not restricted to, GM crops development, research, and application.

validating, and publicizing research data about Bt-cotton performance, it remains difficult to make useful comparisons in developing country contexts (Stone, 2012). As Bt-cotton already triggered widespread societal debate about GM crops, the attempted marketization of Bt-brinjal, India's first GM food crop, was met with widespread public debate and even fiercer societal opposition. Eminent Indian scientists were vocal in their disagreement over the need for and safety of Bt-brinjal (Yadugiri, 2010). Finally, a nation-wide public consultation process induced by the Ministry of Environment and Forests (MoEF) resulted in the imposition of a moratorium on Bt-brinjal in 2010 (Ramesh, 2010). The Indian public appears equally sceptic of the alleged benefits of GM food crops, and the public's role in the imposition of the moratorium on Bt-brinjal is unprecedented. In both India and Europe, 'the public' seems to influence the development of GM crops. The fierceness of this public opposition became most apparent when farmer activists engaged in direct action in their fight against the symbols of transgenic seed technology. In the late 1990s, farmer activists destroyed GM crop field trials in France and India (Bonneuil, Joly, & Marris, 2008; Akhil Gupta, 1998, p. 331; Herring, 2006). Direct action in the form of field trial destruction happened throughout the 2000s, mostly in France, Germany, the United Kingdom, and Switzerland (Kuntz, 2012).

Many actors in the GM crops controversy in India and Europe make arguments and claims in reference to wider public opposition to transgenic crop technology. 'The public' is accordingly invoked by many actors in this techno-scientific controversy and the underlying problem is conventionally understood as hinging on the publics' insufficient understanding of the science of biotechnology and its mistrust in the way policy-making institutions use science in decision-making processes. Public rejection is today still framed as hinging on the lack of a fact-based public debate (Torgersen & Schmidt, 2013). Such a perspective envisions improved and tailored communication to a public consisting of emotional, ill-informed, and passive subjects as a solution (see e.g., Sinemus & Engelhofer, 2007). In contrast, other views take the GM crops debate as emblematic for the complex relationship between science, the state, and society in techno-scientific controversies (see, e.g. Borbone, 2009; Jasanoff, 2005a). In various agro-ecological, cultural, historical, political, and social contexts, 'the public' is spoken of and referred to as a source of authority and legitimacy for making claims and decisions on GM crop technology. Yet, it is difficult to speak of 'the public' as a singular entity. Who or what makes 'the public' beyond opinion surveys or public protests is unclear. The assumption in both India and Europe, of 'the public' as a homogeneous entity that positions itself vis-à-vis other social worlds of the GM debate, such as the market, policy-making, and science, obscures our understanding of the democratic governance of GM crop technology. The public instead takes various forms, it is constructed differently by different actors in different contexts, and as such remains difficult to grasp and conceptualise (cf. Appadurai, 1988; Cody, 2011; Scott & Ingram, 2015). In other words, despite its pervasive role in the GM crops debate and in shaping the technology's development, the detailed contours of 'the public' remain elusive.

In this book, I therefore look closely at the concept of the public as a multiplicity, a multiplicity that is continuously reconstructed by the actors in the debate about GM crops. Understanding publics in their multiplicity will provide an explanation to the question why the risks of GM crops are so fiercely contested; and it will give us a better understanding of the nature of democratic governance of technological risks in a globalized world. The central question I address in this qualitative social science thesis therefore is: What is the role of publics in the

current controversy about the risks of GM crops? In answering this question, I want to explain the development of GM crops by tracing how this technology gets shaped by public involvement in this issue. At the same time, I argue that publics are not a static entity but that they also are shaped in the process of the debate. In other words, I ask how publics shape the development of GM crops, and how a multiplicity of publics are constructed in the various arenas in which the controversy about GM crop technology takes place. The GM crops debate is a strategic site to study the construction of publics, since transgenic seed technology involves more questions than only about its scientific and technical aspects: it touches upon agrarian, environmental, economic, and socio-political issues too.

Although there are many concepts of democracy, with many different interpretations about which mechanisms make a system of governance democratic, we can assume that the 'consent of the people' in decision-making, i.e. the consent of publics in the way they are governed, remains one of the most basic principles of democratic political order (Dahl, 1998; Held, 2006b). Yet, in 2007 the European Commission Report "Taking European Knowledge Society Seriously" (Wynne & Felt, 2007) identified a lack of legitimacy and public mistrust in the governance of science and technology. Therefore, it makes sense to study the interrelations between technological innovation and democratic development by looking at the mutual shaping of GM crops and their publics in this ongoing controversy. Understanding publics as a multiplicity will also help to answer the question that prompts my broader motivation to understand the democratic governance of science and technology: How do GM crop technology and public involvement in this issue shape democratic political culture in a globalised techno-scientific world?

This book follows the approach developed in Science and Technology Studies (STS) that derives from the notion that modern society is pervasively constituted and shaped by science and technology, making it a technological culture (Bijker, 2006a; Hommels, Mesman, & Bijker, 2014).[2] Technological disasters such as the Three Mile Island nuclear accident in the late 1970s, the Chernobyl explosion and the Bhopal gas accident in the mid-1980s, the food scare around bovine spongiform encephalopathy (BSE) in the 1990s, as well as the enduring controversy about genetically modified organisms (GMOs) show that the risks of science and technology pose a problem of legitimacy for political leaders and the experts of techno-science alike, not least because the former rely heavily on the latter's expertise in political decision-making (Funtowicz & Ravetz, 1993; Leach, Scoones, & Wynne, 2005; Nowotny, Scott, & Gibbons, 2001; Wynne, 2005). In that vein, political sociologist Charles Thorpe argues that "in the context of globalisation, mediating structures of representation and the delegation of authority to experts are increasingly perceived as removing real power from citizens and populaces" (2008, p. 78). Over the last two decades however, in Western democracies and developing countries alike, new social movements have re-politicised technical and scientific issues that were previously rendered outside political debate by the processes of neoliberal economic globalisation. Societal controversies about techno-scientific issues are important sites for the enactment of democracy. Accordingly, STS scholars have argued that the deeply techno-scientific character of our societies necessitates studying closely the attempts to democratise decision-making on techno-scientific issues. (Bijker, 1995a; Bijker, Bal, & Hendriks, 2009; Nowotny, 2003; Sclove, 1995).

[2] Bijker (2006a) explains that studying technological culture goes beyond the recognition that society consists of social systems and technological systems. It implies studying technologies and societies as cultural phenomena. In a similar vein, Appadurai (Appadurai, 1988) suggest the notion of the public to be culturally constituted.

In that sense, techno-scientific controversies serve as a focal point for studying the democratic concern about who controls crucial policy decisions in an age of increasing complexity of science and technology (Nelkin, 1995, 1979, 1992). Controversy about technology can therefore be understood as a process in which will-formation occurs due to political deliberation amongst different actor groups who attach different meanings to the same technology. However, such deliberation takes varying degrees of institutionalisation (Hamlett, 2003).

By studying the role of publics in the GM crops debate, I ask not only how the construction of publics impacts technological development, but also how we can understand the construction of publics to reflect the development of democratic political culture in times of globalised techno-science. Looking more closely at the construction of publics in a technological controversy such as the debate about GM crops will accordingly yield a better understanding of democratic political cultures. The question that links the construction of publics to the issue of democratising science and technology decision-making is then how and what sort of publics can shape policy processes under which conditions. Yet, as I will show, the construction of publics is not restricted to the policy process, but occurs in other arenas of the controversy, too.[3] Additionally, simply calling upon (or constructing) publics does not necessarily mean that debates about technological risks become automatically more democratic, i.e. giving the people more control over decisions about technological development. It could even be the other way around.

In the following, I first explain in more detail what GM crop technology is, how it differs from other seed producing technologies, and which GM crops get cultivated in India and Europe. I then commence by outlining the theoretical framework with which I approach the study of science, technology, and society. Thereafter, I provide a short review on the concept of publics and how I intend to use this notion for my study of the multiple, elusive publics in the GM crops controversy. The section that follows clarifies my qualitative research methodology, how I have gathered empirical sources, with which methods I have studied them, and a note on the contextual contingencies of drawing on the Indian and European debates. This will be followed by an outline of the three empirical chapters in which I study the construction of publics in different arenas of the GM crops debate.

The Controversy about GM Crops

Traditional breeding techniques have been employed since the Neolithic Revolution when human societies transitioned from hunting and gathering to settlement and agriculture. Starting from around 10.000 B.C., this process involved the modification of the natural environment through deforestation and irrigation to cultivate land. It also included the domestication of plants through selective breeding of crops, i.e. those plants with the most desirable traits, such as increased yield, were chosen for breeding the next generation of plants for food and feed. Traditional plant breeding uses the naturally occurring variations in the genetic make-

[3] In outlining the organisation of this book, I will specify how I use the concept of 'arenas' further below. For now, it is sufficient to describe controversy as polycentric, involving various individual and collective actors, groups and institutions who conflict and compete over problem definitions and related solutions across different fields from risk assessment science, to public imaginaries, and policy-making.

up of plants to combine these in the next generation of crops. Traditional breeding is different from genetically modifying crops through biotechnology applications. Genetic modification (GM) refers to the direct manipulation of an organism's genetic information contained in its DNA by altering, inserting, or transferring DNA sequences from one species to another in the laboratory. Accordingly, the EU Directive 2001/18/EC on the Deliberate Release into the Environment of Genetically Modified Organisms defines an organism as genetically modified: "if its genetic material has been changed in a way that does not occur under natural conditions through cross-breeding or natural recombination" (EU, 2001, Art.2).

Figure 1: Laboratory experimentation with new GM crop varieties, Swaminathan Research Foundation, Chennai (source: author, 2013)

With the discovery of the DNA double helix structure in 1953, which described the basic genetic structure of most living organisms, new strands of the life sciences emerged, such as molecular biology and genomics. This development coincided with the dramatic social and economic shift advanced capitalist economies underwent from industrial manufacturing to post-industrial knowledge-based economies, in which the biosciences gained particular importance (Schurman & Munro, 2010). The quick advances in these new sciences contributed to the growth of knowledge about genetics, which not only improved scientific understanding of living organisms, but also made possible the technological intervention into their molecular structure through editing and rewriting. Particularly the development of gene-slicing technique by biochemists Herbert Boyer and Paul Berg, and professor of medicine Stanley Cohen in 1973 was a path-breaking development. It allowed transferring DNA pieces, whole genes or longer stretches of DNA, from one organism to another across species barriers. The technique enables cutting strains of DNA, sticking them together, and introducing them into other organisms from a different species or kingdom with which the source organism would not breed in nature – recombinant DNA (rDNA) research and transgenic technology were born.[4] The gene-splicing technique allowed introducing new traits into plants that did not occur naturally in the species, but could be taken from other organisms, for instance bacteria, to insert them with traits such as tolerance to chemical treatments and resistance to pests. Genetic modification happens in the laboratory, where from successfully transformed cell cultures first plants are grown (see figure 1, above; and figure 2, below) which then get selected based on phenotypical analysis and gene sequencing to reproduce the plants with the desired trait in the greenhouse. These techno-scientific developments led to further capital investments in molecular biology research. This resulted in the development of an integrated life sciences industry throughout the 1980s and 1990s, particularly in the United States, which formed the seedbed for agricultural biotechnology (Schurman & Munro, 2010).Already in the 1970s, when transgenic research was still confined to the laboratory, controversy arose as to the potential biohazards of these newly developed techniques. While some molecular biologist called for a voluntary moratorium on certain experiments with rDNA (Berg et al., 1974), several scientific conferences were held in the United States to discuss how to proceed with research on GMOs (e.g. the Asilomar Conferences, see Berg et al., 1975). These developments prompted the US National Institute of Health to issue guidelines for rDNA research in 1976 (Gisler & Kurath, 2011). Already at the time, there were concerns about risks of genetically modified bacteria, viruses, and fungi inadvertently escaping the containment of laboratories, unpredictable long-term consequences for human health and the environment, and questions about public involvement in decision-making on transgenic technology development (Straton, 1977).

[4] Genetic modification of plants is more precisely described as *transgenic* modification, which refers to the fact that plants are changed by means of inserting genes derived from another species that is usually not sexually compatible with the target organism (such as inserting a gene from bacterium into a plant). There is also cisgenic (using genes from the same species) and subgenic (where genes are silenced but no other genes are inserted) modification techniques. Transgenic modification however is the most common technique used, and currently all commercialised GM crops are based on transgenic insertion. I therefore use the terms GM crops and transgenic seed technology interchangeably.

Nevertheless, it took many years and huge investments by large transnational corporations (TNCs) to come up with marketable GM seed technology to be used in open fields.

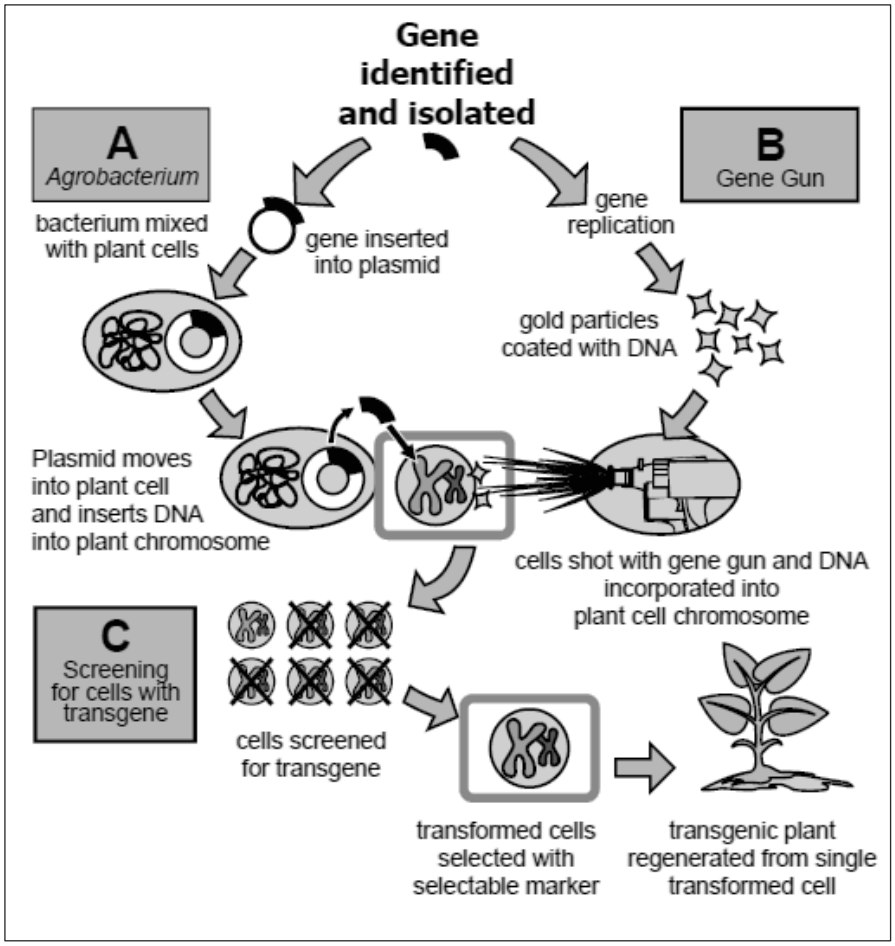

Figure 2: Transgenic insertion of gene into host plant cells, Indian government information leaflet (CEE 2010b, p.8)

The first transgenic crop seeds were commercialised in 1996, when Monsanto Corporation gained market approval for three insect-resistant Bt-crops in the United States. Since then, industry- sponsored sources suggest that transgenic seed technology has been a great success. For instance, the International Service for the Acquisition of Agri-Biotech Applications (ISAAA) publishes annual reports on adoption rates of transgenic crops amongst farmers all over the world. These reports claim more than 18 million small and large farmers in up to 30 industrial and developing countries enjoy multiple agronomic, environmental, economic, health, and social benefits of transgenic soybean, maize, cotton, canola, alfalfa, sugar beet, papaya, and others (e.g. James, 2016). Civil society organisations critical of the optimism of such reports point to the fact that there are primarily only four commercial transgenic crops:

maize, soy, cotton, and canola; and these are modified with one or both of just two traits: herbicide-tolerance and insect-resistance (CBAN, 2015).

Herbicide-tolerance (HT) traits are thought to make field-management less work and carbon intensive since weeding through ploughing is replaced by herbicide sprays which affect weeds, but not the transgenic HT crops.[5] Insect-resistant (IR) traits are induced into plants with transgenes from the soil bacterium *Bacillus thuringiensis* (Bt). This modification is thought to reduce the need for pesticide applications since IR crops produce their own, pest-specific pesticides. These two traits and four crops account for 99 per cent of the globally commercially grown GM crops in the last two decades, and only ten countries account for the overall majority of acreage under GM crop cultivation, (CBAN, 2015; James, 2016, see also table 1 below).[6] Indeed, herbicide-tolerance has been the most widespread cultivated GM trait in soy, maize, cotton, canola, sugar beet, and alfalfa. Recently, an increasing percentage of GM crops combines several traits for herbicide-tolerance and insect-resistance (so-called stacked traits) mostly in GM cotton, soy, and maize (James, 2016, pp. 93-94, see also table 1 and figure 3, below).[7]

Table 1: Global area of GM crops (2015/16) by crop, in million hectares (James, 2016, p.90)

Crops	2015	%	2016	%	+/-	%
Soybean	92.1	51	91.4	50	-0.7	-1.0
Maize	53.6	30	60.6	33	+7.0	+13
Cotton	24.0	13	22.3	12	-1.7	-7.0
Canola	8.5	5	8.6	5	+0.1	+1.0
Alfalfa	1.0	<1	1.2	<1	+0.2	+20.0
Sugar beet	0.5	<1	0.5	<1	0	0
Papaya	<1	<1	<1	<1	<1	<1
Others	<1	<1	<1	<1	<1	<1
Total	**179.7**	**100**	**185.1**	**100**	**+5.4**	**+3.0**

Also, while producers of transgenic seeds continue to make promises about additional GM crop traits other than HT and IR, NGOs such as Greenpeace suggest that after more than 20 years of commercialisation, GM crop research has failed to deliver such innovative traits

[5] In developing countries, weeding is usually done manually. The rationale to use HT GM crops accordingly is to reduce labour costs; chapter three will provide more information on how HT and IR transgenic insertions are understood to be working in the field by the various actors in the debate.

[6] Kalamkar (2013) notes that the US, Canada, and Argentina together account for almost two thirds of total GM crops acreage in the world, while GM crop acreage is limited compared to conventional non-GM crops in most other countries. A recent civil society report lists the US (40 per cent), Brazil (23 per cent), Argentina (13 per cent), and India and Canada (each 6 per cent) accounting for 88 per cent of total global GM crop cultivation (CBAN, 2015).

[7] An example is the GM maize SmartStax™ which comprises eight IR and HT gene insertions. A recent version of a popular Bt-cotton variety (Bolgard II™) sold in India also has stacked traits: it contains two genes (Cry2Ab and Cry1Ac) conferring insect resistance, instead of only one (such as with Bolgard I™).

(Greenpeace, 2015).[8] In Europe, the first and only transgenic crop to be approved for cultivation is the insect-resistant Bt-maize MON810 by Monsanto Corporation in 1998. MON810 was reauthorized for cultivation by the European Food Safety Authority (EFSA) in 2009. Based on a safeguard clause in EU regulation however, 19 out of 28 EU member states (amongst them Austria, Bulgaria, Croatia, Cyprus, Denmark, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, as well as Wales, Scotland, and Northern Ireland) had prohibited the cultivation of this transgenic crop on their territories by 2016.[9] In 2013, only three years after its initial approval, the General Court of the EU withdrew the only other GM crop cultivation authorisation for BASF's Amflora potato.[10] Moreover, due to widespread opposition to GM crop technology and the slow regulatory process in the EU, major GM seed producer Monsanto Corporation withdrew all its pending cultivation approval applications in 2013 (Hope, 2013; Midgley, 2013).

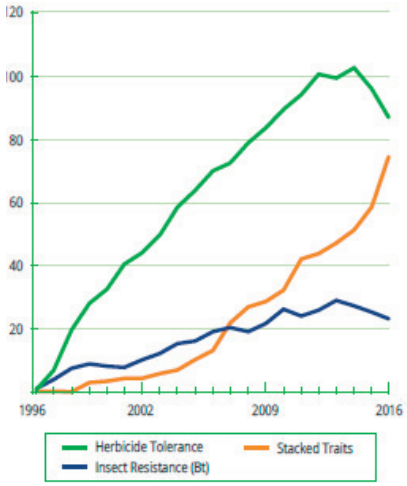

Figure 3: Global area of GM crops (1996-2016), by trait, in million hectares (source, James, 2016, p.93)

[8] A notable exception are small-scale cultivations of virus-resistant GM Papaya and Squash, on approximately 1000 hectares each in the US in 2016. In the US, where most GM crops have been approved by regulatory authorities, there are also GM variants of (number of events in parentheses): apple (3), chicory (3), flax (1), melon (2), plum (1), potato (43), rice (3), rose (2), sugar beet (3), tobacco (1), tomato (8), and wheat (1); but all these are grown in negligible quantities as compared to 20 canola, 23 cotton, 43 maize, and 24 soybean GM traits (James, 2016, pp. 8-15).

[9] After authorisation by the EU authorities, EU member states can restrict the cultivation of a GMO on their territory in reference to Art.23 of Directive 2001/18/EC (safeguard clause) or Art.34 of Regulation (EC) 1829/2003 (emergency measures) – such restrictions must be justified on scientific grounds that show risks to human health and/or the environment (EU, 2001, 2003). Austria and Greece also prohibit the import of Mon810. Since 2015, Directive (EU) 2015/412 gives the member states more flexibility to restrict the cultivation of a crop based on environmental or agricultural policy objectives (EC, 2015). However, in 2017, the European Court of Justice ruled Italy's ban of MON810 unjustified (ECJ, 2017), which is likely to have implications for the cultivation ban in other member states, too (DieZeit, 2017).

[10] BASF's Amflora potato was modified to produce a higher content in starch for industrial use.

In 2002, insect-resistant Bt-cotton was the first transgenic crop to be authorised for cultivation in India, though the technology had been grown illegally in the country for a couple of years, i.e. outside the purview of biosafety and bio-property institutions (Herring, 2007). In 2010, the introduction of India's first transgenic food crop, insect-resistant Bt-brinjal, was halted by the imposition of a moratorium by the Ministry of Environment and Forests, after extensive public consultations throughout the country (Ramesh, 2010). Transgenic crop producers intensified their efforts to gain cultivation approvals on developing markets, such as India. Despite the failure of marketing Bt-brinjal, Indian regulatory authorities intend to clear GM mustard for cultivation in 2017-18 (Mittal, 2017). At the same time, a plethora of other GM crops are in the pipeline for India: cauliflower, cotton, rice, tomato, groundnut, cabbage, potato, sorghum, okra, brinjal, wheat, watermelon, papaya, sugarcane, and rubber tree (CoA, 2012, pp. 398-407). As becomes clear from this overview, the development and spread of GM crops since the invention of transgenic seed technology has been slow, particularly in India and Europe. Despite regulatory hurdles, analysists of the debate frequently invoke public opposition and controversy as decisive reasons for the slow adoption of the technology. So, what are the issues of the public debate about GM crops?

Proponents of transgenic seed technology argue that it will boost yield, reduce input costs (e.g. of pesticides and labour), provide a solution to pest problems, as well as deliver other desirable crop traits in the future such as improved nutritional composition, drought and salinity tolerance, and resistance to plant disease from viruses, fungi, and bacteria. This shall solve a range of problems, from agricultural productivity and environmental issues, to malnutrition and poverty. The opponents of GM crops in contrast argue that the technology bears many risks: to human and animal health, the environment, socio-economic stability, and the integrity of agricultural systems and markets; and that there is too much scientific uncertainty about these risks to market the technology. Previous studies of the GM crops debate have shown that the risk frame is not sufficient to understand the opposition to GM crops (Wynne, 2005). Indeed, its opponents criticises GM crops within the wider context of agrarian change, agricultural systems, and globalisation (Brooks, 2005; Heller & Escobar, 2003; Jackson, 2010). As several reports, such as the United Nation's (UN) International Assessment of Agricultural Science and Technology for Development (IAASTD), have shown, GM crops are not the silver bullet to solve the problems of contemporary and future agriculture. Instead, agro-ecological approaches might be far more sustainable and efficient in the long run, although it is unclear whether GM crops have been unsuccessful because of policy decisions, their history of commercialisation, or because the technology itself is inappropriate (IAASTD, 2009; UNCTAD, 2013).

Since this book is about the development of GM crops and the role of the public in the debate about this technology, I will look closely at the actors, arguments, and arenas of the controversy in the following chapters. For I want to explain the role of publics in the GM crops controversy, I not only studied the meanings people attach to the technology, its risks and benefits, as well as the wider issues being raised in the debate, but I also paid close attention to how publics are constructed in the debate by various actors. Let me, as a next step, explain with which theoretical frame I approach the analysis of science, technology, and society.

A Constructivist Approach

My theoretical point of departure is constructivist Science and Technology Studies (STS), more specifically the theory of the Social Construction of Technology (SCOT) developed by Bijker and others (Bijker, Hughes, & Pinch, 1987; Bijker & Law, 1992; Kline & Pinch, 1996; Pinch & Bijker, 1984b, 1987). Constructivist technology studies originated from the opposition to the notion of 'technological determinism' which was the standard view of innovation and history of technology until the 1980s. Technological determinism states that technology (1) develops as an autonomous force with intrinsic properties, and that it (2) shapes society through economic and social impacts, i.e. that technological development determines social change (Bijker, 1995c; see also Bimber, 1990; M. R. Smith & Marx, 1995; for more explanation of technological determinism, its empirical relevance, and critique, see Wyatt, 2008).[11] Instead, constructivist STS explains the relationship between science, technology, and society differently. It suggests an integrated study of these domains and regards scientific facts and technological artefacts as social constructs (Sismondo, 2004). Inspired by the insight from the sociology of scientific knowledge (SSK) that science and its product, knowledge, are socially constructed (Collins, 1983; Shapin & Schaffer, 1985), the social shaping of technology perspective suggests "that technology does not follow its own momentum, nor a rational, goal-directed, problem-solving path, but is instead shaped by social factors" (Bijker, 2006b, p. 684).[12] A constructivist view regards technology as equally socially constructed; and as threefold: technology is (1) sets of physical objects or artefacts, (2) human activities in the sense of designing, using, and handling such artefacts, and (3) knowledge, i.e. what people know about and do with technology (Bijker, 2006b; MacKenzie & Wajcman, 1999).

The SCOT model explains how technology can mean different things to different groups of people in different contexts; it suggests to open "the black box" of historical and contemporary technology (Bijker et al., 1987). Institutions, organisations, organised and unorganised groups of individuals assign shared sets of meanings to technology. These groups differ

[11] Bimber explains there are at least three interpretations of technological determinism: normative (when the norms of technology such as efficiency and productivity are removed from political discourse about values), unintended consequences (unanticipated social outcomes of technological development beyond human control), and nomological (technology rests on laws of nature and therefore exercises causal influence on social practice). He regards only the latter as truly deterministic because it makes the strongest claims about social change directly tied to an "incremental logic of technology and its parent, science" (Bimber, 1995, p. 89). The idea of technological determinism, as intellectually outdated as it might appear, is empirically still highly relevant, in particular in the debates about technological risks, such as the GM crops controversy (cf. chapter three; see also Wyatt, 2008).

[12] SSK explains how scientific ideas, theories, and experiments are the outcome of social processes within the scientific community: different scientists interpret scientific findings differently – there is interpretative flexibility of scientific facts. Bijker and Pinch applied this idea to technology. Their SCOT model is also rooted in the symbolic interactionism of the Chicago School of Sociology. Symbolic interactionism goes back to the pragmatist philosophy of Dewey, Pierce, and Mead. It suggests that human social conduct is symbolic, i.e. the ability to understand and interpret each other depends on our use of language and symbols in communication; and our interpretation of these symbols and of the action of others. Symbolic interactionism states that: individuals act based on meanings objects have for them; interaction takes place in socio-cultural contexts that define situations; meanings emerge from interactions with others in society; and meanings are subject to a continuous interpretative process (Blumer, 1969).

based on their knowledge, power, and the position within social structure they are embedded in. The latter in turn privileges certain interpretations over others because of culture, hierarchy, laws, policies, power relations, and other factors that make up the wider socio-cultural background of any technological system. So-called 'relevant social groups' share the same set of meanings they ascribe to a technology, such as problem definitions and suggested solutions. This means the interaction between different relevant social groups shows that the same technology can have different meanings. For instance, transgenic crops can be interpreted by some social groups as solving problems of low productivity, whereas others do not agree to such a problem definition. To them, GM crops might aggravate issues of inequality because transgenic seeds are much more expensive than conventional seed varieties. The same reasoning goes for the risks of GM crops: while its proponents argue the risks of this technology to be known and manageable, others regard such risks as uncertain and potentially endangering ecology and livelihood, for example when the pollen from GM crops contaminates organic non-GM plants in neighbouring agricultural fields. Different groups ascribe different meanings to the same seed technology, i.e. there is more than one interpretation of what GM crops are.

Accordingly, SCOT suggests that technologies are subject to a culturally framed process of construction and interpretation – the interpretative flexibility of technology. In a technological controversy, interpretative flexibility means that the various meanings ascribed to a technology are subject to "growing and diminishing degrees of stabilisation" (Pinch & Bijker, 1984b, p. 416). As long as the meanings ascribed to technology by different relevant social groups differ significantly in a technological controversy, the technology's meaning will not stabilise and the controversy will not reach closure. Not only science and technology are socially constructed, but such notions linked to it, such as expertise, risk, and democratic decision-making on these issues are socially constructed too. This applies in particular to public debates about technological risks (Bijker, 1995b; Bijker et al., 2009; Fischer, 1990; Jasanoff, 1990; Renn, 2001; Wynne, 1996).

The aim of this dissertation is then to analyse the interpretative flexibility of GM crops and their risks, and the various publics involved in the current debate about transgenic crops. My aim is not to declare GM crops a success or failure, but to study how actors come to reach their judgements on this technology. In that sense, I follow the suggestion of SCOT to apply the principle of symmetry developed in SSK, which insists on using sociological explanations for successful as well as unsuccessful technological innovations symmetrically (Bijker et al., 1987). I am going to analyse the development of GM crops in India and Europe and the role of publics in three empirical chapters. Each of these chapters turns to a different arena of the GM crops controversy: chapter two looks at how scientific expertise is constructed in GM crops risk assessment, chapter three studies the various issues actors connect to the risks and benefits of GM crops in their ideas about our sociotechnical future with(out) GM crops, and chapter four looks at the construction of public participation in policy-making on transgenic crop technology in the Indian case of Bt-brinjal. What connects the chapters theoretically is the social constructivist perspective of technology and of publics. Not only transgenic crops get assigned different meanings by different social groups. I suggest that 'publics' are subject to such an interpretative flexibility too.

As some have argued, social constructivism needs to engage more closely with the concepts from democratic theory if it wants to make convincing arguments about the democratisation of science and technology (Brown, 2015; de Vries, 2007; Latour, 2007; Thorpe, 2008). Social constructivist STS has been subject to the criticism for employing vague conceptions of democracy, including weak theorising on such concepts as 'publics', and for lacking engaging with the normative dimension of such work (Brown, 2007, 2009, 2015; Durant, 2011; Giere, 1993; Radder, 1996; Russell, 1986; Winner, 1993).[13] However, in the last two decades constructivist STS has produced work that explicitly addressed such issues as the societal impact of technology, the role of technology in democracy, questions of social justice, livelihood, vulnerability, gender issues, and the politics of risk (e.g. Bijker, 1995c; Bijker, 1999, 2003, 2007, 2017; Bijker et al., 2009; Bijker & Bijsterveld, 2000; Bucchi & Neresini, 2008; Hamlett, 2003; Hommels, 2005; Hommels et al., 2014; T. P. Hughes, 1998; Marres, 2005; Wajcman, 1995, 2004, 2005; Wynne, 1995). In particular the 'third wave debate' on the role of experts in democracy between Harry Collins and Robert Evans on the one hand (Collins & Evans, 2003), and Sheila Jasanoff (Jasanoff, 2003) and Brian Wynne (Wynne, 2003) on the other, fruitfully put the underlying conceptions of democracy in STS research on the table (Durant, 2008, 2011; Wynne, 2008). More recently, STS has turned towards studying publics and politics more explicitly, to which I will turn in the next section.

Publics & Politics

The GM crops debate has been subject to a plethora of social scientific inquiry, none of which has focused explicitly on the concept of publics. For instance, Gottweis (1998) has studied the discursive framing of biotechnology policies and public debates from the 1980s to the early 1990s. He shows how official policy narratives about biotechnology framed GM crops as an opportunity to boost Europe's competitiveness in the agro-food industries. At the same time, ecological counter narratives were transformed and incorporated into institutionalised risk assessment and regulatory practices. Other studies have compared the policy systems of the United States (US), the United Kingdom (UK), and the European Union (EU). Jasanoff (2005a) for instance compared those countries' biotechnology policies, regulatory processes, and heterogeneous cultural contexts to explain the differences in national science policy practices. Also, David Toke (2004) studied the links between cultural attitudes in the US, UK, and EU to explain jurisdictional differences in scientific risk assessment to show how institutional path dependency has made policy frameworks insensitive to public concerns about GM crops. Others took the GM crops controversy as a lens through which to study the EU's democratic deficit: Levidow and Carr (2010) show how EU institutions promoted agricultural biotechnology not only as a natural, but also social order, which in turn became a legitimacy problem for representative democracy and its public accountability.

[13] The SCOT model has been criticised in particular for an alleged normative relativism (Russell, 1986; Winner, 1993). However, STS researchers can help to make the normative dimensions of techno-scientific controversies explicit through their analysis. As Bijker argues, scholarly work does not necessarily restrict itself to distanced theoretical and conceptual analysis, but can also combine academic agendas with political and societal engagement to actively shape the worlds of scholarly inquiry (Bijker, 2003, 2017).

Others have focused on how civil society opposition to GM crop technology has shaped stringent regulatory criteria based on the precautionary principle in Europe, leading to trade policy conflicts between the EU and the US (Bernauer, 2003). Rachel Schurman and William Munro (2010) looked at how the anti-biotech movement managed to transform transgenic crops into a highly contentious social problem and how this redefinition had a subtle and sometimes profound impact on the industry's attempt to market their products. Abby Kinchy (2012) investigated the impact of 'genes out of place' on farmers and rural communities in Canada and Mexico. She shows how the scientisation of political considerations about GM crops routinely excludes less powerful actors and marginalises their input into regulatory debates.

These studies provide a clue as to the relevant social groups of the GM crops debate, and to the mutual shaping of technological development and democratic political culture. Though they leave out two things: (1) they focus exclusively on Western contexts (the global North), and (2) they do not explain *how* the publics they implicitly refer to come into being; i.e. how publics are *constructed* by various actors in the debate remains unclear. Also, most of these studies focus on institutionalised forms of political contestation (science policies, legal frameworks, and institutional relations) while they leave out other arenas in which technological controversies take place.[14] As Jasanoff notes for the case of biotechnology , we "need new theoretical resources for bringing the missing public back into studies of science and democracy" (Jasanoff, 2005a, p. 248). I want to take these issues as a starting point to discuss the crucial concept of 'publics'. In doing so, I draw on three bodies of literature from political science, anthropology, and STS.[15]

The public' is not a neutral, descriptive concept, but a term with cultural, historical, and political ramifications. The concept has its normative foundation in classical liberalism (Gilmartin, 2015; Scott & Ingram, 2015). It is not my intention to review the extensive political science literature on liberalism here, but to briefly review Jürgen Habermas' theory of the public sphere, which at least since the deliberative turn in democratic theory has become a cornerstone for studying the role of publics in contemporary democracy, not only in political science literature (Dryzek, 2000; Fraser, 1990; Hamlett, 2003) but also in anthropology (Cody, 2011). In *The Structural Transformation of the Public Sphere* (1989, original 1962), Habermas locates the rise of a bourgeois public sphere in seventeenth and eighteenth century Europe, where private property owners actively engaged in a democratic discursive space to mediate between society and state to keep the latter in check. The paradigmatic sites of the public sphere were print media and coffee houses as places for public deliberation. Its proper functioning rested on the premise that such deliberation was based on reason and commu-

[14] An exception here is Jasanoff's (2005a) study of biotechnology policies in the US, UK, Germany, and the EU in which she shows how public engagement in policy-making on biotechnology gets shaped by national culture of deliberation, participation, and representation (civic epistemologies). Jasanoff argues that technological and political development shaped each other to the extent of challenging liberal democracy, i.e. in the case of the EU, democratic control was set aside in favour of technological development which created problems for democratic accountability.

[15] This review by no means claims to be exhaustive and representative of all scholarly work in these domains. I rather chose the literature cited here based on its usefulness for understanding and analysing my empirical material. I will explicate sources and methods in more detail in the following section.

nication free of coercion to allow all citizens independent of class and social status to participate in the definition of the common good.[16] Due to processes of commodification, competition, monopolisation, and the rise of mass culture in a capitalist economy however, the public sphere has since degenerated "from a public critically reflecting on its culture to one that merely consumes it" (ibid., p.177). Another important work on publics is Benedict Anderson's *Imagined Communities* (1983) which focuses not on the emergence of publics as such, but on the formation of national communities as social constructs. Anderson's thesis is important here because it explains the mechanisms for forming a common identity amongst people who do not know each other. Standardisation of language and the capitalist dissemination of the products of printing technology were key in creating a sense of belonging to a group of people as a *political subject*, the nation.

Both Habermas' and Anderson's works point to the centrality of print mediated communication that allows for the imagination of political communities as abstract collective entities bound together by the means of common discourse. Anthropologist Francis Cody explains that their works point to the importance of publicity, i.e. the mass circulation of text that allows for such a self-recursive mediation of collective political subjectivity, so "an abstract assembly of strangers could understand themselves to be acting collectively" (2011, p. 39). Yet, Habermas' theory of an elitist public sphere is not applicable to current conditions of globalised capitalist production.; and Anderson's idea of national communities does not serve to explain how public will-formation occurs within a nation state, where relevant social groups compete to shape decision-making on matters pertaining to the whole political community. Also, both works, in assuming the public as a *singularity*, can hardly serve as a universalising blueprint for the construction of a *multiplicity* of contemporary publics, particularly if we look at places like India, where the experience of modernity is different from the cultural, historical, and political contingencies of Western Europe (Appadurai, 1996; Kaviraj, 2011).

Nancy Fraser draws attention to the importance of multiple subaltern counter-publics that emerge in response to dominant forms of publicity. These counter-publics are made of members of subordinate social groups who engage in "parallel discursive arenas" (1990, p. 67) in which they construct oppositional identities and voice alternative interpretations and thus widen the discursive space. Although oppositional discourses are habitually excluded from speaking for 'the public' at large, they equally aim for publicity, though it remains unclear whether to locate such counter-publics through the content of their discourse, their social position, space of articulation, or cultural style (Cody, 2011).[17] The increasing scholarly interest in the formation of publics in South Asia provides us with an answer to this problem.

A range of scholars doing empirical work in India have argued that colonial rule imposed the idea of 'civil society' as part of Western liberal thought on the subcontinent's political

[16] In his later work, Habermas made substantial adaptations to his theory. Although the days of the bourgeois public sphere have long passed, his conceptions of discourse ethics and communicative action still serve as theoretical foundation for attempts to institutionalise the norms of deliberative democracy, e.g. through participatory policy-making today (Habermas, 1970, 1986, 1996b; see also, for instance Hamlett, 2003). In chapter four on the public consultations on Bt-brinjal, I will return to this issue.

[17] Counter-publics by themselves are not necessarily expanding the democratic credentials of discourses. Rather, such publics may even practice their own modes of exclusion and marginalization, and they make even take anti-democratic and anti-egalitarian stances (Fraser, 1990).

history. Nevertheless, civil society as a notion of publics defies the actually existing forms of collective political subjectivity in postcolonial states (Chakrabarty, 2000; Kaviraj, 2011; Scott & Ingram, 2015). Partha Chatterjee's distinction between civil and political society provides a more nuanced perspective based on the study of postcolonial India (Chatterjee, 2004, 2011): Civil society refers to the institutions placed between private individuals and the sovereign nation state. Its members enjoy full citizenship rights, e.g. in discussing techno-scientific and knowledge production issues with state agencies and actors involved in the formal economy. However, civil society does not represent the entirety of political subjects. Chatterjee theorises 'political society' to be constituted by those citizens who "are only tenuously, and even ambiguously and contextually, rights-bearing citizens in the sense imagined by the constitution" (Chatterjee, 2004, p. 38). These members of the population, such as rural migrant labourers, slum dwellers, street vendors, rag pickers, or sex workers are not regarded as members of civil society. Although members of political society are within the state's territorial jurisdiction, their political relationship to the state is different. These subjects "make their own associations and movements to negotiate with the state" (Varughese, 2012, p. 37), i.e. they engage in non-elite forms of mobilisation and participation, and their activities are "often illegal and contrary to good civic behaviour" (Chatterjee, 2004, p. 40), in particular if their livelihoods are at stake. Members of political society neither can claim full legal settlement of issues pertaining to them, nor are they granted juridical protection and legality. Rather, the state manages this part of the population to reduce potential unruliness and latent conflict. Political society stands therefore in stark contrast to civil society in the public sphere.

Based on empirical case studies from India and drawing on Chatterjee, Shiju Sam Varughese (2012) provides a political-philosophical analysis to understand how lay people in postcolonial contexts engage with techno-science and the state beyond the liberal public sphere. Varughese explains that civil and political society as distinct spheres of engagement produce different kinds of publics. To Varughese, publics are a heterogeneous political category with stratified capacities for social and political agency. He differentiates between scientific citizen publics, quasi- publics, and non-publics. Scientific citizen publics enjoy full citizenship rights and engage in risk discourses through institutionalized forms of deliberation. Being part of civil society, these publics are therefore by definition an "elite domain of legitimate participation in politics" (Varughese, 2012, p. 245). Scientific citizen publics deliberate in public spheres and engage in institutional mechanisms with the state about techno-scientific projects.

This constitutes a problem for the members of political society, who do not have full citizenship rights or the capacity to exercise them. Their engagement is accordingly different: they exercise alternative modes of negotiation and confrontation with the state and economic actors. For instance in the 1990s, India saw demonstrations against nuclear reactor construction projects in Kudankulam (Tamil Nadu) and Jaitapur (Maharashtra) by village communities, blockades and sabotage of bauxite mining projects in the Niyamgiri hills of Odisha[18] by tribal

[18] In 2011, Indian Parliament adapted the Constitution (113th) Amendment Bill to rename the state of "Orissa" into "Odisha". Since at the time of India's colonization, the British had renamed Indian state and cities, such renaming is widely regarded as part of the process of decolonisation. Other states and cities have also been renamed for the same reason, such as Kerala (formerly Travancore-Cochin), Tamil Nadu (formerly

communities, and riots against Kentucky Fried Chicken restaurants in Karnataka's capital Bangalore by socialist farmers' groups. Such forms of protest and direct action have resulted in increased efforts of the Indian state and its security forces to police and contain farmer assemblies (see figure 4 below).

Figure 4: Heavily policed assembly of Karnataka Rajya Raitha Sangha (KRRS) farmers' union in Bangalore (source: author, 2012)

These events are situations in which the paralegal acts from political society enter the stage of politics through their potential unruliness. Varughese labels these collective subjects "quasi-publics". Their claims and demands usually do not gain recognition as legitimate, i.e. their legal settlement is deferred unless they transpire the discourse of scientific citizen publics with the help of media and judicial agents. When it comes to techno-scientific development, the risk discourse civil society engages in can only insufficiently capture political society's concerns with livelihood issues intrinsically linked to those techno-scientific risks.[19]

Finally, there is a third domain of those parts of the population who neither enjoy full citizenship rights of scientific citizen publics, nor the paralegal existence of quasi-publics.

Madras State), Karnataka (formerly Mysore State), Mumbai (formerly Bombay), Chennai (formerly Madras), Kolkata (formerly Calcutta), etc. (ToI, 2011).

[19] "Many techno-scientific issues which raise serious alarm in civil society may be ignored or differently utilized as a livelihood resource by the quasi-publics based on how these issues and risks may support their daily struggle for existence" (Varughese, 2012, p. 248).

Not being considered part of political society, these "non-publics" have an extra-legal status in which they experience violence and death as guinea-pigs and victims of techno-scientific projects. Such non-publics nevertheless function as a reference point for the activation of both quasi-publics and scientific citizen publics. For instance, Vedwan (2007) shows how the Indian environmental NGO Environmental Support Group (ESG) successfully drew wider public attention to the issue of pesticide pollution of groundwater resources by redefining the subject of their campaigning strategy. ESG reframed pesticide pollution as an issue of interest to the consumerist middle class by including goods such as Coca Cola and Pepsi sodas in their campaigning efforts. By widening their construction of publics relevant to the problem of pesticide pollution beyond farming communities affected by the environmental consequences of excessive pesticides use, ESG constructed environmental issues as sites of consumption. The NGO thus successfully enrolled consumer publics in their attempt to draw greater attention to environmental concerns about pesticide technology (Vedwan, 2007). Varughese himself also offers another example about the widespread application of the pesticide Endosulfan in Keralan Cashew plantations in the 1970s that led to severe health problems such as cancer, miscarriages, infant mortality and physical deformation, hormonal disturbances, and a range of unlabelled syndromes in rural communities. While first political society and later civil society produced the publics to legitimately establish Endosulfan as the cause of the health effects to effectively engage with the Indian state for a ban of the pesticide in 2011, the victims were never compensated.[20] What is important here is that although non-publics cannot legitimately participate in deliberations with the state-techno-science duo, they are "constantly being referred to when civil society and political society get activated" (Varughese, 2012, p. 251).[21] The anthropologist Ritty Lukose draws a similar distinction between political publics and citizen publics, the former being rooted in an anti-colonial legacy, the latter linking to ideas about market-driven efficiency and the freedom to consume (Lukose, 2005). Finally, Varughese argues that although the focus on civil society keeps them often out of view, non-publics and quasi-publics are present in Western countries as well. Yet, how are publics constructed in debates about scientific and technological development?

Recent STS scholarship, particularly the work of Noortje Marres, on publics draws on an object-oriented notion of politics to show that the articulation of contested entities lies at the heart of techno-scientific controversies (Barry, 2001; Bennett, 2010; Marres, 2005, 2007, 2010; Wynne, 2005). From this derives a distinctive perspective on public involvement in political contestations about techno-scientific issues which is based on the pragmatist philosophy that originated in public sphere theories of the 1920s. Political philosophers at the time were in deep disagreement over the contours of democratic politics and the role of publics therein: Walter Lippmann (1927 (2002)) for instance rendered the public a phantom and Carl Schmitt

[20] When the Stockholm Convention on Persistent Pollutants banned Endosulfan in 2011, India's Supreme Court prohibited the application, but not the production of the pesticide for export. The Indian victims of Endosulfan however remained at the threshold of political society. Instead of receiving legal recognition and compensation, their bodies were exposed to biomedical observation and intervention to study the effects of Endosulfan on biological systems and to classify the unknown health effects triggered by the pesticide (see Vedwan, 2007).

[21] Non-publics may include altered life forms or future generations who are or will be affected by techno-science but who cannot be legitimately included in decision-making processes. Chapter three will take this idea further.

(1923 (1985)), in his disregard for democratic politics, dismissed the idea of the public as an empty shell reduced to a formality in parliamentary democracy. The American pragmatist John Dewey in contrast argued for the importance of publics for democracy. Dewey's pragmatic approach to publics and politics emphasises problem solving: People's shared experience of harm over time becomes a problem upon which collective action (that deviates from habitual ways of political engagement) of the affected actors follows. Publics emerge out of common action in response to a problem that is beyond their control and not taken care of (Dewey, 1927 (1991)). This means those affected by a common problem and who interconnect through their activities in response to it constitute a public. A public therefore "consists of all those who are affected by the indirect consequences of transactions to such an extent that it is deemed necessary to have those consequences systematically cared for" (Dewey, 1927 (1998), p. 285). From this view, publics as collective political subjects emerge from the issues around techno-science that negatively affect them.

Noortje Marres suggests that Dewey's philosophy offers a distinctive perspective on the democratisation of science and technology: publics are concerned about the articulation of issues, so-called issue-based publics. She suggests, along with others, to study such publics as the association of actors that turn a given problem, or issue, into an object of politics (de Vries, 2007; Marres, 2005). Publics form around issues; they can be discursive and material constructions, while they are always performed and mediated (Bennett, 2010; Le Dantec & Di Salvo, 2013; Marres, 2007; Mukherjee, 2016).[22] Accordingly, this perspective regards democratic processes "as practices of issue articulation" (Marres, 2007, p. 761). Since techno-scientific controversies are important sites for the enactment of democracy (Bijker, 1995a; Sclove, 1995), we should therefore focus on how such issues are defined, and what sort of associations and relations between different actors emerge in the debate, when studying the democratisation of science and technology. Since technology is subject to interpretative flexibility, a techno-scientific controversy is most likely host to multiple problems and therefore multiple issue-based publics. It therefore makes sense to regard the publics of the GM crops debates in India and Europe not as a static, off the shelve conceptions. Instead, by means of my empirical investigation, I will show that publics are contingent and temporary, continuously evolving, and therefore multiple and elusive.

So far, I have emphasised my understanding of publics as the formation of collective political agency. The capacity for publics to know themselves depends crucially on common discourse, means of representation, mass mediation, and self-abstraction in order to create a sense of belonging of people who do not know each other, but who are affected by a common problem. At the same time, publics are not only self-referential, but they also aim to address audiences. Such publics are not bound to nation states necessarily. Instead, they take local, national, and transnational forms mediated through cultural expressions (Cody, 2011; Fraser, 2007; Orsini, 1999). The conceptual refinements offered by postcolonial studies and STS add the important qualification that the notion of publics always carries normative implications about conceptions of democratic politics, the role of citizens, as well as attempts

[22] In a recent article on the campaign actions of survivors of the Bhopal gas accident in 1984, Mukherjee suggests that the issue-based controversy about long-term toxicity of the chemicals released from the industrial disaster, non-humans in the form of toxic chemicals and soil samples became part of the survivor's construction of a political collective, a "chemical public"(Mukherjee, 2016).

to democratise decision-making on techno-scientific issues. In asking about the role of publics in the current controversy about GM crops in India and Europe, this book empirically maps the construction of transgenic crops and issue-based publics involved in the debate about this technology. Let me explain how, i.e. with which methods I studied the GM crops debate.

Sources & Method

My investigation of the GM crops controversy and its publics in India and Europe follows a qualitative research design. By studying the arguments and arenas of the controversy, I seek to provide an in-depth contextualised understanding of the lived social experience of the actors in the controversy, the meanings they attach to GM crops and their risks, and how publics are constructed in the debate. I followed an ethnographic approach towards studying the controversy about transgenic crops to understand the interpretative flexibility of GM crop technology and the construction of publics. Ethnographic research comprises of the use of qualitative research methods, including observation during field visits, conducting interviews, and listening to what people say in the places where they act and live (Hess, 2001; Spradley, 1980; Walsh, 2004). Although combining qualitative interviews with field site observation is an ethnographic method, I did not conduct an anthropological or ethnographic study as prescribed by the methodological guidelines of these disciplines (cf. Ingold, 2008). Yet, my methodological strategy can best be described as a multi-sited ethnography. Let me explain next what multi-sited ethnography refers to. I will then describe how I collected and analysed my empirical data in the form of qualitative interviews, field visits, and documents.

Multi-sited ethnography

Multi-sited ethnography emerged in anthropology as an adaptation of ethnographic methods to more complex objects of study not contained to a single site of intensive investigation but which span multiple sites of observation and participation (Marcus, 1995a, 1998, 2011). This methodological strategy has been used by Jasanoff to study biotechnology policies, regulatory processes, and legal frameworks in the US, UK, Germany, and the EU (Jasanoff, 2005a); and it has been devised as an approach particularly suitable for STS researchers to contextualise the tracing of different groups and various sites that engage in or get shaped by science and technology (Hine, 2007; Krauss, 2011; Morita, 2013). Multi-sited ethnography recognises that in a globalised techno-scientific culture, the field sites for studying debates about technology are "rarely remote, rarely disconnected from the world system, and frequently part of one's own society" (Hess, 2001, p. 238). For instance, an understanding of the multi-sitedness of techno-science in a globalised world can help to explain the situatedness and mobility of scientific knowledge production across cultures (W. Anderson, 2000). Multi-sited ethnography thus departs from ethnography's conventional in-depth focus on a single site of scholarly scrutiny and focuses instead on the circulation of people, ideas, knowledge, and objects; and

on the connections, associations, and relations among different sites. Yet, it retains ethnography's approach to social science research as contextually rich and descriptively thick (Falzon, 2009).[23]

Multi-sited ethnography first developed in anthropology and the term was coined by anthropologist George E. Marcus (1995a). It was quickly picked up by such disciplines as cultural studies and STS as a way to ethnographically reconstruct both the subjective experience of people, and the systemic associations and connections that tie multiple sites of cultural production to each other (Fortun, 2009; Hine, 2007; Morita, 2013). It is based on the recognition that field sites as bounded territories are conscious constructions of the object of research. Since contemporary globalised culture is characterised by intense communication flows, and the circulation of artefacts, knowledge, and practices, studying globally circulating objects and practices in one single site only offers limited insights (cf. Appadurai, 1996; Castells, 2000). Multi-sited ethnography as a research strategy instead aims "to examine the circulation of cultural meanings, objects, and identities in diffuse time-space" (Marcus, 1995a, p. 96).

This approach prompts the researcher to *follow* these relationships and to demonstrate their interconnectedness on the basis of first-hand ethnographic research to understand and describe these connections. Multi-sited ethnography emphasises that the construction of scale is inherent to fieldwork research practice, i.e. in the definition of the object of research. Rather than prescribing a standardised methodology, it offers an open ended sensitivity for studying and understanding how different scales, e.g. spatial, temporal, structural, are connected around the object of research (Fortun, 2009). Multi-sited ethnography also takes contextualisation differently in the sense that the researcher not only investigates the context of each specific research site, but also puts into perspective the relationships between the various sites of investigation (Morita, 2013). These multiple sites can be commodity chains, production processes, or travelling technological artefacts, but equally debates, ideas, metaphors, narratives, forms of political opposition, etc. that the researcher follows. I will explain how I discern the sites of the GM crops controversy by employing the sociological concept of 'arenas' as a heuristic metaphor below when outlining the structure of this book.[24]

The GM crops debate is emblematic of the circulation amongst various sites that multi-sited ethnography scrutinises. GM crops circulate, not only as artefacts, but also as a set of ideas, as meanings of its potential benefits and risks, as imaginaries of what futures it might bring, as an artefact subject to regulatory decisions, and also in the form of the various people

[23] The idea of ethnography as 'thick description', i.e. of people's experience and behaviour and the context in which it is observed, has been coined by anthropologist Clifford Geertz (1973). Including verbatim interview accounts and other rich descriptive information of the controversy that I studied can be seen in this light.

[24] Marcus (1999) notes himself that there are obvious cases that allow constructing the object of research as multi-sited, such as tracing transnational migrant movements geographically, or following global flows of objects, capital, and expertise. However, there are also non-obvious cases, where the multi-sitedness is more difficult to establish: when relationships between different sites of activities are not clear or appear disconnected - spatially, temporally, and socially. In such cases, ethnography can meaningfully contribute to discovering and understanding the relationships between various sites. I believe that the enduring global controversy about the risk of GM crops and public involvement therein is a good case for understanding both GM crops, and its elusive publics, as multi-sited phenomena.

and institutions involved in the controversy. This became very tangible when comparing the various field sites I had visited: corporate offices in Brussels and Delhi, laboratories in Ghent and Chennai, NGO offices in Brussels and Bangalore, activist work in rural India and urban Berlin, etc. Equally, the publics of GM crops circulate, too. For instance, NGOs in Europe frequently refer to developing countries' publics to emphasise relations of dependency they associate with GM crops. Indian civil society organisations also refer to the 'European public's' scepticism towards GM crops. GM crop producers in Northern Europe and the US advertise their products as responding to the needs of small-scale farming in the Global South. These kinds of circulation become traceable in different sites that each have their own context, but which also share a common context in an era of globalised techno-science where the same technology is thought to entail the same risks and benefits to society independent of contextual contingencies.

As the GM crops controversy is polycentric, spanning different spatial, temporal, and social scales, the object of study (GM crops and their publics) is not as clearly bounded as might appear on first sight. Marcus (1995a) notes that not all sites can be studied with the same fieldwork practices, but that the intensity and quality of ethnographic investigation may vary from site to site. This is not a cheap excuse for a weak ethnographic practice, but rather to stress that the researcher needs to argue why certain sites need to be studied "thickly" and others "thinly" (Marcus, 1998, p. 21; 2011). As will become clear in the course of this book, some chapters rely more, some less on ethnographic insights, while the whole research process followed the strategy suggested by multi-sited ethnography.[25] Yet, engaging in multi-sited ethnography should not be taken as if the researcher studies all social groups involved in the GM crops debate as *one* community. Rather, multi-sited ethnography is a useful strategy to follow the globally circulating objects of the GM crops debate: the various meanings attached to the technology and its risks, as well as the multiple publics that shape the debate and emerge from it at the same time. How to follow such objects in circulation?

The interpretation and analysis of my empirical data was ongoing throughout the research process. The underlying principle of this process is characterised by a constant interaction between problem definition, data collection, data analysis, and more focused data collection. I was inspired to treating ethnographic data in such a way by what has been termed grounded theory, originally developed by Glaser and Strauss (1967).[26] Yet, this research is not grounded theory *per se* since I began my investigation of the GM crops controversy not from a point of theoretical emptiness. My approach to understanding technology starts from the theory

[25] In the most literal sense of the term, the sites I visited to study the development of GM crops and their publics in India and Europe are multiple: agricultural fields, board rooms, cafes, farmer rallies, laboratories, libraries, NGO and corporate offices, parliamentary buildings, street-level demonstrations, university campuses, etc.

[26] A central idea of grounded theory is the inductive approach to data gathering and analysis. This means to induce theory from empirical material in an ongoing interpretation to complement empirical insights with existing theoretical and conceptual work in a reciprocal fashion. Strauss' ideas were deeply influence by the pragmatist philosophical tradition of the Chicago school of sociology. Since pragmatism informed symbolic interactionism, the *spirit* of grounded theory fits well with both, the theoretical frame of constructivist STS, and the conceptual take on publics that I follow in this book. Although my research strategy was *inspired* by grounded theory, my work cannot be said to strictly follow the conventions of this approach that is mostly used in anthropology and ethnography.

of the social construction of technology (SCOT) which offers a distinctive perspective on technological controversy (Bijker, 1995c; Bijker et al., 1987; Pinch & Bijker, 1984a). However, I wanted to understand the elusive concept of the publics, and how various different publics are constructed – the research strategy of multi-sited ethnography allowed me to do exactly that. In that sense, my approach to publics can be understood to follow multi-sited ethnography as a methodology. The aim of such an approach is to move beyond merely describing empirical phenomena towards conceptual abstraction and understanding (Charmaz, 2001, 2014). Accordingly, this book's focus on publics is a product of such an approach to data gathering and interpretation, which not only combines empirically grounded insights with existing theory, but also has the potential to reveal conceptual shortcomings of the latter. In that spirit, I focus on the mutual shaping between various meanings of technology (GM crops) in circulation and the forms of social organisation that accompany it in democracy (publics). I chose additional relevant concepts and theories based on their usefulness for understanding the arenas of the GM crops controversy and the construction of publics therein. In order to avoid further theoretical abstraction at this point, I will introduce these concepts and theories in the chapters that follow. Let me explain next how I gathered and analysed empirical data in the form of qualitative in-depth interviews, ethnographic observations, and documents.

Interviews

The main empirical source of my analysis consists of 52 semi-structured in-depth interviews with key actors of the controversies in India and Europe, such as activists and campaigners, bureaucrats, civil society organisations, farmer representatives, government officials, industry advocates, journalists, representatives from transnational as well as local NGOs, researchers, and scientists (see appendix I for a detailed list). I chose the interviewees by reviewing central documents of the debate, such as the report on the Bt-brinjal consultations in India (CEE, 2010a), reports on conferences about biotechnology and GM crops organised by the EU institutions (e.g. Van Est et al., 2012), as well as government documents, newspaper articles, NGO reports, scientific publications, weblogs, and websites of the GM crops debate. Moreover, I got in contact with many informants by employing the snowball method, i.e. I asked interviewees for more contacts to actors involved in the GM crops debate. This was a useful strategy not only to enrol further interviewees, but also to identify actors' allies and their opponents, and thus the complex networks of the GM crops controversy. In India and Europe, actors from civil society organisations and NGOs were very open to be interviewed. This proved much more difficult with GM crops advocacy organisations in Europe, and almost impossible with government officials and policy-makers in India. In Europe, I encountered few barriers in my attempts to interview EU policy-makers and civil society representatives, but industry spokespersons, particularly from any of the larger GM seed producers frequently denied interviews. Scientists directly involved in regulatory processes were equally sceptical to talk about their views.[27]

[27] I assume members of the EU institutions are more used to talking to researchers than their Indian counterparts, which explains why they were more easily accessible than Indian government officials. Scientists

I conducted these semi-structured interviews using topic guides and taking account of the interpersonal nature in which trust and rapport are essential for acquiring knowledge about the interviewees' world views and meaning constructions (cf. Byrne, 2004; Roulston, 2010; Silverman, 2001). The interviews were conducted in person (except for two interviews via skype and telephone, see appendix I), held in English (the working language of my informants and myself), took between thirty minutes and two hours, and were digitally recorded with the permission of the interviewees. In some cases, interviewees objected to recording because they preferred sensitive information and viewpoints not to be on tape, or because the presence of a recording device made them hesitant to speak freely. In those cases, I took handwritten notes on paper. Subsequently, I transcribed recordings and notes. Upon request I provided my informants with the transcript of our conversation to allow them to provide additional comments or clarifications. I also sought authorisation for the direct quotes I used from the interview material from my interviewees directly. Initially, I coded the interview transcripts in an exploratory manner with the help of the computer programme *Atlas.ti.* After I had developed a coding scheme that was workable, I continued coding the interview transcripts by hand.

My fieldwork happened largely in the years 2012-2014, with two empirical visits to India from February to April 2012, and from January to March 2013. Interviews and field visits in Europe took place throughout the years 2012-2014. I conducted interviews in India in various urban and rural sites such as Bangalore, Bhubaneswar, Chennai, Chamaraja Nagar (Karnataka), Hyderabad, Mumbai, New Delhi, and Pastapur (Andhra Pradesh). In Europe, most interviews took place in Brussels, but I also met informants in Amsterdam, Berlin, Gent (Belgium), and Hamm (Germany). To conduct these qualitative interviews, I visited my informants usually at their workplaces. In some cases, I met interviewees at cafes or restaurants, at conferences, and campaigning sites. Although mostly scheduled in advance, some interviews were held ad hoc, and sometimes under the open sky. In India, it was not uncommon amongst civil society actors to invite me to their homes to conduct the interview since that was the most convenient place for them to meet and talk freely, or simply because their home was also their work place. In other instances, I attended farmer meetings organised by NGOs, agricultural conferences organised by state and industry, and meetings and conferences at the European Institutions in order to get an understanding of my informants' life worlds, and to get in contact with further potential interviewees. Conducting interviews in these settings also allowed me to take ethnographic notes of the working environment and

involved in regulatory advice to government frequently were unwilling to be interviewed on GM crops referring "to the highly politicised nature of the issue" and advising me to study official documents instead (private correspondence, 2014). Industry representatives were most difficult to get in touch with. For instance, Monsanto Corporation responded to interview requests by sending a number of publicly available documents and referring me further to the contact webpage of their agencies in various countries. Upon contacting these however, I was either referred back to Monsanto's public relations agency at their headquarters, or I did not received a reply. My efforts to speak to other transnational corporations involved in agricultural biotechnology and GM seeds such as BASF, Bayer, and Syngenta, remained equally futile. I had similar experiences in India. However, I am glad that representatives of industry advocacy organisations such as Brussels based EuropaBio, the Foundation for Biotechnology Awareness and Education (FBAE) in Bangalore, and the Association of Biotech-led Enterprises (ABLE) in Delhi granted me their time and trust for interviews.

the events in which the actors were involved - assemblies, conferences, demonstrations, meetings, and rallies are fertile grounds for generating ethnographic data.

In some instances, I spent considerable time in the environment of my informants. At a three day long conference organised and sponsored by the Indian government and various agricultural corporations in Delhi, I not only observed the way people talk in such a setting, but also how they make connections and meet their networks for lobbying activities. At a farmer jury meeting in Bhubaneswar (Odissa), I observed for three days the attentiveness and determination with which rural communities try to understand and cope with the implications of modern agricultural technologies brought to them by state policy. At a day-long demonstration in Brussels, I saw the fierceness of activist agitation and discussed the goals of street protest with activists; and at conferences at the European Parliament, I witnessed the professionalism, technocratic argumentation, and the role of science in discussions about policy-making first-hand. At the inauguration of a farmer's university in the BR hills close to Mysore in Karnataka, I slept on the ground amongst farmers from all over Southern India for several nights. With the help of interpreters, this provided me with the chance to discuss with them their ideas about agriculture and the issues they see implicated with GM crops in their own words. Particularly in India, sharing meals with my informants emphasised the cultural meaning and importance of food. Certainly, these ethnographic moments contributed to my understanding of these actors' life worlds.

In several instances, I was lucky to meet the right people who put trust in me as a researcher and invited me to such events or granted access when necessary. At times, my foreignness to the Indian context allowed easy access, at other times my background as a European researcher precluded my attendance at certain events. In Europe, such matters of access played less of a role.[28] Since the actor landscape of the GM crops debate is rather complex, and because there are differences as well as similarities between the arenas of the controversy, I will provide more information on the respective actors in the introduction to the empirical chapters. I complemented my ethnographic approach to interviewing and participant observation with document analysis to cross check the information, insights, and interpretations I gathered during my field work.

[28] Since late 2011, Indian NGOs that received funding from abroad became increasingly the subject of government restrictions. In 2012, Indian Prime Minister Manmohan Singh portrayed such funding flows as a threat to Indian national interest: Foreign funded NGOs' activities allegedly endangered India's development while it was not clear whose interests these organisations were representing (Lakshmi, 2012; TimesofIndia, 2012). Many NGOs critical of the social and environmental consequences of large technology projects were targeted, such as organisations campaigning against GMOs and nuclear energy. By 2013, 4000 smaller Indian NGOs, as well as the Indian Social Action forum, a network of 700 NGOs had their permission to receive foreign donations revoked (Lakshmi, 2013). Activists and NGO personnel regarded the Indian government's actions as curbing dissent and intimidating activists (Sunderajan, 2012). In this context of hostility and suspicion towards foreign funding, several civil society groups were hesitant to welcome me to meetings they had, since my presence at the time could have been interpreted as linking these organisations to foreign funding, which in turn might have subjected their work to greater governmental scrutiny and policing. To not endanger their work, I could not attend a number of civil society meetings. I subsequently conducted the interviews with representatives from these organisations in private.

Studying text and documents

Document sources compliment qualitative interviews and ethnographic observation (Glaser & Strauss, 1967). I gathered textual materials in the form of publicly available documents: information leaflets; newspaper reports; opinion articles; pamphlets; posters; research papers in agronomic analysis, toxicology, and environmental impact studies; reports by government, industry, and NGOs; weblogs by activists, political commentators, and journalists; and websites dedicated to the GM crops controversy. I also looked at visual sources such as documentaries about GM crops (Bhatt & Kanchan, 2009; Robin, 2008; Sainath & Bhatia, 2009) and pictures and illustrations in industry and civil society information materials. I identified these documents through systemic research of various online resources, like websites of government institutions, advocacy groups, and civil society organisations; and through various search engines on the World Wide Web. I also conducted systematic newspaper searches and gathered document sources at conferences, field visits, or my interviewees provided me with additional material. I collected these documents from the time period between 2002 (the release of Bt-cotton in India) and 2014.

Documents serve as repositories of information and meaning constructions, and they remain accessible and in circulation beyond the moment of production (cf. Prior, 2012). Documents are forms of text (just like interview transcripts), in which meaning constructions of the GM crops debate circulate. They can accordingly be analysed for their content and as part of a discourse. I follow Hajer's definition of discourse as a "specific ensemble of ideas, concepts and categorizations that are produced, reproduced, and transformed in a particular set of practices and through which meaning is given to physical and social reality" (Hajer, 1995, p. 44; cf. Hajer & Versteeg, 2005, p. 175).[29] Understanding texts as being part of a wider discourse allows identifying regularities in discussions and debates, and patterns of interaction and networks amongst the social groups of the GM crops controversy. My analysis of documents therefore focuses not only on the meanings produced therein, but also on the circulation and exchange of these meanings, e.g. of the risks and benefits and the constructions of publics in the GM crops controversy. This perspective on text regards language not as a neural medium but as a domain in which our knowledge of the social world is actively shaped. Language does not reflect reality neutrally and objectively, but it actively constructs and organises that social reality (Tonkiss, 2004). Such an approach to discourse is particularly suitable to study the circulation of symbols, meanings, and the politics of knowledge which symbolic interactionism is concerned with (Keller, 2011).

Documents, interview data, and ethnographic field notes are part of discourse and can be studied as texts that circulate in the debate about GM crops. There is a tradition in STS to study technological controversies with the help of framing analysis (e.g. Epstein, 1995), which was initially developed by Goffman (1976). Framing analysis is a multi-disciplinary

[29] Hajer's definition implies a Foucauldian understanding of discourse, which sees (the use of) language to be linked to specific forms of social practice. From this view, what is written and said is inextrinsically linked to human social action. Hajer (2005) refers to the circulation of text in discourses as 'discursive structures'. Such structures might not be obvious because every discourse has its own argumentative rationality (e.g. a risk-based discourse is distinctly different from a discourse that revolves around notions of social justice or political sovereignty).

social science method that aims to uncover how dominant definitions and constructions of issues in a controversy come about; it focuses on discursive constructions of problem definitions, the diagnosis of causes, the forming of moral judgements, and the formulation of solutions (Epstein, 1996; Kuypers, 2006). This approach to analysing discourse has been used to study the controversies around agricultural biotechnology, yet the concept of publics has remained largely out of view in that literature.[30] For instance, Gottweis (1998) analyses the discursive framing of European biotechnology policy and public debates in the 1980s and 1990s to explain how agricultural biotechnology was re-framed by policy-makers in order to harness societal concerns about environmental risks. Bernauer (2003) compares the framing of biotechnology regulation in the US and EU to explain how interest groups struggled for market influence and to shape regulatory decisions. Toke (2004) studies discursive frames to compare policy systems of the US, UK and EU to explain how institutional rigidity made science-based regulation a constraint that led to culturally-based differences in the regulation of biotechnology. All these studies have in common their focus on the use of language in shaping policy practices. Yet, they all leave the notion of 'the public' black boxed, since their conceptual and theoretical foci lie elsewhere. In this book however, I approach the GM crops debate differently – I do not exclusively focus on social groups' attempts at shaping policy-making processes, but I also look at how notions of reliable scientific knowledge and ideas about sociotechnical futures are sites where publics are constructed alongside the various meanings attached to transgenic crop technology.

The methodological flexibility of multi-sited ethnography to my data collection and analysis explicitly focuses on the discursive construction and mutual shaping of GM crops and their publics. Therefore, I study my data with a textual analysis in broad interpretative, symbolic interactionist way: I put less emphasis on rhetoric and instead focus on the various ways the actors in the GM crops controversy symbolically construct the issues around transgenic crop technology that they see to impact their lives, and how these meanings circulate. In that sense, I follow a pragmatist conception of data generation, analysis, and conceptualisation based on symbolic interactionism. This does not privilege the culturally contingent structures that frame analysis emphasises, but equally takes into account an understanding for the actors' subjective sense-making practices, what place and identity they inhabit in their social worlds, and how they construct solutions to the problems they face in their lives. Looking at human meaning constructions this way allowed me to identify not only the most dominant (hegemonic) issues within and across different arenas of the GM crops controversy, but it also offers a nuanced understanding of the manifold ways in which technological and political development shape each other. This can help us to understand and reflect on cultural specificities, including our own. Let me finally outline what lies ahead.

[30] As I show in the literature review above, Noortje Marres (cf. 2007) argues that public controversy around techno-scientific issues aims for the articulation and political accommodation of such issues. Yet, there is a lack of understanding (by empirical evidence as well as theorising, I would argue) why this matters for democratic culture.

The Arenas of the GM Crops Debate

In order to organise the presentation of my investigations into the complex and multi-sited controversy about GM crops, and to create analytical order in this scattered empirical field, I draw on the analogy of "arenas" to devise the following chapters. The arenas I have chosen as cases to study the complex and polycentric GM crops controversies in India and Europe pertain to: 1) scientific risk assessment of GM crops; 2) publicly circulating ideas about socio-technical futures with(out) transgenic crops; and 3) policy-making on this technology. Let me explain what the concept of arenas refers to and how I employed it to structure this book.

The etymological root of the word "arena" (from the Latin *harena*) refers to an enclosed place of combat that is strewn with sand (Klein, 1971, p. 48). The Latin origin of the word alludes to the central stage of Roman amphitheatres around which audiences gathered to watch executions and gladiator combat. These arenas were strewn with sand to soak up the blood unavoidably flowing in the violent spectacle. Applying such a metaphor to the various sites of the GM crops controversy is no exaggeration. Actors and analysts alike use words that refer to combat, fight, and war in describing the debate. For instance, controversy about scientific assessment of the potential risks of GM crops has been referred to as a "battlefield" (Waltz, 2009); the opposition to GM crops has been framed as a "crusade" fought with "war strategies" against the technology (Janabi, 2014; Specter, 2014); and the debate as such has been depicted as "a global war of rhetoric" (Stone, 2002, p. 611).

In sociology, social arenas theory is used as a conceptual framework to study the diverse social processes of collective action as well as the actions and interactions of collective actors and organisations (Clarke & Star, 2008; Strauss, 1978; Strauss, Schatzman, Bucher, Erlich, & Sabshin, 1964).[31] Social arenas theory aims to qualitatively study structures, processes, and consequences of such interactions (Clarke, 1991)[32]. With its relativist and constructionist outlook, social arena theory is rooted in pragmatist epistemology with which Chicago sociologists have studied the making of communities and organisations (e.g. Blumer, 1978; E. C. Hughes, 1971), which suits my own approach to studying the controversy about GM crops and the construction of publics.[33] In arenas, "various issues are debated, negotiated, fought

[31] Anselm Strauss named his frameworks social worlds/ arenas theory. Social worlds are "universes of discourse" (Mead, 1983, 1972), which include not only forms of communication and symbolisation but also "activities, memberships, sites, technologies and organizations" (Strauss, 1978, p. 121). Strauss defined social worlds as the foundation of affiliative mechanisms through which people organise social life, i.e. groups that share commitment, resources, and ideology to an activity (Strauss, 1978). As described above, I prefer the concept of "relevant social groups" because it takes into account the role of technology more explicitly, and I restrict myself here to the notion of *arenas* because of its heuristic usefulness as a metaphor for organising the chapters of this book.

[32] As Clarke (1991) notes, to interactionists, structures are persistent conditions or aspects that remain in place, i.e. stable and predictable for some time. Structures are the consequences of prior actions reproduced through present actions and experienced or perceived as obdurate (Blumer, 1990; Strauss, 1985). Structures are based in the commitments of individual actors to collective action such as economic development, social movement organizing, or state building (Strauss, 1982). Yet, structural aspects are not unchanging, they just change more slowly than other aspects of social situations.

[33] Clarke and Star (2008) explain that using social arenas theory as a framework fits symbolic interactionist approaches in both ontology and epistemology, and is particularly useful for studying technological controversy.

out, forced and manipulated by representatives" of different social groups (Strauss, 1978, p. 124). Public debate about technology in turn can be conceptualised as "a set of interactions and conflicts in diverse arenas, which seek to define the cognitive and normative content of a given problem" (Bonneuil et al., 2008, p. 7). In this sense, the notion of arenas as a heuristic concept has helped me to identify the most contested sites of the GM crops controversy, where the meaning of transgenic seed technology and its risks is debated, and where various notions of the public are constructed by a multiplicity of actors.

In science and technology studies, social arena theory has also been used to locate institutional and political actions that aim to influence collective decision-making or policies on risk issues: Rather than defining geographical spaces or organisational systems, the arenas metaphor is more useful for describing the "symbolic location" of political actions (Renn, 1992), i.e. the various meanings actors ascribe to risk issues and the work they put into shaping policies thereon. Instead of describing interests and motivations of the actors involved, this strand of research focuses on how actors and social groups aim to mobilise resources to shape policy decisions[34]. In the following chapters, I take the construction of publics as social groups' intentional, though not always strategic action, with which they the aim to shape political decision-making on GM crops. As Renn (1992) notes, not all political actions are strategic and actors often are convinced that the meaning they ascribe to artefacts, practices, and knowledge is an adequate representation of reality. Depicting these meaning constructions is what my analysis of the interpretative flexibility of GM crops and their risks aims for.

In their study of how GM field trials were constructed as a social problem in France at the end of the 1990s, Bonneuil et al. describe arenas as "sites where individual and collective actors interact to define the cognitive and normative dimension of a problem" (2008, p. 205). Not only will the different meanings ascribed to technology (interpretative flexibility) be at the focus of my analysis, but I will equally study the epistemic and normative dimensions of the debate and how such issues reflect in policy-making. My ultimate aim is to understand the mutual shaping of GM crop technology, science, and publics (science, technology and society) to better understand the democratic governance of technological innovation. According to Strauss, it is the commitment to action that defines human social life. Accordingly, in arenas the analytic focus is on action, where the units of action are collective entities present in the situation (Clarke, 1991). The arena metaphor thus allows me to devise different sites where actors' action is the symbolic construction of GM crops and their risks, and where respective publics are constructed as a unit of collective action. The arenas of the GM crops debate that I have carved out analytically can be seen as exemplary sites where the structures underlying contemporary efforts at shaping collective decision-making on GM crops can be made visible, and thus where the democratic governance of technological innovation can be scrutinised.

[34] Renn remarks that the nature of actors' intentions are irrelevant "unless the goals themselves are used in a debate to improve one's opportunities to gain resources" (Renn, 1992, p. 184). Renn advises to focus primarily on actions that aim to influence policy-making. Arenas theory assumes that individual and collective actors "can influence the policy process only if they have sufficient resources available to pursue their goals" (ibid., p.181). In that sense, we can conceive of constructions of the public to constitute a resource for shaping collective decision-making.

GM crops, their risks and respective publics are constructed differently in the debate. The arenas metaphor constitutes a way to organise the controversies that I have studied in India and Europe. Arenas are different from the field sites I have visited in this multi-sited ethnography, yet also deeply related to the issues problematised in these various settings. Clarke notes that there is competition both between problems and between different problem definitions within and across different arenas (Clarke, 1991). Similarly, Bonneuil et al. describe arenas as having differentiated "carrying capacity", (2008, p. 205) i.e. out of many problems connected to an issue, only a few can be addressed in each arena. Different problem definitions imply potential winners and losers, responsibility for producing risks and bearing the vulnerability emerging from being exposed to risk, and therefore its relevant concerned publics. The arenas metaphor allows me to put the cross-cutting issues of the debate into order and to focus on both, actors' perceptions as well as the structures underlying the symbolic location of GM crops. I will argue that publics are constructed along with the issues raised in the debate.

The arena concept is a useful heuristic tool to devise the structure of the following empirical chapters. I have identified three arenas in which I describe how various relevant social groups construct GM crops and their risks, where publics shape the development of GM crop technology and where publics are constructed at the same time: scientific risk assessment, the construction of futures with or without GM crops, and policy- making on transgenic crop technology. My empirical analysis begins with chapter two, titled *More than Just Rats – Toxicological Risk Assessment Publicly Contested*. There, I study the case of a contested long-term toxicological feeding study (Séralini et al., 2012) on rats which was retracted from its publishing journal after more than a year of fierce public debate. I start from the prolific notion that the debate about transgenic crops is based on public concerns primarily focused on issues of risks to human health (cf. e.g., Rauner, 2017). I ask why the paper by Séralini et al. (2012) oscillated between being recognised as scientific and not being recognised as such. In reconstructing the debate between scientists, civil society groups, industry representatives, public media, and regulatory authorities, to show how scientific and public debate about this publication intertwined. The actors in that arena differed over the question how the boundary between science and politics should be drawn. Rather than merely discussing the publication's scientific merits in terms of method, experimental design, and data analysis, the actors in this arena problematized the politicisation of toxicological knowledge production on GM crops very differently. Public involvement in this debate reflects the various political issues connected to scientific risk assessment of the potential health risks of GM crops. In this chapter, I show the scientific discourse on technological risks to have inherent limitations. Instead, the way that publics formed around Séralini's long-term feeding study reveals the institutions of scientific risk assessment to get complicated in the face of a range of political issues, despite various actors' attempts to confine the debate to the realm of toxicological experts and science alone. Although the opposition to GM crops is most commonly explained by referring to public concerns about its potential risks to human health, the chapter concludes that public involvement in the debate about Séralini's long-term rat-feeding study points to a multitude of other issues, which I explore in more depth in the second empirical chapter.

Chapter three explores the manifold meaning constructions and wider issues various actors attach to GM crops and their risks. In *Imagining Futures with(out) GM Crops: normativity, temporality, and publics,* I ask how the actors of the GM crops debate in India and Europe imagine and symbolically articulate sociotechnical futures with and without GM crops, and which publics are constructed along with such imaginaries. I describe how industry and civil society actors, as well as scientists involved in the debate construct desirable and undesirable futures – and to and from which publics such futures speak. I specifically look at how various advocacy organisations, NGOs, and civil society groups construct competing visions of the future that resonate in the debate as collectively shared imaginaries of GM crops. The concept of imaginaries is helpful to identify publicly circulating ideas about how society's future might look like with the science and technology of transgenic crops. Yet, these imaginaries are conflicting and contested. This opens up the discourse on risks not only to issues of the environment and ecosystem, but also allows considering wider concerns about agrarian futures, ideas about technological innovation for economic growth, and the politics of knowledge production that the actors invoke. By exploring these issues, I show the debate about the sociotechnical futures with(out) GM crops to be deeply implicated with normative ideas about technological and social development– the futures imagined are equally about the role of technology as well as about what is good and desirable for the political community, i.e. the envisioned evolution of technical *and* social orders. Despite explaining the normative underpinnings of sociotechnical imaginaries of the GM crops debate, I also want to understand where these visions of the future come from, i.e. I explain the relationship between the actors' interpretations of past agricultural development and their visions of a future in order to understand the underlying temporal logics of sociotechnical imaginaries, their corresponding construction of GM crops, and their relevant publics.

The final empirical chapter looks at a case of policy-making on Bt-brinjal, India's first GM food crop. In chapter four, *The Bt-brinjal consultations: Publics in the Arena of GM Crop Policy-Making*, I study how publics had an impact on the regulation of Bt-brinjal in India. After extensive public consultations throughout the country just before Bt-brinjal had reached marketing stage, the Minister of Environment and Forests Jairam Ramesh imposed a moratorium on Bt-brinjal in 2010. To understand the relationship between public engagement and policy-making, I first reconstruct the Bt-brinjal consultations in which a broad array of actors from civil society, the corporate sector, the farming community, and science were involved. Then, I discuss the most crucial reasons that motivated the minister's decision in response to the public consultations. In this chapter, I accordingly ask which publics were constructed in the Bt-brinjal consultations and how these shaped the moratorium decision in order to explain what conditions made Jairam Ramesh impose the moratorium. The Bt-brinjal consultations constitute an intriguing case of publics engaging in the democratic regulation of techno-science in the global South that has not been empirically investigated so far. Deriving from the literature on public engagement that suggests institutionalisation of public participation creates greater legitimacy for policy decisions, I investigate the meanings actors attached to the process of the Bt-brinjal consultations. My analysis of the issues these actors raised in the consultations helps to explain how heterogeneous issue-based publics emerged in the arena of Indian GM policy-making, and how actors perceived of public engagement as democratising decision-making on Bt-brinjal. As I will show, invoking public engagement

mechanisms as a remedy to the shortcomings of liberal representative democracy needs to be sensitive to context, and the historically and culturally contingent traditions of democratic deliberation. Based on my analysis of the multiple publics constructed in the Bt-brinjal consultations, I suggest that European democracies can learn from Indian argumentative and discursive heterodoxy, while at the same time, we need to be aware that calls for public engagement may not necessarily yield the democratising effects theorists of deliberative democracy suggest. This insight can contribute to a more critical scrutiny of attempts to institutionalise such processes around technological controversies in India, Europe, and beyond; and it helps to understand the democratic governance of technological development in a globalised word. In the concluding chapter, I will reflect on my findings and set these in relation to the wider question about how GM crop technology and public involvement in this issue shape democratic political cultures. How to understand the mutual shaping of GM crops and its elusive publics in terms of lessons to learn about the democratic governance of technological development and techno-scientific controversy necessitates to shortly reflect on the possibilities and limitations of comparison through a multi-sited ethnography.

A Note on Contextual Specificity

A straightforward systematic comparison of qualitative cases is difficult when studying the contextual richness of specific cases across cultures with the method of multi-sited ethnography. However, the qualitative social science inquiry I offer here still allows for the identification of similarities and differences between the Indian and the European context. Yet it remains difficult not to overemphasise their contextual (cultural, historical, political) specificities, e.g. the livelihood of two thirds of India's population directly or indirectly depends on agriculture and India's land holding structure is mostly small-scale. In contrast, Europe's agrarian structure is entirely different, i.e. farming is largely industrialised and only a minority of the population is involved in agricultural activity. Also, not reproducing prejudice (e.g. about corruption), and over-emphasising internal homogeneity versus heterogeneity and ambiguity, are challenges a qualitative social science inquiry has to face. Instead, I aim at identifying the overlapping issues and objects of politics to emphasise the differences where these significantly contribute to explaining the interpretative flexibility of transgenic crops and publics alike. Since regulatory principles, study protocols, structures of global trade, and technology transfer harmonise in a globalised world, those differences can be expected to apply despite the universalising forces of globalisation between nation states and cultures.

Nevertheless, the central unit of analysis in this thesis is not the nation state, but GM crops and the publics constructed in the debate about this technology. While comparative studies take the nation as the central unit of comparison, the physical boundaries of nation states are less important when studying technological culture in which technological artefacts, scientific knowledge, and the networks around them are globally operational. In a globalised world, cultural entities are less based on national boundaries but on transnational scapes made up of ethnic, technological, and financial flows and networks which can be co-constitutive but also disjunctive. This gets complimented by flows of media and (counter-) hegemonic grant narratives (Appadurai, 1990). Although the ongoing process of globalisation

undermines the legitimacy of the nation state as a unit of analysis, it "has not yet undermined the existence or the power of the nation and, in practical terms, many phenomena are still defined in national terms" (Livingstone, 2003), such as specific histories, cultures, and policy environments.

In the case of the GM crops controversy, the choice of the unit of analysis of GM crop technology and the discourses about it are more obvious than possible comparisons across national boundaries. Europe itself is not a country, although the multi-level governance of the European Union with its legislative supremacy over national regulations resembles the institutional power of a modern nation-state and of an international regime alike (Moravcsik, 1998). Yet, the EU has its own regulatory and political culture arising from the paradox between deep economic and superficial political integration (Majone, 2007). Equally, it is difficult to make claims for India as a nation state, which is difficult to access in its cultural, linguistic, and political diversity regarding the spatial and temporal limits set by the ethnographic methods I employed for this research. Any social science research that claims to still make statements about similarities and differences across countries needs to avoid both, reconstructing uncritical assumptions about conceptual and theoretical universality, i.e. the methodological fallacy of methodological nationalism on the one hand, and only drawing on relativist contextualisation for explaining the units of analysis on the other (Beck & Grande, 2010). Accordingly, asking what we can learn from comparing the Indian and European debates about the risks of GM crop technology, and how issue-based elusive publics shape and get shaped in these controversies, necessitates not taking the nation-state as a unit of analysis, but rather as the context of study (Livingstone, 2003).

In terms of the broader question I ask about the democratic governance of techno-science, differences in democratic culture may constitute a point of mutual learning for Europe and India. For instance, Amartya Sen (2005) has described the discursive plurality and argumentative heterodoxy which is so emblematic of India's deliberative culture, from which European democracy can surely learn. At the same time, the high degree of institutionalisation of civil society involvement in policy-making and of public participation exercises in the European Union might either be an inspiration for the Indian polity, or might become subject to change depending on the experience with the regulation of such technological innovations as transgenic crops in other parts of the world. It will be a question though, to what extent we really can compare democratic governance in such contexts as different as India's and the European Union's polities by means of a qualitative social science inquiry.

Chapter 2

More than Just Rats - Toxicological Risk Assessment Publicly Contested

Introduction: a debate about lab rats

The most prominent concern with GM crop technology is the potential risks to human health it might entail. It is up to science to assess these risks through tests and experiments, and there is considerable disagreement amongst scientists as to the potential health effects of GM crops (Krimsky, 2015). In September 2012, toxicologist Gilles-Eric Séralini and colleagues published a paper in the scientific peer-reviewed journal *Food and Chemical Toxicology* (Séralini et al., 2012). The paper was based on the analysis of a long-term toxicological feeding study of Monsanto's herbicide-tolerant GM maize (corn) NK603 and its associated herbicide Roundup™.[35] The study reported that rats fed for two years with Monsanto's NK603 developed more tumours and died earlier than controls fed with non-GM feed. It also showed that the tested animals developed cancers when the Glyphosate containing herbicide Roundup™ was added to their drinking water. In the scientific literature and public media alike, Séralini et al.'s publication became fiercely contested. Some were quick to argue it resembled a piece of "pseudo-science" (Arjo et al., 2013) because it did not adhere to established standards of scientific risk assessment in toxicology, which prescribe feeding studies for a duration of merely 90 days.[36] Yet, others warned that scientific findings pointing at potential risks of GM crops are frequently subject to a politicised debate in which attachments and vested interests are at play and where powerful actors aim at delegitimising scientific knowledge production which questions product safety. In such cases, science gets muddled with politics, these commentators warned (Bardocz et al., 2012).

Toxicological risk assessment investigates the potential health effects of GMOs in feeding studies with mammals. These follow standardised test protocols, such as the guideline 408 on testing of chemicals prescribed by the Organisation for Economic Corporation and Development's (OECD, 1998) for assessing the potential toxicity of GM crops. Regulatory bodies, such as the European Food Safety Authority (EFSA), base their own testing protocols on these guidelines (e.g. EFSA, 2011b, 2011c) and applicants need to follow these protocols in the risk assessment dossier they submit to EFSA. In the case at hand, the standard test design became subject to controversy. Since Séralini and colleagues did not adhere to established protocols of scientific risk assessment, the status of their publication as proper scientific knowledge was fiercely contested.

The debate however was not confined to expert deliberation about the facts and standards of toxicological risk assessment, but public scrutiny became important, too. Unlike earlier debates about toxicological experiments that showed potential adverse effects of GM crops in mammalian diets (e.g. de Vendomois, Roullier, Cellier, & Séralini, 2009; Séralini,

[35] Usually, GM crop risk assessment studies are commissioned and sometimes conducted by the producers who apply for market approval of their product. In the EU, as elsewhere, there are no publicly funded facilities to conduct toxicological and other risk assessment tests. This poses a structural problem for policy-making since it has to rely on the applicant's studies to assess the health impacts of such products (interview Koëter, 2012). Séralini and colleagues intended to address this problem by conducting their own feeding study, and prolonging it to two years, instead of the standard toxicity studies in rats that prescribe a duration of 90 days.

[36] EFSA recommends a duration of 90 days for oral toxicity testing since 2011 (EFSA, 2011c). Since 8 December 2013, the European Commission Implementing Regulation (EU) 502/2013 makes 90-day testing mandatory.

Cellier, & de Vendomois, 2007), the controversy about Séralini et al. (2012) transcended the institutional settings of peer-reviewed scientific publishing. Instead, the publication opened up scientific expertise to outside critical scrutiny as public involvement raised political issues around toxicological risk assessment. The debate neither confined to toxicology, nor to the arena of science, but the publication raised a storm in the public controversy about the health risks of GM crop technology in Europe and beyond (Butler, 2012a; HuffingtonPost, 2012; Vidal, 2012). For instance, Friends of the Earth Europe presented the study's findings as a sign confirming serious public health concerns and called upon the EU to stop all imports of GM food and feed (FoE, 2012). Also, in reaction to the publication, a couple of countries stopped importing NK603. So, the controversy about the toxicological facts of the Séralini et al. (2012) publication reverberated with the political concern about the regulation of GM crops.

Regulatory bodies reacted to the debate, too. EFSA evaluated Séralini et al. (2012) and concluded that it was not rigorous enough to justify sufficient doubt as to EFSA's previous evaluation of studies that had confirmed the safety of NK603 (EFSA, 2003, 2012b, 2012d). After prolonged controversy, the editorial board of the Elsevier journal *Food and Chemical Toxicology* (FCT) retracted the paper because of its "inconclusiveness" in November 2013, a year after its publication (Hayes, 2013a, 2013c). Yet, many actors who saw merit in Séralini's study questioned the scientific base of the editorial decision and alluded the retraction intended to silence dissenting scientific voices on the toxicological assessment of GM crops. However, a year after the retraction, the Springer open access online journal *Environmental Sciences Europe* republished the study in an extended and adapted version (Séralini, Clair, Mesnage, et al., 2014), referring to the need to make the content of scientific controversies available to the scientific community for critical discussion, experimental refinement, and further knowledge production.

Séralini et al.'s long-term feeding study, as well as the retraction decision remain subject to fierce debate till date. The controversy still constitutes a reference point for both sides to the contestation about the potential health risks of GM crops today. In this chapter, I trace the debate surrounding the publication, retraction, and republication of the toxicological risk assessment study on the potential long-term in-vivo toxicity of the herbicide tolerant GM maize NK603 and its associated pesticide on rats (Séralini et al., 2012). The controversy about Séralini et al.'s publication is a strategic case to study the role of toxicological risk assessment on GM crops, as well as the contested boundary between science and politics. In this chapter, I ask how the publication by Séralini and colleagues became subject to contestation over its status as reliable and trustworthy scientific knowledge: What made toxicological risk assessment become such a contested object of public debate? How did the paper's status oscillate between being recognised as scientific and not being recognised as such?

The controversy about Séralini et al.'s paper on the potential long-term toxicity of KN603 and Roundup™ could not be accommodated in the institutional settings of scientific publishing and the regulatory assessment of its results. Instead, publics formed around epistemic issues such as the methods and standards of scientific risk assessment, and the question whether the study had scientific merit or not; but also around more fundamental questions about the authority and reliability of research and its practitioners, and the role of regulatory authorities and technology producers in assessing the risks of GM crops. As the debate about

the paper's contested status as scientific knowledge became a public controversy, the arenas of scientific and public debate intersected and mutually shaped each other. The pragmatist conception of publics and politics that I follow in this thesis suggest that issues arise when problems cannot be accommodated within existing frameworks of knowledge production and policy-making. Publics in turn form around such contested issues (Marres, 2007). The issues discussed in the debate were not only about what constitutes proper scientific method, but also about the status of the institutions of scientific risk assessment themselves. As Gieryn suggests, when scientists and their expertise leave the world of scientific journals and laboratories to enter the social world where "they are called upon to settle disputes" (Gieryn, 1999, p. ix), science itself becomes the object of contestation. As I will show in this chapter, when a scientific controversy embroils in political issues, scientists alone cannot settle debate, but other actors become important, too.[37]

The case of the Séralini publication and its retraction is exemplary for its representativeness of the social meaning and authority of science for scientific practitioners *and* publics alike, i.e. of the relationship between science and society (I. Welsh & Wynne, 2013). This is because the potential health risks of GMOs and their scientific assessment have been and still are the most fiercely contested of all arenas in the debate about GM crops (Rauner, 2017; Wales & Mythen, 2002). Some argue there is enough data confirming the safety of the technology (Nicolia, Manzo, Veronisi, & Rosellini, 2014; Snell et al., 2012), while others doubt there is sufficient evidence as to the absence of health risks (Domingo, 2000, 2007; Domingo & Bordonaba, 2011). As activist David Sanchez explained in an interview, "food [and food safety] is becoming a really important issue all round Europe, even in countries where it was not before" (interview Sanchez, 2013). This means toxicological risk assessment becomes more important in the public debate about transgenic crops. Moreover, the actors in the controversy refer to risk assessment science not only to confer power and authority to their truth claims about GM crops and the risks involved with this technology, but they also frequently deny the validity of counter arguments to their position by placing their opponents into the realm of bad-, pseudo- or bogus-science; science that is riddled with value commitments and ideological convictions, in short: politics.

Therefore, I ask in this chapter, how the peer-reviewed scientific publication of Séralini and colleagues (2012) was redefined as a political issue, and how it oscillated between being recognised as scientific and not being recognised as such. In the following, I focus on how the toxicological feeding study became an object of public involvement. To do so, I describe how the actors of the debate raised issues in constructing science as the legitimate jurisdiction to decide on the question whether GM crops pose risks to human health or not – and how they defined the boundary between science and politics. When the boundaries of science get challenged in public discussion, actors make the relationship between facts and values in the making, breaking, and sustaining of scientific authority explicit. This means that epistemic authority is enacted when science is publicly contested. To better understand this process of enactment, I draw on the insights from STS about the co-production of technological and

[37] By definition, scientists alone cannot solve controversies that get embroiled in political and institutional interests; and even if those scientists involved would reach consensus at some point, regulatory issues and policy implications would not immediately and decisively get settled (personal communication author with Thomas Gieryn, 2018).

social orders (Jasanoff, 2004). This means that the credibility of science is not to be taken for granted, but instead needs to be explained (Bijker et al., 2009; Jasanoff, 2005a). I want to show how the boundaries between facts and values, and between science and politics became issues of contestation. The concept of boundary work (Gieryn, 1983, 1995, 1999) helps to better understand the dynamics of the debate and to explain how the study did (not) succeed to be recognised as reliable and trustworthy scientific knowledge.

Issues, Publics, and Boundary Work

In the following, I chronologically reconstruct the scientific and public debate about the Séralini et al. (2012) study, from the day of its publication in November 2012 up to the time of its retraction a year later, and the ensuing months in which the debate continued. I conduct a textual analysis on a variety of documents of the controversy across different genres. I study texts that appeared in the scientific journal *Food and Chemical Toxicology* (FCT) as scientific publications. FCT is an important international scientific journal in the field of toxicology.[38] Since the debate played out in public media, I also take into account texts published in public print and online media, such as editorials, opinion and news articles, and weblog entries that circulated widely at the time of the publication and retraction. I chose these texts based on their prominence in relevant fora, such as GM crops related websites, civil society publications, and European and international news media. I also include the reactions of European and national regulatory authorities, and organisations representing GM producing industries. Civil society materials by various NGOs, as well as generic contributions (petitions, open letters) to the debate are also part of the analysis. I complement these sources with information that I gathered in qualitative interviews with key actors of the debate: CRIIGEN researcher Gilles-Eric Séralini, civil society activists, industry representatives, scientific and policy officers from the European Food Safety Authority (EFSA), and representatives from the European Commission's Directorate General for Health and Consumers (DG SANCO). I chose these data based on their richness for the analysis of how various actors responded to the publication, and how publics formed in their articulation of "issues that have insufficient institutional support while also requiring political settlement" (Marres, 2007, p. 771). Drawing on such a variety of sources allowed me to trace the object of politics in the controversy about the scientific merits of the publication. In my analysis, I focus on how actors constructed the opposition between science and non-science, and science and politics. I scrutinised how the textual frames and speech acts of the debate construct meaning, the role of context (time, type, and author of text), and intertextuality (explicit and implicit references between texts) to understand the meanings actors ascribe to the issues they come up

[38] The journal *Food and Chemical Toxicology* describes itself as an internationally renowned scientific journal that publishes original research on the toxic effects of natural and synthetic chemicals in animals and humans. The toxicological assessment of food, drugs, chemicals, and biotechnology products are within the journal's explicit scope. In 2016, FCT had an impact factor (= average number of citations received in a particular year by papers published in the journal in the two preceding years) of 3,977 and a citation score (average citations received per document published) of 3,99 (Elsevier, 2017). All letters to the editor in FCT are freely accessible online.

with (Bainbridge, 2011). Interview data served to provide more background and in-depth information on various actor's positions in the controversy about toxicological risk assessment. For the analysis, I coded these texts and structured them chronologically and according to the issues they raised.

As Marres indicates, the focus on discursive framings of a techno-scientific debate is insufficient to trace the objects of politics in a socio-ontological fashion. Rather, we need to understand issues as "particular entanglements of actors' attachments" and to "credit these entanglements as sources and resources for enacting of public involvement in controversy" (Marres, 2007, p. 775). Marres draws on Gomart's and Hennion's (1999) use of the term attachment to describe how actors' ontological associations and issue definitions are characterised by 'active commitment' and 'dependency' between human and non-human entities. Consequently, when scrutinising public involvement as object-oriented, the material and technical attachments and associations at stake in the controversy become important for my analysis, too, such as standardised test protocols, ideas about proper scientific method, notions of scientific impartiality, and questions about the institutional design of risk assessment. This brings me to the concept of boundary work that I use to explain how various actors construct the difference between science and non-science, and to understand how the actors connect other issues of the debate to the case of toxicological risk assessment.

Boundary work is a concept introduced by sociologist Thomas Gieryn (1983) that offered a new approach to the study of the characteristics of science. It denies as essentialist earlier attempts by philosophers, historians, and sociologists to describe science in terms of its openness to falsification (Popper, 1959), the strength of its paradigms (Kuhn, 1962), or its normative structure (Merton, 1973). Instead, Gieryn describes science as a cultural space with no essential or universal qualities. He suggests the sociology of science to ask "how people sustain the epistemic authority of science as they seek to make their claims and practices credible (or useful) by distinguishing them from unworthy claims and practices of some nether regions of non-science" (Gieryn, 1999, p. xii). Science therefore can be understood as a struggle for credibility. Truth claims are presented to convince others that a knowledge-generating practice is trustworthy and authoritative, or not. Such attempts to pursue or deny epistemic authority find expression in the rhetorical construction of boundaries between science and non-science to establish and maintain such demarcations.

Boundary work, in Gieryn's words is "their [scientists'] attribution of selected characteristics to the institution of science (i.e. to its practitioners, methods, stock of knowledge, values and work organisation) for the purpose of constructing a social boundary that distinguishes some intellectual activities as non-science" (Gieryn, 1983, p. 782). Boundary work is about constructing science as an arena different from others, set in spatial relation to places where it is not. As Ezrahi (1990) points out, boundary work is a mode of social ordering that delegates authority to social institutions by demarcating what belongs to science and what to politics. Boundary work constitutes a rhetorical act of *representation* of science as the uniquely best provider of knowledge. The properties of science depend on its other, on what is being excluded from that cultural space to establish, sustain, or breach the boundaries of trustworthy and reliable knowledge production. The aim of boundary work is thus to differentiate between insiders and outsiders of that cultural space (Gieryn, 1983, 1995, 1999). In the analysis, I accordingly scrutinise how various actors in the debate about Séralini et al.'s (2012)

publication construct the opposition between facts and values and between science and non-science, or politics.

Boundary work is a classical concept that has been used foremost in science studies. Some authors suggest to analyse technological objects (Star, 2010; Star & Griesemer, 1989), organisations (Guston, 1999, 2001) and spaces (Mahony, 2013) in terms of boundary work. These works describe the concept to explain not only dividing but also coordinating functions across social worlds (Bal, Bijker, & Hendriks, 2002; Halffman, 2003). The concept has recently been used for studying how civil society actors build interdisciplinary networks to advance their ideologies with the help of science (Harsh, 2014); and to understand science-policy interactions in risk analysis and governance, suggesting that more attention needs to be paid to the dynamics between various actors in the making of boundaries (Hoppe, 2008).[39] I follow this line of thought and suggest that not only scientists, but also many other actors engage in boundary work. This is pertinent when scientific risk assessment as a decisive step towards the market entry of technologies becomes the subject of controversy. Empirically, my focus on the public debate reverberates with Marres' contention that STS has been too preoccupied with organised public involvement practices, leaving important ways of issue-articulation unattended (Marres, 2007). In that sense, the public debate about the Séralini study emerges as an arena in which the public-isation of issues distils specific points of contention from the divergent associations that make up issues – those around scientific risk assessment of GM crops. As Marres suggests, to articulate a public affair is to demonstrate that existing institutions are not sufficiently equipped to deal with an issue and that it requires the involvement of outsiders. The public debate about the Séralini study is an instance where actors from outside established institutions of scientific risk assessment raise issues around the latter, and where as a consequence the boundaries between science and non-science, or politics, are fiercely contested.

Bijker et al. (2009, pp. 145-148) make four qualifications to Gieryn's concept that will be important in the ensuing analysis: First, boundary work is not only rhetorical but also involves social and material techniques in the construction of the space of science vis-à-vis politics. Social and technical associations at stake, such as value commitments, the financing of research, and professional associations between science and other social reams (activism, industry) become important for the analysis, too. That is despite most of boundary work happening rhetorically. Second, boundary work is not only a matter of strategic concerns but there are also structural aspects to the relationship between science and non-science. The relationship between science and non-science and the policing of scientific knowledge is institutionalised for example in the codified bureaucratic procedures of regulatory authorities. Government institutions, such as the European Food Safety Authority (EFSA) take risk assessment studies as the basis for providing judgements on which regulatory decisions about new technologies are made. EFSA frequently decides on the merit and relevance of scientific publications in case of controversy and disagreement; it functions as an institutional arbiter of science. EFSA as an institution and the codification of toxicological risk assessment procedures are part of the structures that give science its epistemic authority on deciding on the risks of GM crops.[40]

[39] For a review of the literature on boundary work, see Spruijt et al. (2014).

[40] From the perspective of symbolic interactionism, structures are persistent conditions that remain in place, i.e. stable and predictable for some time. Structures are the consequences of prior actions reproduced through

However, the logic of context and the resistance to boundary work by some actors implies that boundary work needs to adapt to the demands of its audience, i.e. to problems in policy-making and those raised in public debate from which the very structure of toxicological risk assessment gets criticised. This is despite the claim that regulatory institutions regard themselves as science-based and not influenced by any form of public debate about the risks of technology (interview EFSA, 2014). Third, Gieryn primarily focuses on the relationship between scientists and non-scientists for cognitive authority. However, there are "more boundaries at stake than just one" (Bijker et al., 2009, p. 147). Consequently, the contextual contingencies of defining boundaries and how these overlap deserve analytical attention. So, not only the science and non-science boundary, but also the distinction between science and politics, facts and values, and between risk assessment and risk management (a core principle in EU legislation that foresees EFSA to engage in risk assessment only) are subject to boundary work. Fourth, based on their analysis of the Dutch Health Council, Bijker et al. suggest that scientific advisory bodies strive for being "more scientific than is common in many scientific practices" (ibid.), i.e. we have to scrutinise the techniques actors employ to represent scientists as impartial experts, and regulatory agencies as scientific arbiters, and how actors try to maintain such ideal constructions despite the attachments at play. Finally, the concept of boundary work helps to explain the dynamic of the controversy about Séralini et al. (2012) and to understand what made toxicological risk assessment become such a contested object of public debate. I will further explicate the analytical value of the concept as I reconstruct the controversy about Séralini et al.'s (2012) publication, retraction, and republication below.

A New Perspective in Toxicology: Séralini's long-term feeding study

In late 2003, the European Food Safety Authority (EFSA) approved the application for the herbicide tolerant (HT) maize NK603 following directive 2001/18/EC on the deliberate release of GMOs into the environment (EFSA, 2003). Applicant Monsanto had published the results of a 90-day risk assessment feeding study as part of its application to the European Commission, stating NK603 transgenic corn to be as safe as existing commercial corn hybrid varieties (B. Hammond, Dudek, Lemen, & Nemeth, 2004). In its opinion, EFSA's scientific panel on GMOs agreed with the applicant that the sub-chronic 90-day toxicity study with rats fed on maize NK603 showed no consistent differences in the measured clinical, biochemical, and histological parameters. Despite differences in the GM fed rats in average corpuscular volume and haemoglobin in female rats administered with a high dose, EFSA agreed with Monsanto on the safety of NK603: "the applicant concludes that these findings are of no biological significance. The Panel accepts this as a reasonable interpretation of the data" (EFSA, 2003, p. 9). EFSA'S GMO panel considered Monsanto's test results as sufficient to evaluate the safety of NK603 and its derived products for food and feed ingredients and concluded "the information made available by the applicant as sufficient to evaluate the

present actions and experienced or perceived as obdurate (Blumer, 1990; Strauss, 1985). Structures are based in the commitments of individual actors to collective action (Strauss, 1982), such as procedures and institutions of risk assessment. Yet, structural aspects are not unchanging, they just change more slowly than other aspects of social situations.

safety of NK603 maize […]. Therefore, additional experimental studies are not deemed necessary" (EFSA, 2003, p. 11).

The allocation of epistemic authority within the official institutional context of EFSA's work as scientific arbiter did not remain uncontested, however. There was doubt to the risk assessment outcomes and EFSA's evaluation thereof. Gilles-Eric Séralini, a French scientist of molecular biology, with a history of research in endocrinology and carcinogens, together with his colleagues at the University of Caen, re-analysed the data provided by Monsanto. They found dose-related and sex-dependent effects in kidney and liver parameters (de Vendomois et al., 2009).[41] To Séralini and his team, their findings constituted a sign of toxicity, but not a proof. Rather, they described three shortcomings of rat-feeding risk assessment studies: First, they pointed to the lack of reproduced test results. For NK603, such a feeding study had been conducted only once and on one species of mammal. Second, they criticised the low statistical power of Monsanto's experimental design and the statistical tools applied to the data. Third, they deemed the study length of 90 days as experimentally too limited because it merely covered acute and medium-term toxicity. Instead, the researchers concluded that carcinogenesis and endocrine disrupting effects would only show with prolonged tests: "long-term (up to two years) feeding experiments are clearly justified and indeed necessary" (de Vendomois et al., 2009, p. 715; cf. Séralini et al., 2009).[42]

Séralini and colleagues questioned the methodological norms of the 90-day feeding study they re-analysed: generally, the conventions for justified interpretations of biological relevance and the possibility of making inferences based on the assumption of dose-response relationships. More specifically, they shed a critical light on the statistical methods and test design of 90-day toxicity studies for producing false negatives in particular because of study length (cf. Doull et al., 2007; Séralini et al., 2009). The only option Séralini saw was to conduct a long-term study (interview Séralini, 2012). Although each side accused the other of not doing proper science, public debate on these issues failed to emerge. The controversy remained confined to the realm of peer-reviewed scientific publications where the fate of Séralini and colleagues' critical stance was side-lined as not contributing new and reliable scientific knowledge (Doull et al., 2007; EFSA, 2007d). At the time the authorisation for NK603 was due for renewal, EFSA did not take into account the possible shortcomings of

[41] De Vendomois et al. (2009) compared the data for three different GM corn varieties: NK603, MON810, and MON863. For each of the original safety studies, they found inconsistencies and uncertainties in the data interpretation and concluded that existing toxicological research models lack the rigour to explain the signs of toxicity they had found.

[42] In another re-analysis of a different risk assessment study on MON863, an insect-resistant GM maize, Séralini and colleagues (2007) offer similar criticisms about methodological standards: the interpretation of biological significance and subsequent inferences about biochemical data, the choice of statistical model and tools, as well as the composition and size of rat-feeding test groups. Similar to the case described here, EFSA reviewed the study, but refuted it as flawed. EFSA did not consider the re-analysis by Séralini and colleagues as relevant and providing new insights into the toxicity of MON863 (EFSA, 2007a, 2007b, 2007c, 2007d). Séralini noted that EFSA neglected important insights his study had provided: "they had seen some mathematically significant effects but they did not see these were biologically relevant. I disagree; the arguments were nonsense for us as a scientific community working on endocrine disruptors. There was no way out of the debate except to prolongate the tests to see whether these signs would be effectively transformed into disease, or not" (interview Séralini, 2013).

90-day rat-feeding studies and accordingly re-authorised NK603 (EFSA, 2009). This however, was not the end of the contestation about risk assessment of GM crops based on toxicological feeding studies.

Since NK603 had already been authorised, neither would companies conduct such long-term tests, nor would regulatory authorities deem them necessary. At the time, there were only few studies on the potentially adverse health effects of the Glyphosate exposure to humans. At the same time, scientific studies had found residues of the herbicide in parts of the population not involved in agricultural activity, e.g. in the blood of pregnant urban women (Aris & Leblanc, 2011). From 2008 on, Séralini accordingly called on "civil society, food stores, and environmental foundations to raise the funds for such an experiment on the long-term effects of GMOs and Roundup" (interview Séralini, 2013). In 2010, Séralini and his colleagues at CRIIGEN[43] embarked upon a long-term feeding study in their laboratory at the University of Caen in France. On 19 September 2012, they published the results on the assessment of toxic effects of the transgenic herbicide tolerant maize NK603 and the associated pesticide Roundup™ based on a two year rat-feeding study in the international peer-reviewed scientific journal *Food and Chemical Toxicology* (FCT).[44] The CRIIGEN researchers presented their work as a contribution to the debate on the length of mammalian risk assessment feeding studies on the potential long-term toxicity of GM plants (Séralini et al., 2012).

The study followed 200 rats over almost their entire lifespan for two years. Three groups, each consisting of ten male and ten female rats, were given feed containing three different doses (11, 22, and 33 per cent) of Roundup-tolerant GM maize NK603 alone. Three more groups received feed containing the maize treated with Roundup™, and three groups were fed drinking water containing Roundup™ alone in low doses (below the level permitted by regulatory authorities in drinking water). The control group of twenty rats was fed with an isogenic non-GM diet containing 33 per cent maize and was not exposed to Roundup™. The paper stated a higher hormone and sex-dependent lethality of the treated groups, problems with tumours in reproductive organs and disruption of sexual hormones in females, liver damage in males, and kidney damage in both males and females. In short, the study showed that rats feed with NK603 and treated with Roundup™ were more prone to develop

[43] The Comité de Recherche et d'Information Indépendantes sur le génie Génétique (CRIIGEN) describes itself as an international group of interdisciplinary working experts on the risks of genetic engineering, pesticides, and endocrine disruptors. With its prime objective to protect public health and the environment, CRIIGEN conducts studies and 'counter-assessments' on the risks of these technologies. The organization wants to address the secrecy in risk assessment to "expose the inadequacies of our current assessment system" (CRIIGEN, 2015). CRIIGEN has been consulted by a number of national ministries of environment and agriculture, the EU, consumer and retail organisations, as well as environmental protection groups. On various internet sites, commenters accuse Séralini and colleagues of partisanship because of CRIGEN's links to advocacy groups such as Greenpeace and organic farmers unions (Bailey, 2011; Worstall, 2012a).

[44] Séralini explained in an interview the rationale for including the pesticide Roundup, which is usually applied to herbicide tolerant crops, in the long-term feeding experiment: "Only Glyphosate, the so-called active principle has been tested in the long-term by the company. But Roundup contains dozens of components and some of them we found in vitro, and these are up to ten thousand times more toxic than Glyphosate" (interview Séralini, 2013). See, for instance on the toxicity of surfactants in Glyphosate formulations: Bradberry, Proudfoot & Vale (2004)

cancers and to die earlier (50-80 per cent lethality) than the control group (30 per cent lethality) in the long run. The researchers concluded that these findings could be explained by the "non-linear endocrine disrupting effects of Roundup™ and by the overexpression of the transgene in the GMO and its metabolic consequences" (Séralini et al., 2012, p. 4221). This means the researchers reasoned the biochemical and physiological disturbances observed in the experiment were possibly related to GMO and Roundup™ treatments in both sexes with different amplitudes. To them, this prompted the need for further long-term studies to measure potentially toxic effects, because the differences between test and control groups became significant only after four months. Séralini and colleagues therefore argued that in standard 90-day feeding studies, these effects would remain unobserved. Risk assessment instead needed extension by long-term studies.

The findings of Séralini et al. sparked a huge media spectacle. Various speakers, from news commenters, to industry representatives, media outlets, and civil society organisations made claims about the paper and the scientific authority of its authors. The public debate was as much about the paper's findings as it was about the question whether the publication constituted reliable and legitimate scientific knowledge about the potential health impacts of GM crops. This is important because the scientific status of such a publication can have direct impact on regulatory decisions with potentially severe "political, financial and social consequences" (Vidal, 2012). For instance, as a reaction to the publication, Russia banned the import of all US maize (Poulter, 2012), Kenya issued an indefinite ban on all GM crops (Willingham, 2012), and France considered requesting the suspension of the authorisation of NK603 if the study's conclusions were proven valid (20minutes, 2012). Activists from Friends of the Earth demanded the EU to stop importing GM maize, arguing that new scientific findings justified legitimate public health concerns (FoE, 2012). The study had an impact on the Indian GM crop debate, too. In July 2013, India's Supreme Court appointed Technical Expert Committee (TEC) that investigated the implications of GM crop technology for India's agriculture, recommended an indefinite moratorium on field trials with GM crops. The TEC report explicitly referred to the Séralini et al. paper as scientific proof of possible health effects of GM crops (Siddiqui, Chauhan, Kesavan, Ramakrishnan, & Sivakumar, 2013). The ensuing analysis chronologically traces the debate about Séralini et al. (2012) to show which actors raised what issues throughout the controversy.

Questioning Séralini: politics, not science?

On the day of the publication, Séralini and colleagues held a press conference to publicly announce their findings. Simultaneously, they also launched a book (Séralini, 2012) and a documentary (Jaud, 2012) about the study. Both were directed at a broader non-scientific audience.[45] Some perceived this as an unconventional "public relations offensive" (Nature, 2012)

[45] These publications portray the current regulatory system as not geared towards sufficiently investigating the risks of GM crops and agricultural pesticides. Drawing parallels between the risks of GM crops and those of nuclear energy, the book and the documentary make the argument that transnational corporations experiment with dangerous technologies, using society and the ecosystem as a laboratory for generating profit. The imaginary of complex ecology (and to a lesser extend the imaginary of seed sovereignty) that I describe in

and criticised the press conference as a "tightly orchestrated media event", irresponsible to the public and inappropriate for an objective scientific debate (Butler, 2012a). Within hours of the press conference, publicity about the potential toxicity of GM crops and Roundup™ spread through news and social media (cf. Arjo et al., 2013). French newspaper *Le Nouvelle Observateur* titled: "*Exclusif: Oui, les OGMs sont de poisons*" (= Exclusive: yes, GMOs are toxins). The article described the study as a bomb for the GM industry since it revealed that scientific risk assessment so far had fallen short of sufficiently proving GM maize to be free of health risks (Malaurie, 2012). Other news items presented the paper as a "shocking new cancer study", alleging that Roundup™ and NK603 "can cause tumours, multiple organ damage and lead to premature death" (Zuke, 2012). These contributions presented the study to scientifically confirm the potential toxicity and carcinogenicity of GM crops.

The *New York Times* took a more critical turn on the publication, questioning the study's methodology and experimental setup, in particular the size of the test groups and the rat strain being used for the experiment (Pollack, 2012).[46] These issues came back repeatedly throughout the debate. Within hours of the publication, a commenter on economics and public policy titled in *Forbes Magazine*: "Real scientists deeply unimpressed – politics, not science, perhaps" (Worstall, 2012a). This rhetorical construction of 'real scientists' who did not confirm Séralini and colleagues' findings implicitly accused the latter to be 'fake scientists'. Even more so, rendering the study politically motivated explicitly invoked the boundary between science and politics to question Séralini and colleagues' trustworthiness and the reliability of their science. The author not only questioned the study's statistical inferences and experimental design, but also Séralini's integrity and the scientific merits of the publication: As the research had been funded in part by environmental organisations such as Greenpeace, its audience should remain sceptical about the impartiality of the CRIIGEN researchers who, according to the author, shared attachments with anti-GM advocates and thus pushed their agenda against GM crops on unscientific grounds.[47] In his article, Worstall further mobilised the boundary between science and politics: he deemed those supportive of the study's scientific status were non-scientific radical political activists such as "militant […] organic farmers" (ibid.). That view presented Séralini's study to be part of a political campaign in which the researcher was presented to push a politically motivated campaign against GM crops, in which activists tried to invest their arguments with an image of neutral and objective science. Since he located Séralini within such a political network, Worstall rendered the long-term study outside the space of legitimate, objective and impartial knowledge production. The

chapter three on sociotechnical imaginaries in the GM crops debate, clearly informs the arguments in the book and the film.

[46] I am aware news media themselves are not a neutral vehicle of communication of news events to wider publics and other actors. Rather, media agencies and companies have their own interests, agendas, and attachments leading to editorial bias in news reporting (Herman & Chomsky, 1988). Although the news media certainly had its own role in translating the dispute over toxicological test protocols into a definite statement on the toxicity and carcinogenicity of transgenic crops, an analysis of the way specific news agencies represented the debate is not part of my analysis.

[47] Similar accusations had been aired against Séralini in the past. Those opposing Séralini's 2012 publication as unscientific pointed to sources that had previously described Séralini as a "Greenpeace financed scientists" (Bailey, 2011) to draw a narrative of environmental groups' political interests influencing research via funding, and thus compromising the scientific integrity of such research.

fiercest of criticisms indeed appeared within the first few days after the study's publication. It came not only from news commenters, but also from representatives of GM producers.

On 19 September, the day of Séralini's press conference, EuropaBio, the largest advocacy organisation for European biotechnology industries based in Brussels (EuropaBio, 2014a), issued a press release which stated that long-term health effects of GM crops had already been investigated sufficiently.[48] The text refers to authoritative international regulatory institutions such as EFSA, the European Commission and the WHO, which had sanctioned the existing 90-day rat-feeding study as a sufficient and legitimate standard for toxicological risk assessment, to argue long-term toxicity testing was unnecessary (du Marchie Sarvaas & Desaint, 2012). These industry voices used toxicological standards and guidelines to deem Séralini's study unreliable. As Demortain (2013) explains, established testing standards in toxicology are a resource of authority and credibility to argue for preserving the status quo of testing practice in the face of competing expertise that arises in controversies. I will come back to the issue of standards in the debate again further below. Similar to early critics in news media, EuropaBio associated Séralini and colleagues with anti-GM campaign groups, referring to his previous work on GM crops, thus alleging "predetermined bias of the experimenters and the funding groups" (du Marchie Sarvaas & Desaint, 2012).

This line of critique directed at Séralini and colleagues gained further momentum in the days following the publication. Commenters in news media labelled the study politically motivated, as an outcome of value concerns of the involved scientists rather than their serious engagement with facts. In another news comment on September 20, Worstall described the study as "nonsense" and "not very good science" (Worstall, 2012b). He further contrasted the politics of the publication with the existing facts about health impacts of GM crops established by a decade of biomedical research. Worstall explicitly demarcated the paper as non-science while others accused Séralini and colleagues of intentionally misrepresenting results in a news editorial on September 25: "Séralini […] has crossed the line from merely performing and reporting flawed experiments to committing gross scientific misconduct and attempting fraud" (Miller & Chassy, 2012). Another news comment described Séralini's paper as obscuring scientific facts and objectivity by putting forth "pseudoscientific claims", comparing the publication's "emotionally charged, politicised discourse" (Kloor, 2012) to the rhetoric of climate-change sceptics and the anti-vaccine movement, and therefore to non-scientific conspiracy theories.

The argument was that Séralini's research and presentation of his findings were influenced by funding streams and the political values of environmental groups. To the director of GM advocacy organisation EuropaBio, Carel du Marchie Sarvaas, the Séralini et al. (2012) publication was a politically motivated research intended to generate "hysteria". In an interview he explained the study not to be proper science: "it is fake science, activist science that follows the money […]. It is paid for by actors with a vested interest in preventing GM products on the market" (interview Sarvaas, 2012). Presenting Séralini and colleagues as bound up with the interests of environmental NGOs through funding streams allowed the study's opponents to render it illegitimate and unreliable (similar arguments had been made against Séralini previously, see e.g. Bailey, 2011). For part of the funding came from actors

[48] EuropaBio is criticised by civil society activists as a biotechnology industry lobby group (Powerbase, 2010a).

who advocate against GM crops, Séralini's opponents deemed the publication as value laden, politicised, and ultimately unscientific. They opposed this image to an idea of fact-based and ideology-free science. The Europabio representative clearly explained the view that Séralini's publication was the result of science aligning with political activism: "it is paid-for activist science. He [Séralini] is a charlatan, it is fake science" (interview Sarvaas, 2012).

Despite these *ad hominem* arguments about the researchers' allegedly shared values with the political agenda of anti-GM groups on the political left, news media and corporate voices critical of the study unequivocally came up with very similar methodological criticism: the experimental design and interpretation of results had been erroneous, the statistical model employed was inadequate and lacked significance, the number of rats were too few, and the strain of rats was known to develop cancer in later stages of life (du Marchie Sarvaas & Desaint, 2012; Kloor, 2012; Pollack, 2012; Worstall, 2012b). [49] The uniformity of this methodological critique can be explained by looking more closely at the sources these commenters referred to. All of them quoted from or drew on a press release issued by the Science Media Centre (SMC) on 19 September, the day of the publication (ScienceMediaCentre, 2012a).[50] The SMC press release cited a number of scientists critical of the Séralini study with regard to methodology. They questioned the study for lacking statistical significance, and the interpretation of results as biologically irrelevant. They also pointed to errors in data reporting suggesting that the extrapolation of the study's findings were unwarranted. Other arguments referred to the use of the Sprangue Dawley (SD) rat strain as unsuitable, the size of the control group as too small, and unethical treatment of the animals in the long-term feeding experiment.

The SMC, a public institution dealing with the public perception of science and technology, has been criticised for being biased towards industry interests and for receiving funding from the corporate sector (CEO, 2012b; CMD, 2014; Powerbase, 2015b). Also, the scientists cited in the SMC press release appear to have ties with the biotech industry. For instance, Powerbase website which is critical of corporate influence on public policy, lists Professor Maurice Moloney as having previously worked for biotechnology companies Calgene, Monsanto, and SemBioSys where he developed medical GM crops (Powerbase, 2014b). Dr. Wendy Harwood worked at the Department of Crop Genetics at the John Innes Centre, a

[49] A paper published in the Journal of Cancer Research and Clinical Oncology in 1979 showed that the Sprangue-Dawley rat is prone to developing endocrine cancers (86% in males and 72% in females) in later stages of life (Suzuki, Mohr, & Kimmerle, 1979).

[50] UK based Science Media Centre (SMC) was founded in 2002 as part of the Royal Institute of Great Britain which concerns itself with the public perception of science. In 2011, SMC became an independent charity that aims to improve evidence based media reporting on science and technology "for the benefit of the public and policy-makers"; SMC's mission is to stimulate the interaction between scientists, policy-makers, and journalists over issues of science and technology (ScienceMediaCentre, 2012b). SMC has been widely criticised by civil society activists for uncritically promoting GM crops (GMwatch, 2012g; Latham, 2014). The Centre for Media and Democracy (CMD) describes SMC's news as one-sided and uncritically supporting industry positions (CMD, 2014; Sourcewatch, 2012). Journalism scholars have also criticised SMC for lack of integrity and quality of its reporting, and for bias towards industry interests, essentially making it a publicity outlet that ignores disagreements and uncertainties in scientific controversies (Callaway, 2013; Fox & St.Louis, 2013).

plant biotechnology research organisation that develops commercial GM products and engages in science communication publicity activities about GM technology (Hickman, 2012; JIC, 2015; Powerbase, 2012). Another scientists cited by the SMC's press release, Professor Anthony Trewavas also works as a GM scientist and according to corporate critical sources, has a history of involvement with GM industry public relations campaigns (Matthews, 2012; Powerbase, 2009a). In the past, Trewavas had already played a leading role in attacking scientists who published controversial results that indicated potential health effects of GM crops at the end of the 1990s.[51] Such structural relationships between certain scientists and industry, as well as the material and social attachments that come along with such ties can explain these scientists' interest in rendering Séralini et at. (2012) untrustworthy.

The SMC press release foreshadowed a development in the debate that would become central in the controversy about the publication later on: The scientists cited did not only make arguments about methodological shortcomings in experimental design and statistical analysis, or the interpretation of biological relevance in Séralini's study, but they also questioned whether the publication process of FCT was up to standards. They doubted the quality checks of science as such by questioning the scientific merits of the peer-review process and the publishing journal. For instance, Moloney commented that the paper should not have been published considering its anomalies, in particular its statistical weaknesses, which should have been discovered in the peer-review process (ScienceMediaCentre, 2012a). Also, founding member of EFSA Herman Koëter, upon reading the publication and finding it "rubbish again", asked himself: "How the hell does he [Séralini] get published in *Food and Chemical Toxicology*, which is a well-known, established, good quality scientific journal?" (interview Koëter, 2012). Yet, arguments about the quality of the review process only came up later in the debate again. First, methodological issues remained at the core of the debate about the study's status as reliable scientific knowledge.

Less than a week after its publication, two molecular biologists, although not toxicologists themselves, suggested in news comments that the study was "methodologically flawed, irrelevant, uninterpretable" and called for retracting the "fraudulent" paper from FCT because they deemed the publication unscientific (Miller & Chassy, 2012).[52] Miller and Chassy

[51] Most notably, Trewavas was a leading figure in attacking Arpad Pusztai and Ignacio Chapela, scientists who had identified signs of toxicity in GM potato rat-feeding experiments and who argued for more rigorous testing in 1998 (Ewen & Pusztai, 1999; see also, GMwatch, 2012b). Activists accuse Trewavas of bad scholarship for his agitation against organic agriculture without referring to supporting evidence and proper peer-reviewed studies (Powerbase, 2009a). Moreover, in 2001, Trewavas lost a libel case in which he was found guilty of making unfounded allegations against Greenpeace, UK for spreading fears of GM food for financial interest (TheGuardian, 2001).

[52] Henry Miller is a molecular biologist who was amongst the founding members of the Office of Biotechnology at the US Food and Drug Administration (FDA). The FDA in turn has been target of criticism by activists and civil society organisations such as the Organic Consumer Association for not being rigorous enough in its risk assessment of GM crops and generally being in favour of industry interests (Kaldveer, n.d.). Miller is not a toxicologist, but worked as a lecturer in philosophy of science and public policy at Stanford University. Bruce Chassy is equally not a toxicologist, but worked as a researcher in biochemistry and molecular biology at the University of Illinois until his retirement in 2012. Chassy has worked as a consultant for GM companies and was engaged in public relations campaigns for Monsanto to promote GM crops, he also continued to appear as an independent expert on GM crops on industry- financed platforms (Gillam, 2016; Vidal, 2012). In a newspaper interview from 2010, he accused the anti-GM movement as being anti-science:

further argued in accordance with Monsanto Company, that the display of photographs of tumorous rats generated lurid media coverage of what was presented as spectacularly disturbing results in order to create a media hype and scare the public (Miller & Chassy, 2012; Monsanto, 2012a; displaying photos of laboratory animals indeed is unconventional for scientific publications, see figure 5 below). Miller and Chassy did not only appear as news commenters but along with Trewavas, they were cited in the SMC press release as experts. Miller and Chassy also appeared amongst the signatories to a letter to the editor of FCT that asked for the retraction of Séralini et al. (2012) later on. I will come back to this letter in more detail further below.

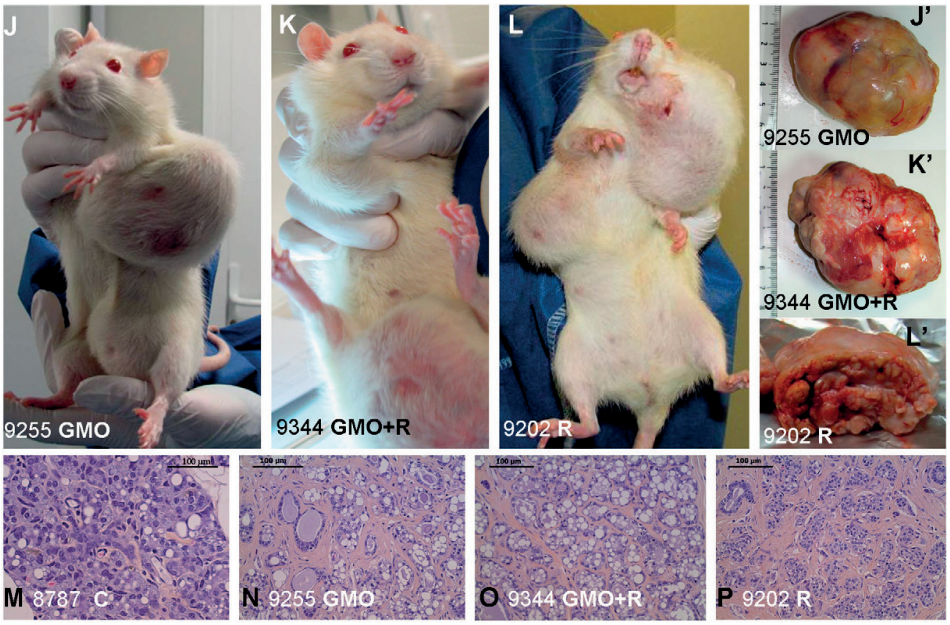

Figure 5: Display of rats with mammary gland tumours, organs, and cell mutations of laboratory rats (Séralini et. al., 2012, p.6)

The German Federal Institute for Risk Assessment (*Bundesinstitut für Risikobewertung*, BfR), as well as Monsanto Corporation, the producer of NK603 and Roundup™, commented on the study within a few days after the publication, too.[53] The BfR had provided a positive evaluation of Monsanto's risk assessment study (B. Hammond et al., 2004) that led to the approval

"their objective to scare people about GMOs, not to advance science" (Tribe, 2010). Later in the public controversy, Miller and Chassy both were signatories to a letter to the FCT editor demanding retraction of Séralini et al. (2012) (Wager et al., 2013).

[53] Tracing the exact dates of the press releases referred to in this paragraph proved to be a challenge. While the BfR's document officially dates 28 September (BfR, 2012), and Monsanto's 1 November (Monsanto, 2012a), both documents were available online at least five days after the publication of Séralini et al. (2012) and were later updated. A dated reference is provided by GMWatch on September 24 (GMwatch, 2012f) which explicitly comments on Monsanto's press release. The latter in turn refers to the BfR statement, which allowed dating the publication of both documents to September 24, the latest.

of NK603 in the 2003 regulatory process. [54] Accordingly, the BfR issued a press release to comment on the added value of Séralini et al. (2012) for the existing scientific knowledge on the potential health effects of NK603. The BfR argued that deficiencies in study design, interpretation, and presentation of the results did not justify the study's conclusions: "the author's main statements are not sufficiently corrobated by experimental evidence" (BfR, 2012, pp. 1-2). More specifically, the BfR criticised the number of rats being too few, and the overall number of test animals not being in line with international standards for long-term feeding studies. It also commented the SD rat is expected to develop cancers if fed *ad libitum*, that the dose of Glyphosate intake was not recorded, and that the raw data provided in the publication were incomplete, which made replicating the analysis impossible. These arguments were largely in line with what Monsanto Corporation argued.

Monsanto's press release drew on the BfR statement and agreed that the study's data did not support its findings. Instead, its conclusions were unwarranted and irrelevant for risk assessment considerations. The company's statement further constructed itself to draw on neutral science. It presented those scientists mentioned in the SMC press release as expert views, labelling them: "toxicologists and public health experts", who upon reviewing the study, had found "fundamental problems" (Monsanto, 2012a). Despite repeating the criticisms about study design and interpretations of biologically relevant dose-response relationships, Monsanto's press release added more critique about method: It suggested that historical data from previous risk assessment studies constituted sufficient evidence for the safety of NK603 and Roundup™ while the key shortcoming of Séralini et al. (2012) was not to take these historical data into account, and not adhering to OECD testing guidelines. How can we understand the critique about method, experimental set-up, statistical analysis, the scientists himself, and the scientific merits of the publishing journal?

We can explain the rhetorical strategies of Séralini's opponents by drawing on what Gieryn describes as "expulsion" boundary work (Gieryn, 1999, pp. 15-17), which aims at policing the boundaries of legitimate knowledge production and the proper norms of scientific conduct. Expulsion efforts focus on a knowledge producer's failure to conform to proper scientific practice in terms of methodological standards (the experimental design, the choice of rats, or the composition of test and control groups), instruments of measurement (such as the statistical model), or the notion of objectivity (non-adherence to international testing protocols and lack of scientific integrity because of funding). Expulsion is not about denying the legitimacy of science as such, but it aims at demarcating who belongs to the privileged arena of science and who does not. The news commenters, corporate representatives, regulatory authorities, and the producer itself that I cited above implied judgement as to what legitimate and reliable science is by referring to the role of methodology, study design, standards, and by pointing to historical data. The SMC press release, the statement by the BfR, and Monsanto's press release were very similar in their critique. By drawing on the network of texts from supposedly neutral scientists, regulatory institutions, international testing guidelines, and standards of good laboratory practice, these actors located themselves

[54] For a GMO application under EU Directive 2001/18/EC, the applicant first submits a risk assessment dossier to a national regulatory authority (in case of NK603 to the German Federal Institute of Risk Assessment – *Bundesinsitut für Risikobewertung* (BfR)) which provides an initial risk assessment report for the European Commission.

within that space of science which allowed them to deny that location to Séralini's rival epistemic account. In the case at hand, this was not only about scientific standards and methods. Expulsion boundary work also happened through *ad hominem* arguments. By labelling the scientists' integrity compromised, and by locating Séralini and colleagues within (subjective) values and politics rather than (objective) facts and science, these actors established rhetorical boundaries so as to expulse Séralini from the domain of reliable and trustworthy knowledge production. The most obvious examples constituted the accusation that the study's outcomes were predetermined because funding for the experiment had been obtained from actors who oppose GM crops, and the accusation that Séralini himself was not interested in the potential toxicity of NK603, but that he wanted to support the anti-GM crops campaign. Yet, there was more expulsion boundary work at play.

The arguments about toxicological standards and the peer-review process show that boundary work went beyond rhetoric, but also involved structural aspects and sociotechnical associations as indicated by Bijker et al. (2009). For instance, representatives from DG SANCO explained in an interview that current regulatory risk assessment is in line with international toxicological standards, which offer extensive and detailed insights in order to make definite statements on the toxicity of GM crops: "we have tests that go from acute toxicity for a few days up to a 90-days study; we have very good visibility and understanding of the potential for toxicity of the product along the whole life. So it is a totally appropriate" (interview DG SANCO, 2013). Drawing on testing guidelines allows labelling any form of knowledge production that deviates from such standards untrustworthy and unreliable – (non-) adherence to toxicological study protocols and standards consequently allowed expulsion boundary work to play into the sociotechnical associations of risk assessment, rather than only rhetorically excluding Séralini from reliable knowledge production.[55] Yet, others oppose this perspective and instead point to the structural problem that for risk assessment considerations, regulatory authorities rely too heavily on experts who have ties to the GM producing industry: "regulatory agencies like for instance EFSA think that the best scientists are working for the industry, because they are better paid. So, if we want to have the best scientists, we need to have scientists from the industry" (interview Gall, 2013). Activist Bekkem from Greenpeace explained further that because of this reliance on industry experts, the Séralini study was not unreliable but instead revealed the regulatory system's structural shortcoming in "lacking the capacity for assessing the long-term impacts of GMOs. Industry studies only focus on short-term impacts […] that serve as a model for human consumption for longer periods" (interview Bekkem, 2013). So, there was not only scepticism as to the scientific merits of the publication.

[55] STS research has shown that boundaries get built into, for instance organisational structures (Guston, 2001) and materialise in buildings and architecture (Gieryn, 2008). Similarly, I suggest here that test protocols and toxicological standards have boundaries of how to distinguish good and reliable from bad and untrustworthy science built into them. Although my data is largely in line with the idea that boundaries are discursively constructed, the special role of technical standards and experimental guidelines make the sociotechnical associations that are more than discourse.

Defending Séralini's Scientific Integrity: the politics of science

The opponents of the study made arguments about study design, methodology, and interpretation of data. This allowed them to situate the CRIIGEN researchers not as fact-based scientists, but as value-driven actors who used science for politics to locate Séralini et al.'s study in the realm of non-science. The supporters of Séralini however, made arguments why the paper should be taken seriously: they replied to methodological considerations, questioned the notion of legitimate expertise in toxicological risk assessment, and critically examined the role of toxicological test protocols and standards. Doing so, they drew the line between science and politics differently. Mute Schimpf, campaigner for Friends of the Earth Europe suggested that "clearly there was a political interest to discredit Séralini's science, disregarding the content of the critique" (interview Schmipf, 2012). I have described the immediate reactions of those who took up Séralini's publication as scientific proof of the potential health effects of GM crops and Roundup™ in the introduction. Let me now turn to the replies to the critique raised against the long-term feeding study and how various actors defended the scientific status of the study within the first week after its publication. The most prominent replies stem from the corporate critical organisation Corporate Europe Observatory (CEO)[56], the advocacy group GMwatch[57], Member of European Parliament Corine Lépage[58], and from the CRIIGEN team of researchers themselves.

One of the methodological bones of contention was the scientific originality of the feeding experiment. Séralini et al. and their supporters explained that the long-term study was the first of its kind as a scientific "life-long toxicological experiment that studies all pathologies" (CRIIGEN, 2012; cf. Lépage, 2012a; Vidal, 2012). Mute Schimpf from Friends of the Earth, Europe agreed it was "the first time a serious study had a long-term scope and came up with results" (interview Schimpf, 2012). The anti-GM website GMwatch went further in rendering the critics' reference to historical data from previous feeding studies inappropriate and unscientific. To them, the long-term study was unique and could not be compared to historical data from short-term toxicity studies of other transgenic varieties using different animals: "it is scientifically incorrect to compare this long-term study with this particular variety of GM maize to other investigations using different GM feeds and different animals" (GMwatch,

[56] Corporate Europe Observatory is a charitable institution that describes itself as a research and campaign group which aims at uncovering the influence of business lobbies on policy-making in the European Union. By exposing corporate influence in various policy fields, CEO aims to address questions about corporate power in policy-making, environmental problems, and issues of poverty and social justice (CEO, 2012b; n.d., interview Sanchez, 2013).

[57] GMWatch is a non-profit organization that „seeks to counter the enormous corporate political power and propaganda of the GMO industry and its supporters" (GMwatch, 2015). GMWatch provides the public with information and comments about GM foods and crops. Founded in 1998, it has received funding not from government or corporations, but from globalization critical and environmental NGOs, charitable foundations, and trusts such as the Courtyard Trust, Food Democracy Now!, Friends of the Earth Europe, Friends of the Earth UK, Isvara Foundation, and the Soil Association, amongst others .

[58] Corine Lépage, member of the Alliance of Liberals and Democrats for Europe group since 2009, was founding member of two French national political parties, *Citoyenneté Action Participation pour le XXIe Siècle* and *Mouvement Démocrate*. In the European Parliament, Lepage has given numerous speeches and parliamentary questions on various environmental and health issues such as GMOs (EP, 2014). Lepage has also been amongst the founding members of CRIIGEN (Lépage, 2012a).

2012h). This explicit construction of what counts as scientific made clear that the boundaries of legitimate and trustworthy science were constructed differently by those arguing for taking the study seriously. These actors also discussed the study's methodological issues, such as test design, the strain of rats, and the use of statistical tools in detail.

The notion of the appropriate scientific method, experimental design, and adequate measurement was as important for Séralini's defendants as it was for his opponents. For instance, Member of European Parliament and founding member of CRIIGEN Corine Lépage argued that the use of the SD rat was justified because it constitutes the standard for most carcinogenicity and toxicity risk assessment (Lépage, 2012b). GMwatch stipulated that the size of the control groups had been large enough to avoid false positives. Instead, that critique applied to industry-commissioned risk assessments which often show deficiencies in reference group composition (GMwatch, 2012f, 2012h). Séralini and colleagues themselves justified their test model in similar terms: the SD rat is commonly used in toxicity testing worldwide; and the size of control groups followed OECD recommendations; the feeding experiment therefore was similar to the design of studies that led to the authorisation of GM crops (CRIIGEN, 2012). Defending the SD rat as an adequate test model is closely linked to the statistical analysis of the study's data set, as well as the issue of historical controls.

Séralini's defendants argued the statistical tools employed in the paper were more varied than those in 90-day studies and therefore constituted a valid method for explaining the qualitative and quantitative differences in the development of pathologies between test and control groups. In that sense, the reference to historical control data from previous risk assessment studies of GM crops was "an unscientific strategy used by the industry and some regulators to dismiss statistically significant findings of toxicity" (GMwatch, 2012e). GMwatch argued that although the practice of historical controls had been introduced by the OECD, these standards were methodologically insufficient for reliable comparisons. The opponents' reference to historical controls were flawed because the case-to-case principle of GM biosafety testing implies that "generalization about safety and testing of GE crops is not scientifically justified based on the review of several studies", as a member of the Union of Concerned Scientists noted (Gurian-Sherman, 2012). Supporters of Séralini instead referred to "an expert statistician" (GMwatch, 2012h) being member of the CRIIGEN research team to construct the study's methodological reliability.

Within two days after the publication of their study, the CRIIGEN researchers issued an informal reply to their critics in which they explained to have followed "a logical scientific method". although they admitted low statistical power of comparing ten treated rats to ten controls, they still believed "to have conducted the highest performance statistics for biochemical data analysis" (CRIIGEN, 2012, p. 1). This is because they considered their statistical model as the "most modern method" to capture a large number of variables and to detect discriminate variables between test groups.[59] At the same time, they dismissed historical controls as too varied and numerous to be relevant comparators. Séralini noted that historical controls are useless because conventional laboratory rat feed used in industry studies is contaminated with toxic pollutants (Séralini, personal communication with author, 2017; see also Mesnage, Defarge, Rocque, de Vendomois, & Seralini, 2015). Instead, the

[59] Séralini and colleagues had chosen OPLS-DA (Orthogonal Partial Least Squares Discriminant Analysis).

pathologies detected in their study were "consistent and numerous enough not to be related to chance" (CRIIGEN, 2012, p. 2).

In reply to the question whether the paper lacked sufficient raw data for a reproduction of the test results, the supporters of Séralini and colleagues threw back the argument at their critics. The debate could only be scientific if the raw data of all risk assessments that led to regulatory approval became available: "Professor Séralini is committed to making public his raw data so that there is a real scientific debate, but only when producers of GMOs and public authorities respect the law and abandon the secrecy behind which they hide their own knowledge by making their raw data publicly available, too" (Lépage, 2012a). Séralini himself explained that he had given the raw data to the editors of FCT and that the producers of GM crops should accordingly make their data accessible to the scientific community for scrutiny and reproduction of results, too (interview, Séralini, 2013).[60] As long as the raw data of the initial market approval of NK603 remained unavailable, they regarded the criticism about lacking raw data of the long-term study as invalid.

While those opposing Séralini were quick to point to the role of values and politics to exclude the study from the realm of trustworthy science, Séralini's supporters shared a different notion of what makes legitimate expertise in toxicology: i.e. they described existing scientific risk assessment as corrupted by economic interests with industry funding, which allowed GM producers control over the publication of research findings. They opposed this to CRIIGEN's research as science free from corporate influence, and instead open to debate about toxicological findings. Accordingly, anti-GM campaign platforms such as GMwatch and GMfreeze[61] termed Séralini and colleagues "independent" (GMFreeze, 2012; GMwatch, 2012e, 2012h). Numerous civil society activists also described Séralini's work as "neutral" and "independent", i.e. autonomous from industry influence (interview Schmipf, 2012; interview Bekkem 2013). MEP Corine Lépage equally referred to Séralini as an "independent expert" and "whistle blower" with an "international reputation" who gets most fiercely criticised by "scientists working for biotechnology firms or who are responsible for the lax manner in which approvals have been granted" (Lépage, 2012a). Instead, Lépage wrote, the personal attacks against Séralini did not resemble "a real scientific debate" (ibid.). As a news comment put it, *ad hominem* arguments feature frequently in controversies that question established risk assessment findings: "the GM industry has traditionally reacted furiously and personally" (Vidal, 2012). The aim of pointing to the personal nature of such criticism and employing rhetoric labelling that presents the CRIIGEN researchers as independent is to construct their knowledge production as autonomous from industry influence, as transparent, and open to debate; and hence more legitimate than the existing risk assessment regime.

[60] EFSA first made the raw data, upon which NK603 was approved in 2003 and reapproved in 2009, available to Séralini in October 2012. As a move towards "greater transparency" in its decision-making process, EFSA finally made the data public for the wider scientific community in January 2013 (EFSA, 2012a, 2013a). As a consequence, Monsanto considered a lawsuit against EFSA for breaching confidentiality agreements (LeMonde, 2013).

[61] GMfreeze is a UK based campaign group that wants to stop all use and import of transgenic crops (GMFreeze, 2014).

As much as the notion of legitimacy through independence was raised to present Séralini and colleagues as trustworthy, their supporters equally denied the critics' the status of legitimate science. For instance, the research and campaign group CEO attacked the SMC press release on which many of the study's critics had drawn: It had quoted scientists who were unqualified in toxicology but instead directly connected to the GM industry. CEO argued that the bonds between such scientists and biotech and agro-chemical producers allowed the latter to stifle independent research on the risks of GM crop technology. Ultimately, this impacted the autonomy of EFSA's regulatory assessment too, because it relied on such expertise uncritically (CEO, 2012b). Other voices raised in the days following the publication similarly painted a picture of Séralini's independence versus EFSA's questionable scientific autonomy (CEO, 2012b; GMwatch, 2012c; Holland, Robinson, & Barbinson, 2012; cf. van de Water, 2012). Their argument was that the knowledge producing practices of industry-funded toxicological risk assessment were corrupted. Consequently, regulatory authorities could not be autonomous if they relied exclusively on knowledge produced by the applicants for the market release of GM crops. So, while Séralini's publication was heavily criticised for being politically motivated, the defendants of the study turned the critique about scientific independence back on the regulatory apparatus, i.e. EFSA itself.

In a study about EFSA's work, the Pesticide Action Network Europe (PAN)[62] alleges that EFSA relies too strongly on corporate-funded science and that it has bonds with industry lobby organisations: "EFSA easily embraces industry ideas while forgetting about their mission to protect people and the environment" (PAN, 2012). Presenting EFSA's experts as implicated with conflicts of interest was not new at the time of Séralini's publication in 2012. An investigation by CEO in 2011 had revealed that EFSA's GMO panel experts neither had the necessary medical expertise, nor were they free of conflicts of interest as defined by the OECD, when BASF's Amflora potato gained regulatory approval in 2010 (CEO, 2011). The controversy about the Séralini et al. (2012) publication allowed for a reinvigoration of this critique: in scientific risk assessment, regulatory authorities rely too much on industry data and on experts linked to those corporations that produce GM crop technology. This mistrust towards EFSA and its experts as risk assessors extends to the EU institutions of risk management, too. As an EU Commission policy officer on biotechnology explained to me in an interview: "Since DG SANCO works hand in hand with EFSA, we suffer from the domino effect, because if you don't trust the risk assessors, i.e. EFSA, you don't trust us". A DG SANCO biotechnology policy officer explained that relying on such experts to be unproblematic because EFSA "has one of the strictest declaration of interest regulations [..and] if you take a pure, absolute approach you do not take anybody" (interview DG SANCO, 2014). Yet, activists oppose this perspective. For instance, David Sanchez from CEO explained that EFSA's definition of conflict of interest is weaker than the OECD guidelines. Ultimately, it is at the authorities' discretion to decide on potential conflicts of interest of its expert panel members, while these in turn are "mainly dominated by biotechnology researchers, or people

[62] The Pesticide Action Network Europe is network organization that comprises of consumer associations, environmental organisations, farmers and trades unions from 19 European countries. PAN's aim is to reduce the use of chemical pesticides and to replace it with sustainable alternative pest control methods to protect public and workers health and reduce the impact of chemical pesticides on the environment (PAN, n.d.).

working with GMOs in a laboratory" (interview Sanchez, 2013).[63] The GM crops controversy has been a fertile ground for arguments about the close ties between certain scientists and the industry ever since its beginnings. This critique has culminated in civil society's demand for institutional reform of EFSA (Antoniou, Robinson, & Fagan, 2012, 2014; CEO, 2012d; Holland et al., 2012; Matthews, 2012; Robinson, 2013b; Robinson, Holland, Leloup, & Muileman, 2013).[64]

In toxicology, conflicts of interest have been identified as a problem more generally. Meta reviews of existing toxicological risk assessments point to a lack of scientific studies independent from industry influence (Domingo & Bordonaba, 2011). Others have found a positive correlation between experts' conflicts of interest and positive outcomes of their GM crop risk assessments (Diels, Cunha, Manaia, Saburgosa-Madeira, & Silva, 2011). Assistant to MEP Corine Lépage, Eric Gall described the consequences of these connections as "a filter to eliminate from public debate all uncertainties and doubts, and to make its [EFSA's] decisions appear as consensus" (interview Gall, 2012)[65]. On the one hand, Gall explained that accepting the long-term feeding study as reliable science would enable a transparent and open-ended debate, which could only advance scientific knowledge production. Admitting Séralini's study as trustworthy science would allow the scientific community to address uncertainties in toxicology. On the other, pointing to the potential conflicts of interest amongst EFSA's scientific experts allowed constructing Séralini to be independent from industry influence, and therefore his knowledge to be more reliable than that created by industry-commissioned studies. The aim of this way of constructing the legitimacy and trustworthiness of

[63] At the same time, several civil society activists argued in interviews that EFSA transgresses the boundary between risk assessment and risk management (for suggesting e.g. risk management strategies to the European Commission), which makes it not a purely scientific, but also a political actor (interviews Sanchez, 2012; Schimpf, 2012; Gall, 2013). Yet, in an interview, EFSA representatives were keen to emphasise the boundary between risk assessment and management, seeing EFSA to be legally commissioned with the former only (interview EFSA, 2014).

[64] A common statement by a group of environmental associations and organic farming networks such as Friends of the Earth Europe, Greenpeace Europe, PAN, the International Federation of Organic Agriculture, and others, asks for a fundamental institutional overhaul of EFSA: addressing conflicts of interests more effectively, establishing a "code of scientific practice", including independent studies instead of industry-commissioned tests, and more transparency, accountability, and public participation in risk assessment procedures (CEO, 2012d). CEO also accuses long-time GMO panel Chair Harry Kuiper to have used his position to influence the work of the panel in a pro-industry way (CEO, 2012b).

[65] In the aftermath of the controversy, anti-GM advocacy groups devote entire chapters about the Séralini et al. (2012) publication in their information and campaign materials. For instance, a publication by the campaign and information group Earth Open Source (Antoniou et al., 2014) dismisses the idea that Séralini et al (2012) was bad science as a 'myth'. The publication explains the meaning of independent research as 'independent of industry influence' and states that reliable studies are difficult to obtain because of the high costs of toxicological feeding tests and the GM industries' withholding of study data due to patenting and intellectual property concerns. This allows the industry control over critical risk assessment outcomes because positive evaluations are presented as non-verified "grey literature" and negative findings are unlikely to get published (pp.74, 89). Meta reviews of existing toxicological studies confirm the difficulty of labelling toxicological research independent because of industry funding (Domingo & Bordonaba, 2011). This creates professional and financial conflicts of interest that are likely to lead to risks assessments that confirm the safety of GM crops (cf. Diels et al., 2011). This critique provokes demands for radical institutional reform of EFSA on the side of civil society organisations and corporate critical NGOs (see for example Robinson et al., 2013).

science is to present the CRIIGEN researchers as autonomous from those conflicts of interest that corrupt established toxicological risk assessment. By referring to the notion of independence, the supporters of the CRIIGEN researchers wanted to present them as more credible and reliable experts than their critics. However, head of EFSA's GMO unit Elisabeth Waigmann did not agree with these allegations. She explained that institutional mechanisms aim at preventing conflicts of interest to impact the work experts do for EFSA: "EFSA is committed to both transparency and independence and on both accounts we are up to date. Our experts have to sign a declaration of interest annually and before every meeting […] we are well-guarded against violations of the principle of independence" (interview EFSA, 2014).

Séralini himself drew the boundaries of legitimate knowledge production and scientific debate along the lines of scientific disciplines. Most of his critics were not scientifically qualified, and therefore illegitimate to criticise his toxicological study: "75 per cent of our contradictors in FCT were plant molecular biologists who had never published before in toxicology […], an expert in plant biology has no background in toxicology" (interview Séralini, 2013). A few days into the debate, Séralini emphasised that legitimate critique in toxicology is bound not only by disciplinary conventions, but also by the mechanisms of peer-reviewed scientific publishing. To him, this made the difference between the hegemony of industry influenced knowledge production and proper scientific debate: "I am waiting for criticism from scientists who have already published material in journals […] on the effects of GMOs and pesticides on health, in order to debate fairly with peers who are real scientists, and not lobbyists" (Séralini cited in Reuters, 2012).

The third issue the defendants of the study discussed within the first couple of days after its publication was the role of toxicological test protocols and standards. While standards for toxicological test protocols have been questioned by various actors since the early 1990s, risk assessment experts have worked hard to reassert the value of standardised tests. Demortain (2013) explains that tactics such as the innovation of test design, incremental change, and consensual modification of test protocols have helped toxicological experts to limit the debatability of their expertise. As we see in the controversy about Séralini's (2012) publication, certain actors referred to toxicology test protocol standards in order to construct the notion of objective knowledge production and to justify the existing expert jurisdiction within the regulatory apparatus. At the same time, the long-term study's non-adherence to established toxicological standards allowed them to exclude it from trustworthy knowledge production. Yet, various actors had more to say about the role of standards.

Séralini's supporters discussed standards in a twofold way: On the one hand, they referred to OECD guidelines for long-term carcinogenicity testing to support the choice of rat strain and the size of test groups (GMwatch, 2012h). On the other hand, they questioned the role of established standards in toxicological risk assessment as insufficient, too limited, and therefore as inappropriate for demarcating reliable scientific knowledge. On September 24, GMwatch opposed toxicological standards to the notion of independent science:

> OECD protocols and GLP [good laboratory practice] rules are not, and were never meant to be, a hallmark of *good science*. Yet, industry and regulators misuse these two standards to dismiss studies done by *independent researchers* […]. Thus OECD protocols

> and GLP rules have become a shield for industry to protect it from findings of independent studies.
>
> (GMwatch, 2012f, emphasis added)

The supporters of Séralini accordingly conceived of standards as protecting GM producers' interest to protect the space of science from intruders that come up with alternative accounts for investigating possible health impacts of GM crops. In their view, Séralini's long-term study was the best example of such an intrusion. Its results disturbed the image of toxicology to know about the health effects of GM crops with certainty. Established test protocols instead were used as a gold standard with which to deprive Séralini of scientific credibility. Yet, an industry representative contended that although rules and standards are reasonably set, the complexity of protocols and costs for testing imply that "only large companies can do it" (interview Sarvaas, 2012). Séralini opposed this view because most product assessments do not follow OECD guidelines very strictly. Further, he alluded these protocols' inherent assumption of dose-response relationships is misguiding because the toxicity and carcinogenicity of endocrine disruptors is not proportional to dose: "there is not always proportionality to the dose in the effects, for example in hormonal effects" (interview Séralini, 2013). Questioning this fundamental assumption of toxicological risk assessment in turn emphasised the need for experimenting with different research methods and test designs, just as Séralini et al.'s long-term study had suggested. In that vein, the CRIIGEN researchers had presented their study as a contribution to the debate on the length of mammalian feeding studies on the potential long-term toxicity of GM plants and not as a proof of carcinogenicity (interview Séralini, 2013).

It is worth noting that Séralini, before he conducted the long-term study on NK603 and Roundup™, in his earlier work on other GM crops, already had questioned toxicological risk assessment standards for not adequately scrutinising biologically relevant effects. A 90-day rat-feeding study on the toxicity of GM maize MON863[66] that had initially been conducted by Monsanto, and which had followed OECD, WHO, and FAO standards, did not assign biological relevance to any of its pathological findings (Monsanto, 2003). Hammond et al. later confirmed "the absence of unintended effects" (2006, p. 149) and EFSA's GMO panel agreed that the feeding study had proven the absence of adverse effects on human and animal health (EFSA, 2004). In 2007, however, Séralini and colleagues reanalysed Monsanto's raw data and found biologically meaningful connections between organ pathology and GM feed (Séralini et al., 2007).[67] The researchers criticised Hammond et al.'s (2006) and Monsanto's (2003) toxicity studies of MON863 for a lack of statistical detail, the statistical models producing false negatives, and a flawed experimental set-up (too few rats, problems in test and

[66] MON863 is a second-generation GM crop engineered for pest resistance by insertion of a gene that encodes a modified Bacillus Thuringiensis protein (Cry3Bb1), an insecticidal toxin that targets sucking pests such as the corn rootworm.

[67] Although EU Directive 2001/18/EC imposes the requirement to make raw data accessible for further scrutiny, Monsanto made its data public only after an Appeal Court decision in Germany in 2005 which forced it to do so. This means Monsanto did not make the study's raw data available to the scientific community until it was forced to do so by a court ruling, despite the fact that it is legally required in EU law to do so.

control group comparisons). Having found signs of hepatorenal toxicity, Séralini and colleagues concluded not that MON863 was unsafe for human consumption, but that "longer experiments are essential in order to indicate the real nature and extent of the possible pathology; with present data it cannot be concluded that GM corn MON863 is a safe product" (Séralini et al., 2007, p. 596). EFSA (EFSA, 2007a, 2007d) as well as researchers with industry connections (Doull et al., 2007) did not agree Séralini's study showed biological relevance, and thus dismissed it. Knowing about Séralini's history of questioning established toxicity testing on GM crops, founding member of EFSA Herman Koëter explained in an interview that EFSA's experts "came to the conclusion that Séralini was a fraud, that he had tried, whatever he could, to come up with something significant" (interview Koëter, 2012). Despite Koëter's allegation of fraud, what is important here is the critical role of standards in toxicological risk assessment that Séralini's 2007 and 2012 studies both pointed to: established test protocols produce falls negatives and therefore possibly defy detecting signs of biological significance. Séralini and colleagues later argued that their analysis of MON863 intended to widen the controversy about risk assessment towards "a debate on standards […] to interpret admitted significant effects between treated groups versus controls as biologically relevant, or not, in toxicological tests in general" (Séralini et al., 2009).

We can understand the critique about standards in the debate about the 2012 publication in a similar way. The CRIIGEN researchers doubted the absence of health effects of NK603 because the design of test standards assumes detecting dose-response relationships with a 90-day test. However, such a time-span would only cover acute toxicology. Instead, there is not always proportionality to the dose, for example in hormonal effects. This accordingly requires a different approach for toxicological risk assessment. Séralini was convinced that only long-term studies can produce biologically relevant toxicity data. By referring to the principle of scientific experimentation and refinement, he explained long-term testing to be an outcome of collective scientific work to determine the most suitable toxicological test design:

> [Monsanto and EFSA] have seen some mathematically significant effects which they did not see these biologically relevant, but I disagree. The arguments were nonsense for us as a scientific community working on endocrine disruptors. There was no way to go out of the debate, except of prolongation of the tests, to see whether these signs were effectively transformed into disease, or not. There was no other experimental way to know.
>
> (interview Séralini, 2013)

Within the first few days following the publication, GMwatch similarly described the role of established toxicological test standards as to exclude alternative approaches like Séralini's, and to provide legitimacy to the existing tests "on the purported grounds that they [industry studies] are more 'relevant to human risk assessment' (OECD conformant) and 'reliable' (GLP)". GMwatch instead argued that "in fact there are no scientific reasons why industry studies should be considered more relevant than independent studies" (GMwatch, 2012f). The arguments about the role of standards show that actors utilized these principles and guidelines to define reliable and trustworthy science – either by sticking to established rules,

or by criticizing their shortcomings and amending the standards necessarily for larger time frames.

The arguments the defendants of Séralini and colleagues made about methodology, the legitimacy and illegitimacy of expertise in toxicology, and the role of standards can be explained through the lens of boundary work, too. The discussion about methodology and standard test protocols aimed at the expansion of the boundaries of science. Gieryn explains that expansion boundary work means that rival epistemic authorities fight over the legitimate extent of the arena of science. While expulsion is about limiting the boundaries of science, e.g. to exclude Séralini from what is considered reliable scientific knowledge production, expansion is about the extension of its existing frontiers, i.e. the inclusion of the long-term study into the realm of trustworthy science (Gieryn, 1999, pp. 15-17). The references above to 'logical scientific method' or 'a proper scientific debate' show that actors questioned the limits of established science, its institutions, practices, methods, and standards to answer the question of the toxicity of NK603. Those supporting Séralini aimed to expand the space of toxicology by reaching beyond the constraints set by established practices (the 90-day study considered sufficient to determine toxicity), methods (experimental set ups and statistical tools) and institutional contexts (the links between regulatory risk assessment and the GM industry) of science. So, the arguments in favour of the CRIIGEN publication were about identifying, enlarging, and demarcating the legitimate epistemic space of scientific knowledge production so as to make Séralini's study appear reliable. This goes beyond existing standards and institutions of knowledge production towards an inclusion of a long-term test protocol in order to determine biologically relevant toxicological effects.

The concept of boundary work can also explain the strategies behind the attempts to render scientific practice and expertise legitimate or not: the dismantling or protection of autonomy. Gieryn explains that actors sometimes aim not at displacing science from its place as epistemic authority, but appropriate it "to exploit the authority in ways that compromise material and symbolic resources of scientists inside" (Gieryn, 1999, p. 17). When politicians or corporates try to instrumentalise science, scientists seek to protect their professional autonomy: the internal standards of inquiry and judgement, or the autonomy to decide what problems research should address. The notion of *independent science* that Séralini and his supporters invoked helped them to construct the long-term study as an outcome of freely thinking and acting scientists who follow scientific principles of inquiry to uncover the truth, independent of established institutional constraints that define good science. Séralini's references to the importance of disciplinary expertise and his opponents' attachments emphasised the significance of protecting his autonomy as a scientists while denying the same to his critics.

The notion of independence also helped delegitimising the opponents' attempts to render the study politics rather than science. By pointing to conflicts of interests of corporate and regulatory expertise, i.e. the material and financial ties of his opponents to the GM industry, Séralini explained the consequences of such attachments for understanding and dealing with the risks of GM crops: "when there are high economic interests, then science cannot be neutral […] there are not only direct conflicts of interest, but there is a growing frame to allow for the externalisation of risks on the population" (interview Séralini, 2013). So, Séralini and his supporters threw back the argument by pointing to the questionable neutrality of the

study's critics. They opposed the notion of autonomy and independence to the financial and professional conflicts of interest they had identified between certain scientists and industry. In terms of boundary work, Séralini's defendants thus aimed at the protection of scientific autonomy and at expansion; i.e. they drew the boundaries of legitimate and trustworthy knowledge production to include Séralini's long-term study. By pointing to Séralini's expertise and protecting his scientific autonomy (to develop a different experimental set up, and to restrict its discussion to the discipline of toxicology), they questioned the reliability and legitimacy of the criticism directed at the study.

Institutions as Arbiters: EFSA and FCT

On 26 September, one week after its publication, the European Commission requested EFSA to review Séralini et al. (2012) (Butler, 2012b; EFSA, 2012a).[68] Two days later, EFSA published a preliminary assessment in which it pointed to inadequacies in the study's design, analysis, and reporting (EFSA, 2012d): missing reflections on the strain of rat and sample sizes; inadequate description and analysis of feed composition; non-adherence to international test protocols; unwarranted conclusions as to the biological relevance of the results; and unconventional statistical methods. Despite the conclusion that the study was "of insufficient scientific quality to be considered as valid for safety assessment" (Geslain-Lanéelle, 2012), EFSA officially asked the CRIIGEN researchers to clarify these issues. It took until the end of November for EFSA to publish its final assessment. In the meantime, more actors engaged in concerted actions to draw the boundaries of science.

On 2 October, a letter in support of Séralini and colleagues appeared online. Signed by 200 scientists, the letter exemplified how the study's supporters juxtaposed the structural constraints and material attachments of existing GM crop risk assessment with the idea that science is a process which depends on the notions of integrity, independence, and the public good. To them, science was demarcated by openness of debate to different approaches. To them was an example for the critique of the structural relationship between risk assessment science, regulatory institutions such as EFSA, and the GM producing industry:

> Safety testing, science-based regulation, and the scientific process itself, depend crucially on widespread trust in a body of scientists devoted to the public interest and professional integrity. If instead, the starting point of a scientific product assessment is an approval

[68] One might ask why EFSA evaluated a study that was right away deeply contested for its scientific credentials and methodology. Herman Koëter, founding member of EFSA explained in an interview that "every report we receive will be scrutinised in full detail. That means we would not just neglect it. Every piece of evidence, whether from a strong or weak source will always be considered in the most serious manner" (interview Koëter, 2012). In the case at hand, EFSA received a mandate by DG SANCO on 26 September, 2012 to review the publication and to give advice on whether it yielded new insights that could lead to reconsideration of EFSA's evaluation of NK603 (EFSA, 2012b).

> process rigged in favour of the applicant, backed by systematic suppression of independent scientists working in the public interest then there can never be an honest, rational or scientific debate.
>
> (Bardocz et al., 2012)

The opponents of Séralini equally came up with a coordinated response that aimed at publicly drawing and redrawing the boundaries of reliable science in *Food and Chemical Toxicology* (FCT). In early November, less than two weeks after the publication, the online version of FCT's volume 53(1) published a number of letters to the editor that attack the CRIIGEN publication.[69] These letters aimed at expulsion by representing the study as not adhering to standard conventions of data generation, analysis, and interpretation. Most of them repeated the criticism voiced earlier about experimental design, statistical analysis, presentation of data, and misrepresentation of findings (Berry, 2013; de Souza, 2013; Grunewald & Bury, 2013; B. Hammond, Goldstein, & Saltmiras, 2013; Tien & Huy, 2013). Others asked for more experimental data, for instance on the level of mycotoxins in the rat feed (Pilu, 2013), pointed to possible misinterpretations of toxicological pathology (Schorsch, 2013), or suggested different statistical tools (Olivier, 2012). Yet others referred to EFSA's preliminary evaluation as authoritative proof that the study was not scientific, alleging that CRIIGEN was "more focused to its impact on the media than to the science behind their findings" (Tribe, 2013).

While only one letter to the editor expressed support of Séralini by pointing to the novelty of a long-term toxicological study, others much more explicitly denounced the study as "propaganda" (Trewavas, 2013), and accused Séralini et al. of political bias and intentional fraud (Barale-Thomas, 2013). Yet others alluded the journal's review process lacked rigour to differentiate between what authors present as non-scientific but political anti-GM publicity and science proper: "a robust scientific process has been used to publicise an agenda rather than evidence – as part a campaign against GM technology" (Sanders, Kanoun, Williams, & Fersting, 2013). Others asked the editors of FCT to retract the paper (Tester, 2013) because they regarded it not as science but as "deliberate attempt to manipulate the public debate" (Langridge, 2013, p. 441). Another letter to the editor with 25 signatories also called for retraction (Wager et al., 2013) and labelled the publication's shortcomings as a sign of fraud – the allegation of intentional deceit clearly is expulsion boundary work. These letters invoked the boundary between science and politics by assigning the publication to the latter: political values had corrupted the researchers to intentionally misrepresent their findings. These voices opposed their representation of Séralini et al. (2012) to an image of fact-based and value-neutral science that follows agreed upon standardised ways of knowledge generation, and the peer-review mechanism. Alas to them, FCT had failed in policing the boundaries of reliable knowledge production:

> Indeed, the flaws in the study are so obvious that the paper should never have passed review. This appears to be a case of blatant misrepresentation and misinterpretation of

[69] The publication year for volume 51, issue 1 of Food and Chemical Toxicology is 2013; contents were available online however as from early November 2012.

> data to advance an anti-GM agenda by an investigator with clear and vested interests. We find it appalling that a journal with substantial reputation of *Food and Chemical Toxicology* published such 'junk' science so clearly intended to alarm and mislead. […] We appeal to you to subject the paper to rigorous re-review by appropriate experts and promptly retract it if it fails to meet the widely held scientific standards of design and analysis, as we believe it fails to do.
>
> (Wager et al., 2013)

Many of the authors of these letters already appeared in the debate before, as news commenters though, while many of them had links to corporations which produce or promote GM crops: Hammond, Goldstein and Saltmiras (2013) had worked for Monsanto and Schorsch (2013) for Bayer. Trewavas (B. Hammond et al., 2013; Trewavas, 2013) , who also appeared as an expert in the SMC press release, had been involved with GM industry public relations campaigns, which civil society activists have criticised as "propaganda" rather than science (Matthews, 2012; Powerbase, 2009a). Kanou, Sanders, and Williams (2013) work for the John Innes Centre in the UK, which activists accuse of propagating GMOs uncritically (Powerbase, 2012).[70] Amongst the signatories to the Wagner et al. letter (2013) were also explicit advocates of GM crop technology: CK Rao is the executive secretary of the Foundation for Biotechnology Education and Awareness and Education, Bangalore (FBAE) and Professor of Plant Molecular Genetics CS Prakash is founder of the campaigning website *AgBioWorld* that promotes GM crops (Powerbase, 2009b). Prakash also initiated two petitions asking CRIIGEN to make the study's raw data publicly accessible (Prakash, 2012; unknown, 2012). Other signatories, like Miller and Chassy, who had appeared as news commenters earlier in the debate, also have ties to biotechnology companies.[71]

On November 9, a few days after these letters to the editor appeared online, Séralini and colleagues replied to their critics in FCT (Séralini et al., 2013).[72] The CRIIGEN researchers welcomed the debate as "the way of moving science forward" (ibid, p.477). They insisted that their study was the most detailed lifelong experiment, yet it should not be considered as an endpoint in studying the toxicology of NK603 and Roundup™. In the eight page long reply, they emphasised that existing regulatory assessment seemed to be at odds with findings published in peer-reviewed scientific journals (cf. EFSA, 2007d; Séralini et al., 2007). More specifically, the researchers' replied to considerations about method and testing guidelines, the originality and limits of the study design, statistical tools, and interpretations of the data: They argued that the SD rat strain is prescribed in OECD testing guideline 452 for chronic toxicity studies (OECD, 2009a).[73] While the size of the control group was large enough to

[70] Dr. Wendy Harwood, who appeared as an expert in the SMC press release, also works at the John Innes Centre which is a plant biotechnology research organisation that develops commercial GM products and engages in science communication activities about the benefits of GM technology (JIC, 2015; Powerbase, 2012).

[71] See footnote 52.

[72] Although the publication year for volume 53 of Food and Chemical Toxicology is 2013, Séralini's reply was made accessible as undirected proof version on the web as from 9 November, 2012.

[73] For a detailed summary of their replies to numerous criticisms, see the table provided in Séralini et al. (2013, pp. 478-479).

allow for sufficient comparisons, they explained that historical controls were irrelevant because the diets in those studies had not been controlled for traces of pesticides and GMOs. Explaining their choice of statistical model, Séralini et al. expounded that data does not speak for itself but rather that "biological interpretations and crossing of methodologies are the key" (Séralini et al., 2013, p. 478).[74] They further argued that including historical controls instead "enhances the control variability and heightens the risk of false negative findings" (ibid, p.480) for assessing biological relevance. Finally, the researchers stated that the debate could not be scientific if the data on the original assessment of NK603 remained confidential and therefore unavailable to the scientific community for further study, thus their argument reverberated their supporters' statements about industry's influence on risk assessment outcomes. [75] Séralini and colleagues finally encouraged others "to replicate such experiments with greater statistical power" (ibid, p.482). The call for testing their results by replicating the long-term experiment can be described as inclusion boundary work: The CRIIGEN researchers argued for their experiment to be considered valid science by appealing to the scientific community to apply another quality check beyond peer-review: experimental replication. Calling for verification or falsification through experimental replication constituted a call on the mechanisms of scientific quality checks, which could then decide on the status of the publication as proper science or not.

Finally, on 23 November 2012, EFSA published its final review of Séralini's long-term study (EFSA, 2012b). EFSA criticised the test design, analysis, and reporting of data and results as insufficient. Its verdict was similar to its initial assessment (EFSA, 2012d): the evidence was insufficient to back the paper's results. The conclusions as published could not be drawn because Séralini's analysis lacked essential properties to count as reliable science. Therefore, the study would be without consequences in terms of risk assessment and management:

> EFSA finds that the study as reported by Séralini et al. is of insufficient scientific quality for safety assessments. EFSA concludes that the currently available evidence does not impact on the ongoing re-evaluation of glyphosate and does not call for the reopening of the safety evaluations of NK603.
>
> (EFSA, 2012b)

As Greenpeace activist Bekkem explained, EFSA's judgement on the Séralini et al. (2012) study did not come as a surprise but rather as an institutional defence for EFSA: "once an institution has invested its credit into a decision [i.e. authorising NK603 in 2003], the less likely they would be to question that decision" (interview Bekkem, 2013). Accordingly, expulsion boundary work was also about protecting EFSA's status as scientific arbiter in the

[74] Séralini et al. explained in reply to criticisms directed at their statistical model that Kaplan- Meier's curves on survival used in 90-day studies that led to the approval of NK603 (B. Hammond et al., 2004) have limits given the size of control groups. Instead, they chose PLS regression to yield greater statistical precision in multivariate data analysis (Séralini et al., 2013, p. 480).

[75] Indeed, EFSA later made the raw data for the approval of NK603 available to the scientific community as a move towards transparency in its decision-making process (EFSA, 2012a, 2013a), to which Monsanto reacted by considering a lawsuit for breaching confidentiality agreements against EFSA (LeMonde, 2013).

toxicological controversy: EFSA presents itself as scientific and neutral, and therefore in the position to ultimately judge on the scientific merits of knowledge production relevant to its risk assessment: Elisabeth Waigman, head of EFSA's GMO unit explained in an interview that EFSA is "fully independent; our core business is to do independent scientific risk assessment and to take into account all scientific evidence" (interview EFSA, 2014). Also, not only EFSA ruled on what science it deemed acceptable for policy-making, but also other institutions took a similar role as scientific arbiters. A number of national regulatory authorities and scientific academies excluded Séralini et al. (2012) from reliable toxicological science by labelling the research explicitly unscientific.[76]

On the basis of the "risk assessment community's" (EFSA, 2012c) judgement one might assume the boundaries of science had been authoritatively and finally drawn. At least to policy-makers in the EU institutions, the case seemed to be clear: "EFSA checked it [Séralini et al. (2012)] and many agencies checked it and all of them came to the same conclusion that you could not conclude what Professor Séralini concluded […] and that it was over-interpretation" (interview DG SANCO, 2014). It is a question however, of whom the scientific community consists of according to EFSA, and what place it allows for scientific uncertainty and disagreement. For instance, the Belgian Biosafety Advisory Council (BAC) report on Séralini et al. (2012) included a minority opinion that pointed to the uncertainties of scientific research about the long-term health effects of GM crops. Instead of brushing the study aside, the BAC minority opinion called for further inquiry in order to advance the scientific debate about potential long-term toxicity. Eventually, the minority opinion argued, the initial risk assessment dossiers of NK603 should be reassessed with the same rigour that the CRIIGEN publication had been subject to. In referring to the principles of verification, falsification, and experimental reproduction, the minority opinion called on the principle of scientific debate and exchange of argument: "Rather than rejecting these results, should we not, according to the scientific approach, encourage new experiments to verify the reproducibility of the results by correcting any shortcomings of the current publication" (Bioveiligheidsraad, 2012, p. 9). These critical minority voices, arguing for the expansion of established risk assessment and the inclusion of Séralini's study in the corpus of valid scientific knowledge, remained unheard however.

Public debate faded away after EFSA's judgement and remained sporadic, but no less fierce towards the end of the year 2012. An industry publication mentioned EFSA's negative assessment in referring to GM crops opponents using non-science in their campaign (ISAAA, 2012), whereas news commenters warned that uncertainty in science called for taking the study seriously (Vidal, 2012). A number of MEPs questioned EFSA's scientific integrity because it was relying too heavily on confidential industry data instead of following-up on independent scientific findings such as Séralini's (GMwatch, 2012a, 2012d). Corporate Europe Observatory alleged that EFSA's review had been biased, repeating its allegations of

[76] For instance, six French Academies (Agriculture, Pharmacy, Science, Technology and Veterinary Medicine) published a joint statement not only condemning Séralini et al. (2012), but also the journal FCT for being unscientific (Sciences, 2012). Various national regulatory authorities from Belgium and Brazil, to France and Denmark, and New Zealand/ Australia joined EFSA's refutation of the publication (Entine, 2013).

conflicts of interest against the scientific experts involved therein. CEO contended that instead of contributing to the public debate about health risks, EFSA had applied "a level of scientific standards never reached by the Monsanto study on NK603" (CEO, 2012a, p. 8), which undermined its credibility as scientific arbiter. Finally, a group of environmental networks and organisations published a working paper in which they demanded radical institutional reform for EFSA to address conflicts of interest, to improve the authority's transparency, accountability, and participation; and to change EU law so as to prevent corporate influence on risk assessment studies and outcomes (CEO, 2012e).[77] The debate about the ties between EFSA's experts and industry and the notion of scientific independence to demarcate reliable scientific knowledge gained momentum once more. CEO accused EFSA of having failed in its policy on transparency and independence since the majority of their experts had affiliations to GM producers (CEO, 2013). According to CEO, under these conditions the controversy about toxicological risk assessment of GM crops did not resemble a scientific debate, but rather "an open battlefield for corporate interests" (CEO & Horel, 2013, p. 5).

Then, in February 2013, the scientific journal *Transgenic Research* published an article which repeated the call to retract the paper because of its errors, inaccuracies, and misleading conclusions. According to the authors, the public debate about the publication had not only discredited regulatory authorities, but also to toxicology more generally because it had "caused damage to the credibility of science and researchers in the field" (Arjo et al., 2013, p. 255). It would consequently be necessary to distinguish between "good research" and the "flawed science" of Séralini. Arjo et al. explicitly labelled the publication as an outcome of values and subjectivity with a hidden political agenda: "the real objective of the experiments from the very beginning was to politicize science rather than present objective data to the scientific community" (ibid, p. 265). The authors lamented that FCT's review system was erroneous, and therefore providing "ammunition for extremists" (ibid, p.264) who called for stricter regulation of GM crops. This would increase costs and delay market entry of the technology. The authors further argued FCT had failed in its role as a scientific journal to embody the scientific method, implying wider consequences for science: "the publication of the Séralini article was a clear and egregious breach of the standards of scientific publishing and a grave insult to the integrity of thousands of dedicated scientists around the world" (ibid, p.266). Arjo et al. accordingly explained the only viable option would be for FCT to retract the paper.

Notwithstanding the continuous attempts to dismantle the scientific credibility of Séralini et al.'s long-term feeding study, and despite EFSA's negative verdict on its scientific reliability, the European Commission made an unexpected move. It requested EFSA to design a long-term chronic toxicity and carcinogenicity test protocol for food and feed. In July 2013, EFSA published a guideline for long-term testing whole food feeding studies with a two year

[77] Signatories to this letter were numerous European civil society organisations, amongst them La Via Campesina, European Professional Beekeepers Association, Friends of the Earth Europe, International Foundation for Organic Agriculture EU Group, Health and Environment Alliance, Greenpeace Europe, Pesticide Action Network Europe, BUND Germany, CEO, Demeter International, Earth Open Source, Foundation Sciences Citoyennes France, and the Polish Forum of Organic Agriculture, amongst others (cf. CEO, 2012e, p. 5).

time span (EFSA, 2013b). It was based on OECD testing guideline 453 for the testing of chemicals for combined chronic toxicity and carcinogenicity (OECD, 2009b). Surprisingly, the recommendations given in EFSA's protocol were similar to Séralini's chronic toxicity study design. A representative from DG SANCO explained in an interview that since the debate about the long-term feeding study had pointed to an array of social concerns about regulatory risk assessment, "we decided it would be useful to grant a research project to repeat the study but using the appropriate methodology, with a good protocol and adequate control groups" (interview DG SANC, 2014). The controversy about Séralini's long-term had pointed to a weakness of the standard toxicological risk assessment protocol to which regulatory authorities reacted by designing a new protocol for long-term feeding experiments. As Theodore Porter explains, the definition of more precise rules and procedures through standardization can be seen as a response to weakness and distrust in knowledge production for public policy (Porter, 1995).

Some actors reacted by stating the EU Commission's move validated Séralini's methodological choices that had previously been criticised: the need to adapt the test protocol, the use of SD rats for long-term testing, the size of test groups, the exploratory character of such studies, and the cautious use of historical data as controls (Robinson, 2013a). Séralini's supporters consequently turned the discussion about toxicological testing standards into his favour. To them, EFSA's newly developed long-term testing guideline verified that "Séralini was right all along, and that his research methods are, in fact, more robust than currently accepted methods" (Huff, 2013; cf. Robinson, 2013a). Although Séralini et al.'s long-term study and its results were dismissed by EFSA, it nevertheless provided for the opportunity to address scientific uncertainty about long-term effects of GM crops and the associated pesticide Roundup™ to a variety of actors. As a Greenpeace GMO campaigner explained, the study was to be seen as "a signal for EFSA to improve its long-term evaluation of this technology" (interview Bekkem, 2013). Nevertheless, the official decision to expulse Séralini from the realm of trustworthy science was yet to come.

Retraction and Republication: shifting boundaries of science

On 19 November 2013, a year after the publication of Séralini et al. (2012), *Food and Chemical Toxicology* (FCT) Editor-in-Chief Wallace Hayes sent a letter to the CRIIGEN researchers in which he warned them of retracting their publication in case they would not withdraw it voluntarily (Hayes, 2013c). On 28 November 2013, the day Séralini gave another press conference in Brussels to insist on his innocence regarding allegations of fraud (Casassus, 2013), Elsevier announced the retraction of the publication from FCT, "after a thorough and time-consuming analysis of the published article and the data it reports, along with an investigation into the peer-review behind the article" (Hayes, 2013a). In the retraction announcement, Hayes explained that while there was no indication of fraud or intentional misrepresentation of results, the examination of the raw data revealed that no definite conclusions could be drawn from the study about the toxicity of NK603 and Roundup™. Instead, the number of test animals per group and the use of the SD rat strain did not allow excluding natural variability as the cause for mortality and tumour incidence. Hayes concluded: "ultimately, the

results presented (while not incorrect) are inconclusive, and therefore do not meet the threshold of publication for *Food and Chemical Toxicology*" (Hayes, 2013a). Although retraction could be considered a definite call on the scientific credentials of the paper, public debate gained momentum again and the controversy about the boundaries of science continued.

Commenters in Forbes Magazine were quick to applaud the retraction as confirming earlier attempts at rendering it outside the boundaries of science (Entine, 2013; Worstall, 2013). An Indian biotechnology advocate contended that the anti-GM movement had used the paper "to publicize misinformation about the safety of GM crops". Since the "faulty and misleading paper" constituted politics rather than science, it had to be retracted (Rao, 2013b). Séralini disagreed: inconclusiveness was not a good reason for retraction. He referred to OECD testing guidelines 408, 452, and 453 to maintain that the rat strain and size of test groups were justified, as he and his colleagues had explained earlier. The editor's move instead was "scientifically unsound" (Séralini, 2013). Séralini further insisted that his study was not about carcinogenicity but an experiment on oral toxicity (Séralini et al., 2013). Also, he accused FCT of applying double standards: "only those studies showing adverse effects receive a rigorous evaluation of their experimental and statistical methods, while those that claim proof of safety are taken at face value" (Séralini, 2013). The European Network of Scientists for Social and Environmental Responsibility (ENSSER)[78] commented the retraction as "a flagrant abuse of science and a blow to its credibility and independence [...that] will decrease public trust in science" (ENSSER, 2013). The retraction hence reinvigorated the attempts at boundary making, i.e. the notion of science proper versus politics. The actors repeated most of the arguments that had already been made. Yet, the public debate also changed. This time it was less about the methodological details of the publication, but more about how to define quality mechanisms in science and how to approach the structural relations of toxicological risk assessment: the mechanisms of peer-review as quality control in scientific publishing, and the relations between science, regulators, and industry. The debate therefore was about more than one boundary of science (cf. Bijker et al., 2009).

Most outstanding were a number of letters to the editor of FCT that commented the retraction.[79] Only few welcomed retraction, repeating the paper had been an act of unscientific scaremongering of the public (e.g. Folta, 2014). Yet, others lamented the retraction was unjustified and damaged scientific integrity more generally because FCT had allegedly given in to industry pressure. Retraction was biased, choked the scientific process, and exemplified "corporate control not only of the biotechnology industry but also of the means of publication" (John, 2014; cf. Rosanoff, 2014). Rather, these commenters alluded, "real scientific attitude" would have asked for additional studies to confirm, refine, or falsify Séralini et al.'s (2012) findings (Roberfroid, 2014). A professor of plant agriculture pointed out that inconclusiveness is common in science. Therefore, expecting a pioneering study such as Séralini's

[78] ENSSER is a non-profit network that aims to bring together "independent" scientists for "the advancement of public good science and research for the protection of the environment, biological diversity and human health against adverse impacts of new technologies and their products" (ENSSER, 2014). ENSSER aims at tapping into the European and international debates on new technologies, their risks and regulation, and criticises that the influence of private interests in technological innovation runs counter to public interest.
[79] These letters to the editor became accessible online already in November 2013, whereas the official print publication was in volumes 65 (March, 2014) and 69 (July, 2014).

to deliver definite results would be "incompatible with how scientific research actually proceeds" (Clark, 2013).

Finally, Séralini and colleagues commented in FCT that a lack of conclusiveness did not constitute scientific error. The researchers and their supporters repeated that double standards had been applied because other inconclusive studies had not been retracted (RetractionWatch, 2014a; Séralini, Mesagne, & Defarge, 2014). To illustrate this argument, scientists from ENSSER and the Swiss Federal Institute of Technology compared Séralini et al. (2012) with two industry- commissioned toxicological studies on NK603 and found that all three suffered from comparable deficiencies. However, only Séralini et al. got retracted from the scientific literature (Meyer & Hilbeck, 2013). These authors concluded that conventional risk assessment as well as the EU regulatory system worked insufficiently: "the current approach to declare statistically significant differences between genetically modified organisms and its parents as biologically irrelevant based on additional reference controls lack scientific rigour and legal justification" (Meyer & Hilbeck, 2013, p. 1). They further argued that the mismatch of regulatory principles and risk assessment methodologies between the US and the EU made comparing new data with unrelated historical controls impossible. Rather, using inappropriate historical control data increased background variability, which made false negatives more likely, and therefore impossible to identify toxic effects related to the transgene. According to these arguments it was not Séralini's study, but the practice of using historical control data, which was unscientific.

Member of European Parliament (MEPs) equally criticised EFSA for uncritically brushing aside Séralini's science. Relying exclusively on industry-commissioned studies would put EFSA's impartiality at risk. In a symbolic move, the European Free Alliance of the Greens in the European Parliament invited Séralini as a scientific expert to the EU's the Committee on Petitions to discuss three petitions relating to EFSA's role in the regulatory approval of GMOs. Supposedly, EFSA had failed to "to provide independent scientific advice as it bases its opinion of GMO authorisation demands only on data provided by the applicants" (TheGreens, 2013). Séralini therefore turned into a symbol of independent science as opposed to industry-sponsored knowledge production. When the controversy turned toward the regulatory apparatus, the means of publication and science as such became the bones of contention alike. Moreover, the publishing journal FCT was accused of not guarding the boundaries between science and industry properly.

A particularly outstanding point of contention was a change in the composition of FCT's editorial board a few months before the retraction. In February, 2014, FCT acquired a new Associate Director for Biotechnology. The previously non-existing position at FCT was filled by Richard Goodman, professor for Food Allergy Research at the University of Nebraska. Goodman had worked for Monsanto between 1997 and 2004 and was involved with the International Life Sciences Institute (ILSI, 2012). ILSI has been criticised by environmental organisations for bluntly advocating industry positions on technological risks, from tobacco to GM crops (CEO, 2012c; CEO & Horel, 2013; Loughheed, 2006; Powerbase, 2015a).[80]

[80] Numerous publications by CEO and other corporate critical sources point out that ILSI receives funding from biotechnology, chemical, food, pesticide, and pharmaceutical transnational corporations (CEO, 2011, 2012c; CEO & Horel, 2013; Holland et al., 2012; Powerbase, 2015a). Based on its research on the relations

Goodman's fast-track appointment to the FCT editorial board prompted activists from GMwatch and Earth Open Source to suggest that "that the threat to scientific publishing from industry is real" (Robinson & Latham, 2013). In their view, the appointment of Goodman had seriously compromised the quality of science in FCT, because of his attachments to GM crop technology producers. They suggested that other scientific journals had been captured by commercial interests, such as the journal *Transgenic Research*, which had published a paper titled "Séralini and pseudo- science", accusing him of scientific misconduct and fraud (Arjo et al., 2013). Lead author of this paper, Paul Christou also has connections to the GM industry and a history of debunking scientific studies pointing to potential risks of GM crops.[81] Robinson and Latham warned that the structure of the means of scientific publishing gives journal editors the power to decide on the fate whether knowledge production gets sanctioned as trustworthy science, or not, independent of the actual processes of scientific quality control. Accordingly, they suggested that "the life science industry knows this and has increasingly moved to influence and control science publishing" (2013). Séralini himself contended later that powerful networks of scientists backed by the industry had the aim of dismantling his status as a scientist: "Richard Goodman cited first Paul Christou and both of them were hiding their affiliations to the industry" (interview Séralini, 2013). As Bijker et al. (2009) suggest, social and material associations are important aspects of boundary work efforts. By pointing to science-industry relations and possible conflicts of interest of those involved in scientific publishing, the supporters of Séralini attempted to set the boundaries of science vis-à-vis powerful networks of scientists and industry; to them the publication by Arjo et al. in *Transgenic Research* constituted a prime example of industry representatives posing as scientists in order to discredit dissenting knowledge about the potential risks of GM crops and their associated herbicides such as NK603 and Roundup™.

On December 10, 2013 FCT Editor-in-Chief Heyes published a follow-up comment on the retraction decision in which he insisted that the paper's methods had been "scientifically flawed" stating that "no definitive conclusions can be drawn from inconclusive data" (Hayes, 2013b). Hayes alleged that FCT had been free of conflicts of interest and explained that Richard Goodman's appointment had nothing to do with his former employment at Monsanto. Goodman instead had been excluded from the review process upon Séralini's request (cf. RetractionWatch, 2014a). Finally, Hayes insisted that the retraction, although not based on scientific misconduct, was still in line with the guidelines of the Committee on Publication Ethics (COPE, 2012).[82] He continued to suggest that previous studies such as Hammond et

between industry, science, and regulatory institutions, CEO describes ILSI as an industry-driven lobby organisation "that aims to influence the EU decision-making process by trying to create questionable 'scientific consensus' on issues that are important to their food and biotech industry members" (CEO, 2012c, p. 8). Despite the long-lasting debate about ILSI's relations to industry, the World Health Organisation (WHO) decided to sustain its relations to ISLSI in 2006 (Loughheed, 2006).

[81] Robinson and Latham reminded their readers of a publication in the early 2000s that reported the potential outcrossing of GM crops genes into Mexican wild land varieties of maize (Quist & Chapela, 2001). At the time, Christou had been involved in successful attempts to retract that study (Christou, 2002). For a detailed examination of that case, see Kinchy (2012).

[82] COPE lists the following reasons for a justified retraction of already published articles in scientific journals: misconduct, plagiarism and unethical research, if the respective article has been published elsewhere already, or if the publication is "seriously flawed and misleading" (COPE, 2012, p. 4).

al. (B. Hammond et al., 2004) were in line with GLP rules and OECD standards. Instead, Séralini et al. (2012) had eclectically used these guidelines (cf. ENSSER, 2013). In particular the number of rats were insufficient to substantiate the carcinogenicity findings. Therefore, the paper was deemed unreliable and needed to get retracted (Hayes, 2013b). The retraction justification sparked the debate about the boundaries between science and politics anew, but this time, the controversy centred on the very means of scientific knowledge production, i.e. scientific publishing.

Later the same month, an open letter appeared online that called for boycotting FCT's publisher Elsevier (ISIS, 2013).[83] The authors of that letter called for a reversal of Hayes' decision because none of the retraction criteria laid down by the Committee on Publication Ethics (COPE) such as misconduct, plagiarism, and unethical research had been met. Séralini responded in January 2014 with a letter to COPE in which he alluded Hayes' decision for retraction was unscientific because it was based on "classic human errors that a scientific approach usually tries to avoid" (Séralini, Clair, Mesagne, et al., 2014). Again, the CRIIGEN researchers used disciplinary boundaries to make a point about the decision on the status of their study as proper science: Hayes seemed to have confused carcinogenicity with toxicity protocols; their paper was not a cancer study but a toxicological investigation into the effects of NK603 and Roundup™ on biological parameters of multiple organ functions. Hayes however had made a point about the indications of carcinogenicity not within the paper's objective (Séralini, Clair, Mesagne, et al., 2014). The researchers repeated that inconclusiveness was not an error but a frequent outcome of scientific studies. They thus feared that retraction would have direct impact on GM crops policy-making with a direct impact on public health: "the discredit brought on this study and its conclusions is likely to influence global food-related policies, and may result in a major public health concern" (Séralini, Clair, Mesagne, et al., 2014). Civil society voices agreed with the researchers that the retraction was damaging the authority of science more generally. In February 2014, Welsh anti-GM activists stated: "the retraction of any paper because it is 'inconclusive' has adverse implications on the integrity of the concept of the peer-review process as a critical foundation of unbiased scientific inquiry" (Portier, Goldman, & Goldstein, 2014). To them, public trust in science was to suffer: "the retraction does not really impact how the science will be viewed by scientists, but only how it is viewed by others outside of the scientific community" (ibid.).

In early 2014, another petition appeared online that was signed by 150 scientists who described the retraction as "a bow to commercial interests" and an "attack on scientific integrity" (EndScienceCensorship, 2014). The petition demanded the study to be reinstated, a call which was soon to become reality. On 24 June 2014, the peer-reviewed open access journal *Environmental Sciences Europe* (SpringerOpen) republished the CRIIGEN paper in an adapted and extended version, including the study's raw data (Séralini, Clair, Mesnage, et al., 2014).[84] The publishing editor stated that disagreement as revealed in the controversy about

[83] By late 2015, the latter had been signed by 1400 "scientists" and more than 4000 "non-scientists" from 100 different countries.

[84] In a personal communication with the author in October 2017, Séralini insisted that the CRIIGEN researchers had made all raw data of the experiment available on the Environmental Sciences Europe website upon republication of the study, while Monsanto and EFSA had kept the data of Roundup toxicity studies

Séralini's study was necessary for science more generally, but it needed to be made accessible and transparent: "such methodological competition is the energy needed for the scientific process" (Editor's note in Séralini, Clair, Mesnage, et al., 2014). In a note accompanying the republication, Séralini and colleagues repeated that many of their critics had undisclosed conflicts of interest. They agreed with activists' arguments that the retraction from FCT was "censorship" to silence alternative accounts on the risks of GM crops and to prevent criticism of the existing toxicological risk assessment regime (cf. Robinson, 2014). Instead, they argued that accessibility and transparency of risk assessment data is "the only way in which the scientific community can enter the scientific discussion" (Séralini, Mesagne, Defarge, & Vendomois, 2014, p. 5). Since the retraction intended to silence such discussion, they emphasised that science itself depends on such quality makers as accessibility and transparency. Hence, confidentiality agreements on industry-commissioned risk assessment studies should be removed in order to "adhere to standard scientific procedures of quality assurance" (ibid.).

Again, expansion boundary work was at play, but also more: drawing boundaries based on more general notions related to the structures of scientific knowledge production. By pointing to the expulsion work and silencing efforts of their opponents, the CRIIGEN researchers present the republication as a step towards making scientific procedure and debate transparent and accessible, not only to the scientific community, but also to the wider public. This could only be achieved if the means of publication were independent of industry influence. However, the republication did not go uncontested: While some suggested that the paper had not undergone proper review for *Environmental Sciences Europe* (RetractionWatch, 2014b), its Editor-in-Chief considered the journal's third round of reviews to check for modified content sufficient, since the paper had neither been fraudulent, nor misrepresenting results (Casassus, 2014). Supporters of Séralini even suggested that the republication had gone through "the most comprehensive and independent review" for any GMO risk assessment (Heinemann in GeneticLiteracyProject, 2014), proposing the republication made "science speak[s] for itself" (GMOSeralini, 2014)[85]. At the same time, the same actors who engaged in boundary work against Séralini et al. repeated the same arguments they had made earlier about the study's "insufficient scientific merit" (e.g. Chassy in GeneticLiteracyProject, 2014).

Reflecting on the process of publication and retraction of their study from FCT, Séralini and colleagues described the controversy as having caused damage to science at large, despite its republication. To them, retraction meant censorship of critical research findings which revealed a "historic example of conflicts of interest in the scientific assessments of products commercialized worldwide" (Séralini, Mesagne, Defarge, et al., 2014, p. 2). They also emphasised once more that those who had published criticism of their study in scientific journals such as *Transgenic Research* (Arjo et al., 2013) also had undisclosed links to industry-sponsored organisations such as ILSI. To Séralini and colleagues this explained why their opponents

secret. As noted in footnote 75, EFSA published the raw data on NK603 as a move towards transparency in the course of the debate.

[85] GMO Séralini is a website edited by Claire Robinson from GMwatch. In the face of the debate about Séralini's research, the website aims to provide information about that research to scientists, journalist and the wider public to allow for a 'science-based discussion' of the study: "The research conducted by Séralini's team has serious implications for public health and the environment and should be addressed rationally and on scientific grounds" (GMOSeralini, 2015).

had misrepresented and defamed their study. Also, they alleged those conflicts of interest to reach further into the realms of scientific publishing and science-based regulatory decision-making, thus causing damage to "the value and credibility of science" at large (Séralini, Mesagne, Defarge, et al., 2014, p. 1). To Séralini and colleagues, the debate about their long-term feeding study prompted them to also reflect on regulatory risk assessment of the biosafety of GM crops and the practices of science more generally: First, they demanded transparency of scientific practice and accessibility of data. Second, since the current system of GM crop health risk assessment seemed to be deficient and distorted by industry influence, they called for prolonging toxicological tests conducted by independent bodies as the "only way in which the scientific community can enter the scientific discussion" (Séralini, Mesagne, Defarge, et al., 2014). Finally, critical scientists and civil society representatives published a note in which they emphasised once more that the Séralini study showed signs, but did not claim to constitute a proof of toxicity. Instead, they argued for the need to commence prolonged toxicological tests because of the lack of consensus about the potential health effects of GM crops: "the scarcity and contradictory nature of the scientific evidence published to date prevents conclusive claims of safety, or of lack of safety, of GMOs" (Hilbeck et al., 2015). The Séralini case had started with a debate about the reliability and trustworthiness of a long-term toxicological feeding study, but as my analysis shows, the course of the controversy reveals that the boundaries between science and non-science, or politics were at stake. So the debate turned from questions about reliable method, tolls, and study design into a controversy about the material and social attachments of scientific risk assessment as such.

Conclusion: more than just lab rats

In this chapter, I enter the arena of scientific health risk assessment on GM crops. I follow the controversy about Séralini and colleagues' (2012) long-term feeding study which had identified possible signs of toxicity of the herbicide resistant GM maize (corn) NK603 and its associated herbicide Roundup™ in rats. Although the study had gone through peer-review for the journal *Food and Chemical Toxicology*, it was retracted a year after its publication by FCT's Editor-in-Chief. In the history of published and peer-reviewed science, retracting a study because of inconclusiveness is quite unique (Krimsky, 2015). After its retraction, the paper got republished in the open access scientific journal *Environmental Sciences Europe*. I show the controversy about Séralini et al.'s publication was more than merely about the number or strain of rats used in the long-term toxicity study. To explain how the publication became contested over its status as reliable and trustworthy scientific knowledge, I ask how the paper by Séralini and colleagues became subject to contestation over its status as reliable and trustworthy scientific knowledge: What made toxicological risk assessment become such a contested object of public debate? Moreover, I also want to explain how the publication's status oscillated between being recognised as reliable and trustworthy scientific knowledge and not being recognised as such.

The former can be answered by stating the obvious. Previous discussions on disagreement about the length of toxicological feeding experiments remained within the realms of scientific institutions, i.e. scientific journals (e.g. de Vendomois et al., 2009; Doull et al., 2007;

Séralini et al., 2007; Séralini et al., 2009), though without any change as to the 90-day feeding study standard. Announcing the findings of Séralini et al. (2012) at a press conference on the date of the publication and accompanying the scientific paper with a documentary and a book were strategies that intentionally brought the study's findings to the public realm. In the sense of Noortje Marres' take on issue-based publics, Séralini and colleagues' publicisation of their research findings can be understood to have constructed publics outside the established institutions of scientific publishing where there was no sufficient institutional support to deal with the question of the length of mammalian toxicological feeding studies. Moreover, since the study's results were widely published in news media, the discourse about its findings gained its own momentum. Instead of restricting the reporting about the study to its contribution to the debate about the length of toxicological feeding studies, many press reports and anti-GM crops groups presented the paper's findings as proof of the toxicity and carcinogenicity of GMOs. As a Friends of the Earth campaigner explained: "It is close to impossible to publish something like that without there being a huge hype about it" (interview Schimpf, 2012). Since the long-term study was not only about the herbicide tolerant GM maize NK603, but also about its associated herbicide Roundup™, timing might offer another explanation: the authorisation of Glyphosate on the EU market was about to expire in 2016, making new scientific findings about its potential toxicity important for the re-authorisation process which started as from the year 2012.[86] As Schmipf explained, "Séralini knows the European debate; he must have known what his publication would trigger" (interview Schimpf, 2012).[87]

An explanation as to why the publication became an object of public contestation in part also lies in the answer to the question how the paper's status as reliable and trustworthy scientific knowledge was contested. I suggest that the reason why the study's status as proper science was so fiercely fought over is because the boundary between science and non-science was defined differently by different actors in the debate. The boundary between science and politics being far from clearly defined was a decisive reason for the controversy. I employ the concept of boundary work to explain with which strategies various actors defined this boundary. The concept has been used to explain how scientists represent their knowledge production as authoritative, credible, and trustworthy; and how scientists distinguish their epistemic space and activity from non-science (Gieryn, 1983, 1995, 1999). I show that not only scientists, but a plethora of other actors such as civil society activists, news commenters, regulatory agencies, and the GM producing industry all engaged in boundary work to either

[86] In November 2017, Glyphosate was re-authorised for marketization in the EU despite a petition against this prolongation signed by more than one million EU citizens, and numerous MEPs' opposition to the re-authorisation of the pesticide (TheGuardian, 2017). Yet, the market approval was granted for five years only, as opposed to the EU Commission's initially proposed 15 years. In 2019, Glyphosate will be due for re-assessment by EFSA.

[87] In March 2015, the International World Health Organisation's Agency for Research on Cancer (IARC) classified Glyphosate as probably carcinogenic to humans (IARC, 2015). Monsanto's attempts to discredit the scientific credentials of the IARC were similar to the tactics used against it when the agency declared second-hand smoke carcinogenic in the early 2000s (BaumHeldum, 2017a). The ensuing debate about the IARC study was equally about the boundaries of science and it brought the issue of inaccessible data for reasons of secrecy prominently to the table (see, e.g. Cressey, 2015). The IARC and Séralini cases provide fruitful ground for future comparative research.

include or exclude Séralini et al. (2012) from the realm of reliable and trustworthy science. Consequently, the arena of toxicological risk assessment, once open to public involvement in the form of controversy outside of peer-reviewed scientific journals, enabled various actors to debate issues that had previously not been addressed. Yet, the publics emerging in the debate were "scientific citizen publics" (cf. Varughese, 2012), i.e. the issues were discussed in the liberal public sphere through text and talk by those who had a capacity to show "interactional expertise" (Collins & Evans, 2002) in toxicology. This means the controversy about the long-term scientific study was shaped by the involvement of scientific citizen publics. At the same time, the debate allowed for publics come to the fore where there previously had not been a space to discuss the scope, design, and uncertainties of toxicological feeding studies.

As a consequence, the controversy about the status of Séralini et al.'s publication as legitimate and reliable toxicological knowledge and the delineation of the researcher's work as proper science, or non-science became issues of public concern and involvement in the debate. The question about the reliable way of knowing and understanding the potential risks of this technology shows how GM crops as a techno-scientific subject gets politicised: The controversy is not only about the question how to know about the risks of GM crops, but also about under which conditions scientific knowledge is considered trustworthy and legitimate to be used for policy-making. The central issue of contention was what constituted reliable science in the arena of toxicological risk assessment, and what not, i.e. the boundary between science and non-science. Yet, there were more boundaries at stake: between facts and values, and between ways of knowing about technological risks and ways of dealing with that knowledge. In short, the debate about Séralini e al. was about the boundaries between science and politics. As science moved out of the confines of its closed arena of peer-reviewed scientific journals towards the public realm, the practice of toxicology and its representation of reliable truth became subject to interpretation and debate by various actors. In this debate, the boundaries between science and politics were actively constructed. I suggest that the reason why the study's status as proper science was so contested because the boundary between science and politics was defined differently by different actors.

I show how these actors engaged in expulsion boundary work to render Séralini et al. (2012) non-science: by means of questioning Séralini et al.'s method (test design, strain and number of rats), the instruments they employed (statistical model), and the notion of objectivity (defined through adherence to test protocols and the notion of scientific integrity). Séralini and colleagues were rendered not in line with proper scientific conduct and practice. Accordingly, their work was labelled non-science. Also, expulsion boundary work was expressed in explicit rhetorical constructions that described the publication as politically motivated, as fraudulent, or as activist-, fake-, pseudo- and non-science. However, there was also expansion boundary work at play. While expulsion boundary work was about limiting the boundaries of science to exclude Séralini from what is considered reliable toxicological science, expansion boundary work aimed at the extension of its existing frontiers, i.e. the inclusion of the long-term study into the realm of legitimate and trustworthy science. Various actors, particularly civil society activists, but also scientists agreed with Séralini and colleagues in questioning the limits of established toxicological risk assessment science: its methods (test

design); the notion of legitimate expertise (conflicts of interest); and the need to widen toxicological standards (test protocols) to include long-term studies in order to answer the question of the potential toxicity of NK603 and Roundup™. Those supporting Séralini aimed to expand the space of toxicology by reaching beyond the constraints set by established 90-day feeding studies and the structures of the institutional context of regulatory risk assessment. By referring to the principles of logical scientific method and debate, these actors presented the study as reliable and trustworthy science, and as part of a debate as to how to inquire the health risks of GM crops. Expansion boundary work was about including Séralini and colleagues into the epistemic space of science – if only for debating the value of prolonged feeding trials. As David Sanchez from CEO explained, the principle of scientific debate required taking Séralini and colleague's findings serious: "at least when one scientists speaks out, he can be supported from a scientific point of view". Sanchez warned that in regulatory risk assessment, such debate is impossible, because "it is more and more influenced by industry, so it is difficult to warranty what research is really independent in the assessment of GMOs" (interview Sanchez, 2013). Nevertheless, enabling scientific debate by making the study available to the scientific community was a central motivation for *Environmental Sciences Europe* to republish the paper.

The notion of independence points to the importance of protection of autonomy boundary work, which revolved around questions of disciplinary expertise, and in particular the idea of scientific independence. Séralini himself emphasised the importance of toxicological expertise, for most of the study's critics were not toxicologists. Moreover, many of his opponents had attachments to GM crops producers. This shows how Séralini and colleagues attempted to protect their autonomy as scientists while denying the same to their opponents. The notion of *independent science* that Séralini and his supporters invoked helped them to construct the long-term study as an outcome of freely thinking and acting scientists who follow scientific principles of inquiry to uncover the truth, independent of established institutional constraints that define what constitutes legitimate knowledge production. While Séralini was accused of doing politicised science because CRIIGEN's long-term feeding study had been financed by environmental NGOs, his supporters turned that argument back on his critics, whom they saw to be implicated with financial and professional conflicts of interest. The notion of independence therefore helped delegitimising the opponents' attempts to render the study politics rather than science. By pointing to the intertwinement of corporate and regulatory expertise, and the material and social attachments at play, Séralini and others drew attention to the financial and professional conflicts of interests in toxicological risk assessment. This emphasises the role of active commitment and dependency of actors to social, material, and technical entities and networks in controversies about technological risks – and these issues became part of the boundary making efforts in the debate. Being criticised for the potential impact of funding sources on the study outcome, the proponents of Séralini et al. (2012) could prominently voice a long-standing critique about the relationships between regulatory institutions, scientists, and industry. To them, EFSA's reliance on industry studies conducted by researchers with close attachments to the GM industry revealed the regulatory

science's inherent politicisation, i.e. the industry's influence on risk assessment through funding and the withholding of raw data.[88] As my reconstruction of the debate about Séralini et al. (2012) shows, the boundary between science and politics was actively constructed by different actors in the debate. Since the definitions of how that boundary was to be drawn varied so widely, the paper's status oscillated between being recognised as trustworthy science and not being recognised as such.

The object of contestation seemed to be the paper's methods, statistical tools, inferences of biological relevance and access to raw data. However, as the explanatory power of boundary work infers, the object of the controversy was more than that, but risk assessment science itself. More specifically, it was about the construction of its trustworthiness and reliability beyond questions of method and study design, but about the structures in which risk assessment science operates, i.e. the regulatory apparatus' reliance on industry-sponsored studies, the links between financing and study outcomes, and the role of EFSA in determining which science is to be considered valid for decision-making. As long as EFSA remains financially and legally constrained to conduct risk assessment studies itself, it will have to depend on industry-commissioned studies for regulatory risk assessment (cf. interview Koëter, 2012). Other studies have shown a positive correlation between financial and professional conflicts of interests and positive study outcomes in the evaluation of GM crop health risks (Diels et al., 2011; Mengibar, Pastor-Valero, & Aguado, 2017), and undisclosed conflicts of interest in scientific review bodies dealing with the risks of GM crops (Krimsky & Schwab, 2017).

In the debate about Séralini's long-term feeding study, two images of science distilled. On the one hand those opposing the study drew on an image of science as value-free, neutral, and objective; i.e. science can only be trustworthy if it is not implied with politics. On the other, those supporting Séralini et al. drew on an image of scientific practice that needs to be more accessible, transparent, and clear about its potential conflicts of interest – an image of science that is by implication political but needs to be transparent about it. However, even if scientists could come to an agreement over the potential health impacts of GM crops, their associated pesticides and how to investigate these, it remains questionable whether the downstream consequences, such as policy-making issues would decisively get settled. This is because of the large number of actors involved in the debate about GM crops, and the highly political nature of the subject. So, experimental standards and protocols, even if agreed upon, would most likely not solve the political questions around scientific health risk assessment of GM crops.

In the present case, scientific publishing as a central institution of scientific knowledge production became ultimately the object of boundary work, too. This brings me back to the qualifications about socio-material techniques, structures, and institutions of scientific advice that Bijker at al. (2009) have made to the concept of boundary work, and the additions my analysis can bring to understanding public involvement in scientific debates where the boundary between science and politics is unclear and contested. Bijker et al. point to the importance of boundary work beyond rhetoric; social and material techniques play a role in

[88] The arguments about Séralini and colleagues initially withholding the raw data set of the long-term (2012) study can be seen in the same way. Being criticised for not making the raw data accessible, Séralini and his supporters could draw the attention to standard industry practice to keep such data sets inaccessible, therefore preventing the scientific community from checking and replicating risk assessment outcomes.

constructing the boundary between science and non-science. In particular the arguments about the potential influence of study financing on study outcome featured prominently on both sides of the controversy. In Marres' (2007) words, it was not only the symbolism, rhetoric, and vocabulary of scientific life that actors referred to in constructing the boundary between science and politics, but also sociotechnical attachments of the actors in the controversy became an issue of boundary work. The contested scientific status of such institutions as ILSI and the Science Media Centre illustrated this point. At the time of writing, several law cases against Monsanto Corporation in the United States led to the disclosure of a number of documents (the so-called Monsanto Papers), amongst them emails that confirmed FCT's Editor-in-Chief Wallace Hayes had a contract as scientific advisor with Monsanto as from summer 2012 (BaumHeldum, 2017b; Lemke, 2012). The consultancy agreement between Wallace and Monsanto Corporation reveals Wallace's function as Editor-in-Chief of FCT was compromised by financial and professional conflicts of interest at the time of the debate, which in turn might have influenced his retraction decision. There are also emails that confirm Monsanto Corporation asked the help of scientists to denounce Séralini's publication as "junk science", to dismantle Séralini's scientific integrity, and to petition FCT to retract the paper (Saltmiras, 2012). Insight into these leaked documents offer an explanation as to why the Séralini et al (2012) study was retracted because of its inconclusiveness instead of the official requirements for retraction as laid out by the Committee on Publication Ethics (COPE).

Further, it was elaborate networks of actors that allied in the debate. On the one hand, I show how several scientists have strong ties to the industry. While some of them posed as disinterested observers who presented their arguments about the scientific merits of the study in news comments, the same actors signed letters to the editor demanding retraction of the study, (e.g. Chassy, Harwood, Miller, Trewavas); and others who posed as scientists worked directly for Monsanto (e.g. Saltmiras). Séralini on the other hand was supported by many civil society groups, who shared his arguments, for instance about conflicts of interest of scientific experts in regulatory risk assessment. An important ally of Séralini et al. was also Corine Lépage, who is not only an MEP, but also a founding member of CRIIGEN. The importance of such social ties and material attachments also point to the structural implications of boundary work that Bijker et al. refer to. These became clearly visible when various actors made arguments about the boundary between science and politics based on (financial, professional, ideological) conflicts of interest. For a matter of fact, toxicological feeding experiments are costly, and due of the absence of publicly funded institutions that conduct risk assessment independent from industry (for regulatory approval) and civil society (for counter expertise), both will remain to fund their own risk assessment studies. I argue that such structural notions need to gain more prominence in analysing and understanding controversies about the possibilities and limits of scientific risk assessment.

This also alerts us to the pivotal role of regulatory institutions such as EFSA, which decide on the scientific merit of a study like Séralini et al.'s in order to call an end to controversy. EFSA's role as scientific arbiter makes it appear as if it stands above scientific practice, which involves uncertainty, disagreement, and debate. Although EFSA gives science-based advice to risk managers (i.e. the European Commission), it attempts to distinguish itself from science as a final arbiter of truth, e.g. through institutional mechanisms that shall guarantee the

impartiality of its experts (interview DG SANCO, 2013). Though as we have seen, it is difficult to make experts appear impartial. Although EFSA decided that the long-term study did not merit to be considered for a re-evaluation of NK603 or Roundup™, it was unsuccessful to end the controversy. The paper was republished and thus can be considered to still belong to the realm of science, if only for re-entering the debate about the length, design, and instruments of toxicological feeding studies through a publishing journal. Debate itself is a component of scientific work. Therefore, controversy has and will always be an essential part of scientific knowledge production. Finally, we see that there were more actors involved in the debate than just scientists, and that these actors constructed more than one boundary: between science and non-science; facts and values; science and politics; and between risk assessment and risk management.

What is most striking about the controversy about Séralini et al. (2012) is that the controversy evolved from discussing issues of method and study design, to notions of scientific independence and the structures of risk assessment science, towards central institutions of science itself, i.e. the peer-review mechanism of the publishing journal FCT. The obvious result of such boundary work that puts the integrity of scientific quality control into doubt is that risk assessment science itself takes damage. As a EU Commission policy officer on biotechnology explained "people do not believe automatically in what scientists say", i.e. such public controversy about science produces a problem of trust and credibility, not only in scientific knowledge production, but in the institutions that rely on it, too (interview DG SANCO, 2013). Accordingly, we can conclude that toxicological risk assessment is inherently limited by the uncertainty of knowledge production; and that it gets even more limited when the boundaries between science and politics are fiercely contested. Both sides in the debate about the long-term feeding study aimed to draw the boundary between science and politics to create an image of science that stands either outside politics, or that recognises the intertwinement of science with politics. My analysis has shown however that these demarcation attempts show this boundary to be far from clear. A different perspective is needed.

It might be impossible to render GM crop health risk assessment non-political, despite the attempts by various actors to construct one science or the other neutral, autonomous, or independent. Instead, we need to appreciate the political dimension of scientific knowledge production to make its politicisation explicit. Such a perspective can help to understand debates about technological risks better and to see more clearly the attachments and stakes involved for the actors and decision-makers. Accordingly, this will set the capacity of risk assessment science to answer the questions about the potential health risks of GM crops into perspective: Since GM crops are such a politicised issue, risk assessment needs to be transparent and ready to be contested by contradictory evidence and data interpretation. Moreover, the high degree of politicisation of the debate about the risks of GM crops makes it necessary to look at the wider ideas associated to the technology beyond the question of health risks that feature so prominently in the public debate. The EU Commission policy officer on biotechnology explained to me in this regard, the "discomfort with science, is [also] about the societal model. GMOs are the latest development of a model for agriculture and the economy" (interview DG SANCO, 2013). I will turn to such explicitly political and normative issues in the following chapter which looks the imaginaries of the future with(out) GM crops that actors in the debate construct around the technology.

Chapter 3

Imagining Futures with(out) GM Crops - Normativity, Temporality, and Publics

Introduction: visions of our sociotechnical future

In this chapter, I chart the broader public debate about the risks of GM crops in India and Europe. To understand the political dimension of the controversy, I describe the competing futures that various relevant social groups construct around GM crops. When actors speak of a technological future, they refer to pending issues of the debate, as well as possibilities they see arising from the interrelationships between technological, social, political, and economic change. For instance, some actors present GM crops as a solution to the question of world hunger and increasing agricultural productivity, whereas others doubt that there can be easy technological solutions to such complex problems as malnutrition and food scarcity. Instead, such actors envision GM crops to aggravate problems associated with input-intensive farming practices, in particular with regard to ecological consequences. They instead envision GM crops to create a future in which the ecosystem is out of equilibrium and agriculture becomes impossible. As an Indian activist explained to me in an interview: "when we think of how technological and social change interplay, people mostly link it to tangible and immediate issues, but GM crops have always been a futuristic vision" (interview Kuruganti, 2012). This chapter is about the futuristic visions which actors construct in the debate about transgenic crops.

Studying visions of futures with and without GM crops at play in the controversy allows me to explore the manifold meaning constructions and wider political issues various actors attach to GM crop technology and its risks. To analyse such ideas about how GM crops might shape the future, I employ the concept of *sociotechnical imaginaries*, which refers to the ways in which science and technology are imagined to generate social and economic change (Jasanoff & Kim, 2009). Stone notes the controversy about GM crops has been rife with "deceptive rhetoric spin, and soundbite science portraying the wonders – or horrors – of the new technology" (Stone, 2002, p. 611). Accordingly, I carve out the positive and negative visions of the future which actors of the GM crops debate construct around the technology and its risks. I will show that such imaginaries pertain to various wider political debates which complicate the idea that the controversy can be easily understood in a pro-con dichotomy. Rather, there are overlapping issues and concerns at play that pertain to normative ideas around the role of GM crops technology for agricultural change, environment and ecology, and questions about economic and political development.[89]

Diverging meaning constructions often relate to relevant social groups' clashing interpretations of issues of impact, consequences, risks, and benefits of the technology in question. These varying ideas and interpretations of the potential futures with(out) GM crops not only reveal how divergent meanings attached to GM crop technology conflict and compete with each other, but they also serve as powerful repositories for understanding how actors in the debate envision and discuss societal change. As Giddens explains, the discussion about technological risks is about the idea of controlling the future (Giddens, 1999). In that sense, sociotechnical imaginaries are as much about technological as well as social change that finds expression in the construction of different futures with or without GM crops. So, I ask in

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this chapter: How do the actors of the GM crops debate in India and Europe imagine and articulate sociotechnical futures with and without GM crops? When asking for the normative content of sociotechnical imaginaries, I also want to explain how such conceptions of the future not only reflect the issues of the contemporary debate about the risks of GM crops in India and Europe, but also where they come from, i.e. how constructions of the future connect to various interpretations of the past.

The aim of this chapter is therefore threefold: First, analysing the debate about GM crops through the lens of sociotechnical imaginaries allows understanding the interpretive flexibility of GM crops; the various meanings attached to the technology and its risks, and how the actors in the debate connect GM crops to wider political issues. Second, opening up the analysis of the debate to these wider issues reveals the normative dimension of sociotechnical imaginaries. Constructing visions of desirable and undesirable technological futures for the political community entail highly normative assumptions and ideas about how societal development should look like. Sheila Jasanoff notes that visions of sociotechnical futures reflect the interrelationships between "materiality, meaning, and morality that constitute robust forms of social life" (Jasanoff, 2015, p. 3). The lens of sociotechnical imaginaries therefore allows depicting the prescriptive and normative elements of the debate. Third, I want to address how the various problem definitions and issues about agricultural development, environment, ecology, economy, and democracy not only reveal the normativity of sociotechnical imaginaries, but also I want to show how the imaginaries in the GM crops debate root in the actor's interpretation of the past. Although imaginaries are about identifying visions of desirable sociotechnical futures worth attaining for society, they are often extrapolated from past events which serve as an explanatory and justificatory backdrop for these futuristic visions. Within the wider frame of this thesis, the normativity and temporality of sociotechnical imaginaries serves to understand how publics are constructed in and through competing, conflicting, and contested visions of our sociotechnical future. The wider issues, their normative foundations, as well as the temporality of sociotechnical imaginaries futures speak to and from different publics.

Sociotechnical Imaginaries and the GM Crops Debate

In its earliest form, the concept of sociotechnical imaginaries was developed to explain the social dimension of technological and scientific change from a sociological perspective (Marcus, 1995b). More recently, STS literature has taken up the concept "to show how different imaginations of social life and order are co-produced along with the goals, properties, benefits and risks of science and technology" (Jasanoff & Kim, 2009, p. 141). For instance, in their comparative study of the development and regulation of nuclear energy in the United States and South Korea, Jasanoff and Kim show how the imaginary of nuclear energy is embedded in existing state-society relations and understandings of democracy through the notion of the public good, the construction of publics, and ideas about participation in science and technology decision-making. Jasanoff and Kim define sociotechnical imaginaries as "collectively imagined forms of social life and social order reflected in the design and fulfilment of nation-

specific scientific and/ or technological projects" (Jasanoff & Kim, 2009, p. 120). Within nation states, there are distinct cultures of imagining and implementing technological systems, and these differences are related to the nation's broader political development (Jasanoff & Kim, 2013). The idea of sociotechnical imaginaries therefore is to show how national political cultures are intertwined with "the development and reception of science and technology" (Jasanoff & Kim, 2009, p. 124). Depending on cultural context of the specific nation state, sociotechnical imaginaries also inform what Jasanoff (2005a) has called "civic epistemologies" (Jasanoff, 2005a), i.e. the correspondence between institutionalised practices of knowledge production and application, and a given society's imagination of how science, technology, and social order intertwine (cf. Burri, 2015).

Accordingly, the construction of sociotechnical imaginaries, although important at the level of the nation state, is not exclusive to state actors. Organised groups and institutions such as corporations, environmental NGOs, social movements, and expert bodies produce their own imaginaries (Jasanoff, 2015). The concept has been used to describe non-state institutions' and actors' mechanisms of governance, similar to agenda-setting in conventional policy-analysis that concerns itself with the study of bureaucratic interactions in policy-making: In her study of corporate social responsibility programmes of biotechnology corporation Syngenta, Smith shows that non-state corporate entities construct their own imaginaries of science and technology, for instance by presenting Golden Rice licensing agreements as seamlessly integrating ethics and economic growth objectives (E. Smith, 2015). Also, civil society organisations such as Greenpeace have successfully challenged dominant sociotechnical imaginaries, for instance about Golden Rice in China (Chen, 2015). Social movements construct alternative sociotechnical imaginaries to question official visions of development, national interest, and of the role and place of science and technology in society, to the extent of delaying and changing national technology policies (Kim, 2015).

In this vein, I employ the concept of sociotechnical imaginaries in this chapter: I show how a variety of relevant social groups (consisting of activists, corporate representatives, farmers, journalist, lobbyist, NGOs, politicians, and scientists) construct a multiplicity of competing, conflicting, and contested visons of a sociotechnical future with and without GM crops. This is to identify commonalities and differences of the sociotechnical imaginaries at play in the Indian and European debates. Since the controversy about GM crops is an ongoing debate that is far from closure, the concept of sociotechnical imaginaries is useful for scrutinising this continued contestation in which multiple visions of the future compete for dominance. As various actors envision society's techno-scientific future differently, there are accordingly different imaginaries at play. Jasanoff explains that different imaginaries can coexist either "in tension or a productive dialectical relationship" (Jasanoff, 2015, p. 4), while social actors such as media, courts, and institutions of governance privilege certain imaginaries over others for policy purposes. Also, the concept is more suitable to study an ongoing debate about GM crops as a technology that is already in the world, as in contrast to the conceptual repertoire offered by the sociology of expectations, which concerns itself more with innovation processes of novel technologies, such as nanotechnology, information technologies, and so far unexplored biotechnology applications (see, e.g. Borup, Brown, Konrad, & van Lente, 2006).

Yet, what is the sociotechnical dimension of these imaginaries? As the common sense notion of imaginaries suggests, sociotechnical imaginaries are the ways in which actors conceive of a future with the help of science and technology. These imaginations are not exclusive to the latter, but they are closely intertwined with notions of the good and desirable of the social world. Imaginaries are sociotechnical because science and technology are frequently imagined to generate social change and economic growth for a more desirable future (Levidow & Papaioannou, 2013). In that sense "technoscientific imaginaries are simultaneously also 'social imaginaries,' encoding collective visions of the good society" (Jasanoff & Kim, 2009, p. 123). They not only encode futures attainable through science and technology, but they are also a representation of how society ought or ought not to evolve; hence: *sociotechnical* imaginaries.

The concept bridges the literature on the construction of imaginaries in political and cultural theory and social constructivist approaches to technology and society. Anthropologists for instance have used the term 'social imaginaries' in the study of ideology to address the creative and symbolic dimensions with which people create their ways of living together and represent their collective lives (Thompson, 1984). In his work *Imagined Communities*, Benedict Anderson (1983) defined the nation as an imagined political community in which people who have never met each other form a sense of belonging to a mass political subject (the nation) through shared practices of narrating, imagining, and remembering, mediated by print technology. Philosopher Charles Taylor described the social imaginary as "ways people imagine their social existence, how they fit together with others, how things go on between them and their fellows, the expectations that are normally met, and the deeper normative notions and images that underlie these expectations" (Taylor, 2004, p. 23).[90] While authors such as Anderson and Taylor connect imaginaries to wider schemes such as nationalism and modernity, Arjun Appadurai further explained imaginaries to work on smaller scales of social organisation, as "an organised field of social practices, a form of work (in the sense of both labour and culturally organised practice), and a form of negotiation between sites of agency and globally defined fields of possibility" (Appadurai, 1996, p. 31). The modern social imaginary thus constitutes horizons of common understandings, expectations, and practices that make shared group life possible. Yet, the works by Anderson, Appadurai, and Taylor fall short in taking science and technology more explicitly into account. The concept of sociotechnical imaginaries fills this gap. It is about both, how science and technology are imagined to create a better future for society, and how that techno-scientific society should or should not look like. Accordingly, I want to draw attention to the normative dimension of sociotechnical imaginaries in the GM crops debate.

Jasanoff and Kim emphasise that "techno-scientific imaginaries are not tied to future possibilities solely through scientific or technological practices. They are also imbued with implicit understanding of what is good and desirable in the social world writ large – for instance how science and technology can meet public needs and who even are the relevant publics" (Jasanoff & Kim, 2009, pp. 122-123). Imagination as a cultural resource and essential

[90] Taylor (2004) identifies three dynamics of the social imaginary in modernity: the separation of the economy as a distinct and objectified domain of social life, the emergence of a public sphere constituting itself through performative speech acts, and the idea of popular sovereignty as the invention of 'the people' as a self-constituting group outside formal political institutions (cf. B. Anderson, 1983; cf. Habermas, 1986).

element of social and political life points to the important role of future visions for communities: it helps them to understand social reality and to create ontological certainty (Jasanoff & Kim, 2009, p. 123). Imagination as a source of collective meaning systems can create a sense of belonging to a political community or constitute a way of looking at and differentiating from the Other. It also helps categorising, normalising, and governing populations (cf. B. Anderson, 1983; cf. Foucault, 1979; cf. Said, 1995, 1978). Hence, the concept of sociotechnical imaginaries is a suitable tool for deconstructing the normative character of visions of a collective sociotechnical future.

The framing of technology and its risks, and how these are imagined to play into society's future development reflects competing normative conceptions of sociotechnical development: "different imaginations of social life and order are co-produced along with the goals, priorities, benefits, and risks of science and technology" (Jasanoff & Kim, 2013, p. 141). Imaginaries are deeply but not always explicitly normatively loaded visions not only of what should be done, but also of how and why it should happen. 'Imaginary' thus refers to complex views of the world, embeds in ideological constellations and discursive framings that can shape policy agendas, scientific research, and public policy (E. Smith, 2009, p. 462). Imaginaries are about engendering a variety of possibilities for society beyond the indeterminacy of material conditions such as technological change (cf. Castoriadis, 1975, p. 203; quoted in Thompson, 1984). The concept of sociotechnical imaginaries allows emphasising the deep-seated background understandings and the normative dimensions underpinning technological controversies (Steger & James, 2013). In this chapter, I will show how the possibilities of techno-scientific and social change are constructed through imaginaries by deconstructing how the actors of the GM crops debate relate transgenic crops to wider normatively laden issues they see implicated with the technology, such as food security, ecological stability, or questions about economic development and globalisation.

Imaginaries as a concept allows including the imaginative, visionary repertoires of meaning with which actors construct good and bad techno-scientific futures, which goes beyond the notion of technological frames suggested by SCOT (Bijker et al., 1987). Moreover, understanding techno-scientific controversies from the perspective of sociotechnical imaginaries calls for the scrutiny of the performative and representational dimension of such debates, which in turn enables a better understanding of the democratic character of public debates about technological futures. As Marcus suggests, "the imaginary fills in the cognitive gap and tension that the widespread perceived inadequacy of working practices and concepts create within so many institutions and professions today" (Marcus, 1995b, p. 4). Also, Jasanoff and Kim allude that little attention has been paid so far to studying how sociotechnical imaginaries make and sustain the focus on some risks and benefits of sociotechnical change, while systematically downplaying other ideas about collective risk-taking (Jasanoff & Kim, 2013). Smith remarks in this respect that futuristic visons of technological development may present certain aspects of techno-scientific development as most suitable or inevitable, making sociotechnical imaginaries potentially appear "hegemonic while seeming apolitical or value neutral" (E. Smith, 2009, p. 463). Studying visions of sociotechnical futures through the lens of sociotechnical imaginaries therefore allows unboxing a hierarchy of normative frames that such visions of the future entail.

To understand the relationship between sociotechnical imaginaries, the discourse on risk, and normative frames, we must not only look at policy documents and narratives, but also include material produced by non-state actors, as well as mass media, and visual materials in an interpretive textual analysis of the symbolic and rhetoric elements of such controversies. The analytic focus goes beyond material and organisational resources used to shape imaginaries of sociotechnical futures, and includes the imaginative, performative, and representative repertoires with which the idea of the public good gets shaped by various actors who construct sociotechnical imaginaries (Jasanoff & Kim, 2009). Since we can expect to find a multiplicity of competing imaginaries in controversies about sociotechnical projects such as GM crops, Jasanoff and Kim advise us to approach imaginaries "in the understudied regions between imagination and action, between discourse and decision and between inchoate public opinion and instrumental state policy" (2009, p. 123). We therefore need to look at where imaginaries in public debate are constructed to shape political decisions, how they aim at setting agendas and formulating policy, and the construction of the relevant publics the respective policies are aimed at.

To do so, I draw on qualitative interviews with key actors of the debate, such as Vandana Shiva, who has been described as a rock star of the anti-GMO movement (Entine & Ryan, 2014; Specter, 2014), representatives from larger international NGOs (Greenpeace, Friends of the Earth), and scientists involved in the GM crops debate (e.g. PM Bhargava, G Padmanaban, and MS Swaminathan in India)[91], but also industry advocacy organisations which aim to create a positive public image of GM crops and favourable policy environments for the technology. Sociotechnical imaginaries can originate in the visions of individuals, but only when these become adopted by wider communities, such visions become imaginaries (Jasanoff, 2015). I thus also draw on interviews with internationally less known, but no less important actors of the GM crops debate, such as agricultural activists, grassroots NGOs, legal scholars, and journalists whose imaginaries of the future spread by the visions constructed in textual publications, or through activist work, and which can consequently be assumed to be shared by larger groups of people. I will introduce these actors in more detail throughout the chapter. Moreover, since sociotechnical imaginaries gain traction when communally adopted and shared by social coalitions, I include ethnographic observations of events where such imaginaries were enacted and circulated. For instance, a Delhi conference on *Doubling Food Production in Five Years*, organised by the Government of India and agricultural corporations; or the inauguration of a farmers' school in Chamarajanagar in the Indian state of Karnataka, organised by a the Karnataka State Farmers' Association and the socialist farmers' union KRRS which was attended by hundreds of farmers from all over India. Equally, I observed sociotechnical imaginaries at play in laboratories, at demonstrations and

[91] I chose to interview these prominent figures of Indian science because they belong to the "generation of nation building scientists, who built the edifice of Indian science"(Akbari, 2017). MS Swaminathan and PM Bhargava, both molecular biologists, founded their own research centres in their late careers (Swaminathan Research Foundation, Chennai and Centre for Cellular and Molecular Biology, Hyderabad, respectively). Padmanaban is also a molecular biologist. All three of them frequently contributed to the GM corps debate, taking various positions for and against the technology. Being widely considered eminent figures of science, speaking with the scientific temper, these scientists were also keen to fashion themselves as contributing to Indian science and society since Independence (Bhargava & Chakrabarti, 2003; Padmanaban, 2008). PM Bhargava passed away in summer 2017.

conferences, but also in textual material. I therefore also draw on a variety of documents on the GM crops debate, such as promotion material (arguing for and against GM crops), documentaries, government documents, NGO reports, newsletters by advocacy groups, newspaper articles, and opinion pieces from the European and Indian GM crops debates. I studied these sources for the way they symbolically articulate possible futures with and without GM crops in order to understand how the actors articulate their visions of sociotechnical futures.

In the following, I study the arena of the public debate about GM crops and their risks from the perspective of sociotechnical imaginaries, defined recently by Jasanoff as: "collectively held, institutionally stabilised, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (Jasanoff, 2015, p. 4). My aim in this chapter is to identify how sociotechnical imaginaries are constructed in the GM crops debate in India and Europe, to describe "how truth claims are related to practices and symbols that regulate social life" (Escobar, 1995, p. 12). I take imaginaries as a cultural resource that actors invoke to form visions of the future they can work towards to. Sociotechnical imaginaries help the actors of the debate to understand GM crop technology and its risks, to address larger relevant issues they see implicated with the technology, to shape policy preferences, and to construct the very publics to and from which such visions of the future speak. In addressing a variety of actors, also those outside established policy and techno-scientific elites, and in emphasising the normative character of such imaginaries of the future, the concept allows me to focus on the symbolic, prescriptive, and temporal representation of futuristic visions. These find expression not only in theoretical terms, but also through narratives (e.g. about agricultural, economic, and political developments), images (e.g. of a future society), and metaphors (cf. Wyatt, 2004).

In the ensuing sections, I present four imaginaries that I have identified in the GM crops debate in India and Europe to answer the question how the actors of the controversy symbolically articulate the wonders and horrors of their visions of a sociotechnical future with and without GM crops. In depicting each of these, I show the various meanings attributed to GM crops and their risks, i.e. the interpretative flexibility of GM crops. By explaining how positive and negative visions of the future with and without GM crops connect to wider issues of the debate, I show the normative underpinnings of the sociotechnical imaginaries. By doing so, I answer additional questions such as: How do the actors frame the risks and benefits of GM crops? What are the problem definitions and wider issues attached to GM crops beyond health risk concerns that I addressed in the previous chapter? On what normative assumptions do the actors base their visions of the future? Finally, I will also explain where the sociotechnical imaginaries of the GM crops debate come from, i.e. how these futuristic visions and their ontological assumptions are stabilised and consolidated by meanings attributed to the past. I therefore show how visions of a sociotechnical future are rooted in the actors' interpretation of past agricultural development. Taylor explains that imaginaries allow giving sense to the present, relating to others in power, and comprehending time and space (Taylor, 2004, pp. 27-31).

Productivity for Food Security and Competitiveness

The proponents of GM crops construct the technology as part of an imaginary of productivity for food security. These actors envision the enhancement of agricultural output as the solution to fight the problem of food shortages. In this vision of the future, global demand for food crops can only be addressed by using GM crops to increase yields. In its yearly sustainability report, Monsanto Company for instance puts global food security and a growing world population as the two key challenges facing agriculture today: "food production will need to increase, enabling us to combat hunger, malnutrition, and meet the needs of changing diets and a growing population" (Monsanto, 2012b, p. 8). The underlying rationale presented here is that as world population grows, global demand for crops increases, while less land becomes available for agricultural production. The problem definition is one of productivity; food security is depicted as being at stake without more efficient and productive agricultural technology:

> One of the world's biggest food challenges: productivity. In order to feed the world's growing population and meet global food and nutrition security needs, farmers must produce more food in the next fifty years than they have in the past 10.000 years combined.
>
> (Monsanto, 2012, p. 68)

As Hugh Grant, CEO of Monsanto Company since 2003, stated in a 2008 television interview, GM crops with their supposed benefits of reduced input costs and higher yields constitute the technological possibility that makes the imagined wonders of a sociotechnical future with transgenic crops possible. In this imaginary, GM crops are the only means to respond to the need to increase yields, and thus to guarantee food security: "Doubling food production in existing arable land with ever increasing demand for food, this objective cannot be realised without GM crop technology" (Grant, 2008). Imagining a future in which GM crops provide the technological solution to increase agricultural production to combat malnutrition and hunger takes what I call the Malthusian rationale as its foundation.

Eighteenth century British political economist Thomas Malthus formulated the principle of population which in its simplest assumes that population grows exponentially while the increase in the availability of food supplies is only linear: the growth in human population outruns a much slower increase in agricultural productivity, the latter never being far from collapse. Despite its shortcomings, simplicity, and out-datedness, the basic Malthusian idea that population growth can hardly be met with fixed endowments of natural resources and capacities for agricultural production (unless technological solutions, in this case GM crops, increase productivity), continues to be a resilient way of thinking about agricultural innovation and sociotechnical development (Iyer, 2013; Legwegoh & Fraser, 2015; Southgate, Graham, & Tweeten, 2007). In agricultural economics for instance, population growth, aside from income, is taken as a decisive variable in explaining malnutrition, from which follows the assumption that continual increases in food production through the intensification of cultivation becomes inevitable: "most increases in agricultural production will have to come from more intensive use of land currently being farmed" (Norton, Alwang, & Masters, 2006, p. 21). Equally, the transnational seeds and agro-chemicals producer Monsanto bases the

problem definition to which GM crops pose the solution on a Malthusian rationale as a taken for granted reality. In this imaginary, GM crops are the inevitable solution to intensify agriculture in order to increase its productivity.[92]

In India, the imaginary of productivity for food security has a powerful cultural meaning that is rooted in the historical experience of food shortages and famine which is commonly explained through the Malthusian rationale.[93] The collective memory of India's dependence on imports for food security before the onset of the Green Revolution, and of starvation and malnutrition, activates collective consciousness and motivates policy targets till date (Pritchard, Rammohan, & Sekher, 2013).[94] Political leaders such as president Pranab Mukherjee (Times, 2013) or Union Minister for Agriculture Sharad Pawar (Express, 2013), biotechnologists (Padmanaban, 2013), and think tanks such as the National Academy of Agricultural Sciences (Sud, 2013) frequently invoke the imaginary that GM crops have the revolutionary potential to increase agricultural output. Scientists take a central role in making the imaginary of productivity an imperative to feed the hungry. An Indian proponent of GM crops explains the technology to be the only viable solution to the Malthusian problem: "India urgently needs improved technologies to develop quality seed with traits relevant to regional needs and to increase crop yields by a wider adoption of such technologies as crop genetic engineering" (Rao, 2013c, p. 167).

Professor Padmanaban, molecular biologist at the Indian Institute of Science, Bangalore, who frequently contributes to the Indian debate on GM crops, is convinced the technology will solve the problem of productivity in food production: "the fact remains that we need to produce more food in accordance with the rate of population growth" (interview Padmanaban, 2012). Beyond the Malthusian rationale, Padmanaban raises hopes about a future in which GM crops not only increase yield, but also get modified to entail properties to cope

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[92] In particular in the Indian context, GM crops proponents frequently refer to Norman Borlaugh, one of the so-called founding fathers of the Green Revolution, who in his speech upon receiving the Nobel Peace Price for his work on high yielding crop varieties (a cornerstone of the technologies of the Green Revolution) invoked the Malthusian rationale and the idea of the technological mastery of nature: "We are dealing with two opposing forces, the scientific power of food production and the biological power of human reproduction. Man had made amazing progress recently in his potential mastery of these two contending powers. Science, invention, and technology have given him materials and methods for increasing food supplies substantially and sometimes spectacularly" (Borlaugh, 1970).

[93] According to the Food and Agricultural Organisation of the United Nations (FAO), food security remains an important issue in India: the percentage of the Indian population suffering from malnourishment has only slightly decreased over the last decade from 21,6 per cent in 2001-03 to 17 per cent in 2011-13. India remains the country with the largest number of hungry people in the world with an estimated 213 million food insecure individuals in 2013 (FAO, 2013; FAO, IFAD, & WFP, 2013). A 2013 policy report on malnutrition noted the complexity of the problem that average calorie intake of Indians has fallen over the last two decades while much poorer countries than India, which produce less food, have still done better in addressing hunger and starvation (Singh, 2013).

[94] For a powerful critique of the hypothesis that famines can be explained by food shortages and productivity problems, see Sen's analysis of the 1942 Bengal and the 1974 Bangladesh famines, in which he suggests an alternative explanation based on the concept of entitlement (Sen, 1981) and more recently Mishra who explains availability, accessibility, and adequacy of food supplies to be key challenges (Mishra, 2012). See also Stone (2002) for an explication of how advocates of GM crops have made the Malthusian argument even in times of agricultural overproduction.

with draught and saline soil conditions, and to have enhanced nutritional characteristics: "Think about a technology that improves nutritional value and also gives you better yield. More production and better nutrition – would that not make for a revolution in a country like India?" (interview Padmanaban, 2012).[95] As the quote indicates, GM crops are constructed as a cutting-edge technology that paves the way to a sociotechnical future in which transgenic crops provide the solution to the Malthusian logic of food security endangered by population growth, as well as other problems related to malnutrition and hunger. How do those constructing a sociotechnical imaginary of productivity for food security think about the risks of GM crops?

To the Indian proponents of GM crops, its potential benefits outweigh the risks the technology might bring about. CK Rao, Executive Secretary of the Foundation for Biotechnology Awareness (FBAE), a Bangalore-based "think tank to influence public opinion and government policy [on biotechnology]" (FBAE, 2008), alleges that the risks of GM crops are negligible because existing risk assessment studies have confirmed the safety of the technology.[96] Regarding its potential benefits of feeding the hungry, Rao is concerned that environmental NGOs exaggerate safety concerns to scaremonger the public (interview Rao, 2013). To him, precautionary measures such as the moratorium on Bt-brinjal, India's first GM food crop, are not based on science, but on political considerations. Instead, the regulatory framework on risk assessment is too strict compared to the potential benefits GM crops might bring in the future (Rao, 2012, 2013c). Molecular biologist Padmanaban also states upfront that considerations about risks are overestimated in the face of its potential benefits: "What are those risks? Any of them has no meaning at all, absolutely there is no meaning; because look at malnutrition, look at starvation – all happening in this country" (interview Padmanaban, 2012). The vision of raising agricultural productivity with GM crops

[95] In my interview with Professor Padmanaban, he referred to the example of Golden Rice, which is a GM rice engineered to entail higher quantities of Beta Carotene (making the rice grains deep yellow, thus the name Golden Rice). Beta Carotene is a micronutrient essential for vitamin A provision. Vitamin A deficiency is a consequence of malnutrition and may lead to blindness and increased infant mortality if not treated timely. Accordingly, proponents have argued that Golden Rice could save millions of children's lives a year (Nash, 2000). Civil society organisations however have shown Golden Rice to fall short of fulfilling its promises (Then, 2012). The inventor of Golden Rice, as well as GM crops proponents like Padmanaban in contrast argue that too strict regulations have prevented the technology from reaching the hungry and malnourished (Potrykus, 2010, interview Padmanaban 2012). The WHO however points to a range of other strategies to combat vitamin A deficiency, amongst them diversifying diets and stimulating breast feeding, but not Golden Rice (WHO, 2017).

[96] The Foundation for Biotechnology Awareness (FBAE) advocates biotechnology for the benefit of humans, the environment, and sustainable development through educating the public "about the perceived or potential risks and benefits of this emerging technology", because "it is not very easy for common people to understand biotechnology" (FBAE, 2008). LobbyWatch, a civil society organisation that aims to uncover industry-sponsored public relations communication, states that FBAE has numerous links with major agricultural chemicals and GM seed producers such as Syngenta and Bayer CropScience (LobbyWatch, 2014). In a personal communication with the author (2018), CK Rao insisted that "we have interaction with industry and many of their scientists are our friends, but we do not have any links with industry". Rao accordingly describes FBAE not as industry representatives, but as an "independent science advocacy group" (personal communication with the author, 2018).

constructs the technology as a panacea to fight hunger and malnutrition by increasing agricultural output in the future. In this sociotechnical imaginary of productivity GM crops therefore acquire the meaning of being a necessary step to achieving the goal of food security and solving the problem of hunger. With such benefits for a sociotechnical future in mind, the potential risks of transgenic crops are only of minor importance.

While productivity for food security appears as a powerful imaginary in India, European actors refer to it in reference to developing countries to rhetorically promote GM crops as an altruistic technology for development (see figure 6, below). As studies of Bt-cotton have shown, the proponents of GM crops, most prominently industry actors, agricultural economists, and scientists involved with the development of the technology, have presented biotechnology in a pro-poor narrative for developing countries, emphasising how the technology contributes to increasing agricultural outputs, achieving food security, and alleviating poverty (cf. Glover, 2008, 2009, 2010; Glover & Stone, 2011; Stone, 2012). In its promotion material, EuropaBio, the largest European association for biotechnology industries, which is involved in developing, testing, and commercialising biotechnology products and processes, for instance presents GM crops as a technological silver bullet to not only enhance yields and address the problem of hunger, but also to stimulate economic growth better than conventional crops (EuropaBio, n.d.-a, n.d.-b).[97] The director of agricultural biotechnology at EuropaBio, Carel du Marchie Sarvaas explained the need for GM crops based on the Malthusian rationale:

> Basically, we need to produce more food more efficiently. It is very simple […] more people on the planet, and someone has to produce the food. European productivity has been flat for about a decade, but every country where GM is used has increased productivity - in some places dramatically. We need to produce more food; we need to produce it faster and more efficiently.
>
> (interview Sarvaas, 2012)

In a promotion booklet on GM crops, a Belgian biotechnologist suggests that marginal farmers will benefit from the technology in terms of guaranteeing food security under difficult cultivation conditions: "the potential is enormous […] What GM can do is solve small problems for local farmers. It will significantly help growers secure yields on a regular basis" (Gheysen, n.d., p. 23). The proponents of GM crops refer to a wide array of scientific findings that appear in industry publications and peer-reviewed scientific journals. These studies suggest GM crops to be a technological success in terms of enhanced yields, food security, and economic benefits form small and subsistence farmers in developing countries (Berman

[97] Conceived as the voice of the biotech industry in Europe, EuropaBio lobbies the relevant institutions of the European Union for a more favourable business environment for biotechnology companies (Paul, Steinbrecher, Michaels, & Kuyek, 2004). The website Powerbase, a database by civil society organisations critical of corporate influence on policy-making, describes EuropaBio as a lobby organisation that aims to win public trust in the safety of GM crops (Powerbase, 2010a). Based in Brussels, and consisting of corporate members and national biotechnology associations, EuropaBio represents more than 1800 biotechnology companies, amongst them major transnational corporations that produce GM crops like Monsanto, DowAgro Sciences, and Bayer Crop Science (EuropaBio, 2014a).

et al., 2013; Choudhary & Gaur, 2009, 2012; Kathage & Qaim, 2012; Klümper & Qaim, 2014; Minorsky, 2001; Qaim & Zilberman, 2003; Thirtle, Beyers, Ismael, & Piesse, 2003; Waltz, 2009). Yet, civil society actors question the scientific credentials of these studies, as we will see further below.

Figure 6: "At Monsanto, we believe agriculture has the power to lift people out of poverty" (Monsanto, 2012b, p.121)

There is a second imaginary of productivity at work both in India and Europe, which focuses on the idea that GM crops contribute to making agricultural production competitive for the global market. In a speech at a 2013 conference titled "Doubling Food Production in India in Five Years" in Delhi, President of India Pranab Mukherjee pointed to the potential of GM crops to stimulate India's economic development. In this vision of the future, GM crops stimulate economic growth by raising productivity. This would make India's agricultural produce fit for competing on the global market and thus contribute to overall economic, i.e. GDP growth. Other speakers at this industry-sponsored conference emphasised the meaning they attribute to GM crop technology as contributing to India's economic competitiveness more directly. For instance, a representative of the Indian agricultural biotechnology seed producer Metahelix Life Sciences suggested GM crops embody the public good: "increase in productivity is in the interest of us all, it is a shared goal" (Doubling Food Production Conference, 2013); and a representative from India's Ministry of Agriculture presented GM crops as a means to harmonise with the requirements of global technology-based competitiveness. This perspective naturalises GM crops as an imperative to make India's agriculture competitive in order to gain larger shares in global agricultural export markets. Almost all conference speakers agreed that in order to adhere to the requirement of global commodity markets, the regulatory system on GM crops should be eased and harmonised. They further opined that

improving communication about the technology would decrease the mistrust large parts of the public have towards the developers of GM seed technology. Yet, others present transgenic crops as an essential opportunity for technological modernisation: "India is lagging behind, we have been lagging behind since the Industrial Revolution. We are still paying the price, we are running behind and we are still catching up. We have to catch up with any technology" (interview Padmanaban, 2012). So, despite food security, competitiveness also plays into the imaginary of productivity in India.

In Europe, the imaginary of productivity for competitiveness looms much larger, since the quasi moratorium on the cultivation of transgenic crops is constructed as a missed opportunity for economic growth. Advocacy organisations attribute GM crops the potential to boost Europe's competitiveness in research and innovation (EuropaBio, 2014b, 2014c) and as a technological choice that should be made available to farmers (EuropaBio, 2011b), both to create substantial economic gains in the future (EuropaBio, n.d.-a). In a report titled *Going for Growth*, the Agricultural Biotechnology Council (ABC), which comprises of six major biotechnology companies, presents GM corps as a missed opportunity for technological innovation and economic competitiveness: "Europe is being left behind […] when it comes to investment in agricultural innovations such as advanced seed technologies" (ABC, 2012, p. 12).[98] From the idea of missing out on technological innovation and its associated growth potential for the European economy, the ABC report argues that GM crops could help "to maintain its competitive edge" (ABC, 2012, p. 9; cf. EuropaBio, 2011b). Here, actors promoting GM crops equally argue for making the regulatory requirements less stringent since current regulation prevents European countries from gaining future economic advantages. Despite biotechnology research being conducted in Europe, innovation would take place elsewhere instead: "We risk turning Europe into the world's biotech research hub and not reaping the benefits of the products and services provided by this key enabling technology" (EuropaBio, 2014c).

As a consequence of the current cultivation ban on transgenic crops, these actors see future European competitiveness in global agricultural commodity trade with grim prospects, estimating losses in farmer margins between 400 and 900 Million Euros (ABC, 2012). This, EuropaBio argues, will have detrimental effects in the future: "Continued non-availability of the technology for EU farmers essentially leads to a competitive disadvantage compared to global competitors on world markets. As new seeds continue to come to market in other countries, but not the EU, this gap will widen" (EuropaBio, 2011b, p. 12). If transgenic seeds however were cultivated on about 30 per cent of total European acreage, EuropaBio estimates farm level income benefits between 68 and 480 million Euros for the period 1998 to 2009 (EuropaBio, 2011a). To vest their claims about economic benefits with scientific credentials, industry representatives frequently refer to the yearly reports by the International

[98] ABC comprises of BASF, Bayer, Dow Agro Sciences, Monsanto, Pioneer (DuPont) and Syngenta (ABC, 2012). On its website, the ABC states that it wants to "provide factual information and education about the agricultural use of GM technology in the UK, based on respect for public interest, opinions and concern"(ABC, 2014). The website powerbase describes ABC as a lobby organisation representing industry interests across Europe (Powerbase, 2011). Horlick-Jones et al. (2007, p. 7) suggest that ABC was founded after a public relations campaign of Monsanto failed in 1998 in order to more effectively counter anti-GM arguments.

Service for the Application of Agri-Biotech Applications (ISAAA) which present continuously growing global adoption rates and economic benefits of GM crops (e.g. Choudhary & Gaur, 2009, 2012; James, 2011, 2012, 2014, 2015; James, 2016). Although frequently cited by proponents of transgenic crops, these studies are not themselves subject to peer-review (Stone, 2012).[99] Moreover, there is more to the negative vision of not reaping economic benefits with the continued non-adoption of GM crops in Europe: The developers of the technology might fully withdraw from the European market in the long run. Indeed, news reports in February 2013 stated that BASF had stopped its GM crop segment in Europe (McGrath, 2013); and in July 2013, Monsanto withdrew all pending cultivation approval requests for the European market (except for MON810) in order to focus only on import approvals while concentrating its efforts for cultivation authorisations in expanding markets elsewhere, foremost in developing countries (Hope, 2013; Midgley, 2013). Yet, productivity is not the only normative goal proponents of GM corps present in the controversy.

Those in favour of transgenic seeds complement the imaginary of productivity with another vision of the future that revolves around its suggested environmental benefits. Monsanto Company for instance portrays GM crops as an all-around solution to future challenges in agriculture:

> As demonstrated by the unprecedentedly rapid adoption of this technology among farmers, GM crops can provide farmers with the means to improve yields under weed and insect pressure; decrease tillage to protect soil and water resources; and reduce pesticide applications, thereby decreasing the use of fossil fuels.
>
> (Monsanto, 2014)

This quote from the Monsanto website presents transgenic crops as the solution not only to productivity requirements, but also to resource scarcity, field-management issues, and the need for technologies with a reduced environmental impact. It constructs an image of the future technological perfectibility of agriculture by the wonders of transgenic crops. The construction of GM crops as ecosystem-friendly lies at the core of the sociotechnical imaginary of environmentalism to which I turn next.

[99] The International Service for the Acquisition of Agi-Biotech Applications (ISAAA) is a non-profit organization that promotes crop biotechnology, in particular in developing countries "by sharing and disseminating scientific knowledge to the global community, and by facilitating transfer of technologies to developing countries though public-private partnerships" (ISAAA, 2014). Mayor biotech corporations such as Bayer Crop Science, Mahyco, Monsanto, and US government agencies such as the Department of Agriculture, and USAID are amongst its donors. ISAAA claims its publications are the most frequently cited on biotech crops globally (James, 2014). Still, its reports are not themselves peer-reviewed, while scientific literature on GM crops frequently cites ISAAA reports as authoritative and reliable sources (Stone, 2012). Anti-GM advocacy organisations such as GM Freeze accuse ISAAA of disseminating in its annual reports inaccurate and unreliable data not backed by scientific findings. Instead, ISAAA's reports can be considered publicity for the GM corps industry (GMFreeze, 2009).

Environmentalism

The advocates of transgenic crops construct an imaginary of an environmentally sustainable technology that can be as productive, but with less impact on ecosystems than previous agricultural technologies. The sociotechnical imaginary of environmentalism is at work in both India and Europe and is constructed as a benefit to the environment and farmers directly. An Indian industry representative from the Association of Biotech Led Enterprises (ABLE)[100] contends, "There are social advantages because there are fewer [pesticide] sprays. So, environmentally it is safer […] the farmers will benefit" (interview Seetharama, 2013). This notion constructs GM crops as an option for more sustainable agriculture: "Bt crops are the best option for organic farming. The function of Bt is to decrease pesticide use" (interview Padmanaban, 2012). ABLE representative Seetharama suggests that emphasising how GM crops may address environmental issues will lead to greater public acceptance of the technology: "biotech has endless possibilities. And those kinds of technology will be more acceptable to the public" (interview Seetharama, 2013). Not only do industry actors claim insect-resistant (IR) crops will lead to less pesticides being used in agriculture, but also that herbicide tolerant (HT) crops need less ploughing of the soil, which reduces carbon emissions and prevents soil erosion and compaction, which usually result from cultivation practices with conventional crops (ABC, 2012; EuropaBio, n.d.-b; James, 2016). These arguments are part of the imaginary of environmentalism that foresees responding to the need to practice farming in a more environmentally friendly way – again this imaginary constructs the technological perfectibility of future agriculture.

Industry actors attempt to invest such claims with scientific credibility by drawing on scientific publications. These are however authored by scientists connected to biotechnology consultancy organisations and the biotech industry. This is rather obvious in the case of ISAAA reports, but reviews by scientists connected to the biotech industry appear also in scientific journals. For instance, a meta-review of existing studies on the impact of commercialised GM crops on biodiversity alleges positive effects of the technology on agricultural sustainability, crop diversity, land use, non-target organisms, and pest management.(Carpenter, 2011) Yet, the author works for Crop Life International and the National Centre for Food and Agricultural Policy, which can be considered biotechnology promotion agencies.[101] Others equally related to the industry and its advocacy organisations interpret field-level data to show an overall reduction in pesticide use and suggest a positive environmental impact of

[100] ABLE is an advocacy consortium of Indian biotechnology corporations. It describes its objective as promoting the Indian biotechnology industry across such sectors as agriculture, pharmaceuticals, and informatics in order to create "a positive regulatory environment, encouraging entrepreneurship and investment in the sector, providing a platform for domestic and overseas companies to explore collaboration and partnerships, forging stronger links between academia and industry" (ABLE, 2011) .

[101] Crop Life International advocates the "plant science industry"(CropLifeInternational, 2014). It is funded by and represents biotech companies such as BASF, Bayer Crop Science, Dow Agro Science, DuPont, Monsanto, and Syngenta, and others (CropLifeFoundation, 2017; Powerbase, 2014a). Washington D.C. based National Centre for Food and Agricultural Policy conducts "objective, non-advocacy research, analysis, and education to inform public policy on food, agriculture, natural resources, environmental quality, and rural economics" (NCFAP, 2008), though civil society accuse the organisation of promoting unscientific industry claims with various of its staff being directly related to biotechnology producers (Powerbase, 2009d).

GM crops for the future, particularly in developing countries such as India (Choudhary & Gaur, 2012; Finger et al., 2011; James, 2016; Klümper & Qaim, 2014; Krishna & Qaim, 2012).

One of the strongest arguments the industry puts forward in the imaginary of environmentalism is that GM crops need less pesticide applications (e.g. ISAAA, 2017). GM crops producers suggest quantifying pesticide use to prove the positive (future) environmental impact of transgenic crop technology. For instance, Monsanto Company states in its sustainability report of 2012 that insect-resistant (IR) Bt-cotton has led to an overall reduction of pesticide use by 18 per cent, yet without specifying scientific sources or the timeframe of measurement (Monsanto, 2012b, pp. 10, 126). Although authors linked to PG Economics, a biotechnology consultancy organisation, suggest that "the environmental gains from the GM IR traits have mostly derived from decreased use of pesticides" (Barfoot & Brookes, 2014, p. 155), and that "the environmental profile of HT crops has commonly been better than its conventional equivalent" (p.150), their studies need to be read with caution.[102] These authors state that for the period 1996-2012, pesticide applications have overall fallen by nine per cent making "the environmental impact associated with insecticide and herbicide use on these crops falling by 23,6 per cent" (p.155). More recent studies on the period 1996-2015 by these authors adjust these claims to a 8,1 per cent reduction of pesticide applications resulting in a 18,6 per cent reduced environmental impact (Brookes & Barfoot, 2017). While GM crops proponents use such studies for making predictions about the future environmental benefits to be gained from GM crops, they usually do not recognise the methodological limitations (amount of pesticides applied is not a reliable measure for environmental impact) and limited empirical validity (comparability of data) of such statements.[103]

However, such details seem not relevant in the construction of the imaginary of environmentalism. It is instead much more important for the proponents of GM crops to couple environmentalism with the imaginary of productivity. The issue of pesticide applications allows for a discursive combination of environmentalism with economic benefits. This serves

[102] PG Economics is "a specialist provider of advisory and consultancy services to agriculture and other natural resource-based industries" (PGEconomics, 2014). Powerbase website explains PG Economics to be a consultancy to which the biotech industry commissions the writing of scientific reports. These usually claim GM crops to be extraordinarily successful. Amongst the clients of PG Economics are various biotechnology companies, agro-chemical manufacturers, seed companies and plant breeders. One of the authors (Brookes) has spent considerable time of his career in biotech industry and biotech business consultancy (Powerbase, 2010b).

[103] There are two major limitations of such studies, as recognised by the authors themselves: 1) Although the most common way in which environmental impact associated with pesticide use changes with GM crops is presented in the literature in terms of the volume (quantity) of pesticide applied, based on the Environmental Impact Quotient developed by Kovach et al. (Kovach, Petzold, Degni, & Tette, 1992), "this is not a good measure of environmental impact because the toxicity and risk of each pesticide is not directly related to the amount (weight) applied"(Brookes & Barfoot, 2011, p. 80; 2014, p. 80). 2) Although the authors present data on almost all countries that grow GM crops, "the only country in which pesticide usage data is collected (by private market research companies) on an annual basis, and which allows comparison between GM and conventional crops to be made, is the US" (Brookes & Barfoot, 2011, p. 78; 2014, p. 78). The data presented on all other countries, and the conclusions being drawn from their analysis, should therefore be read with caution. Note also the exact same wording in the 2011 and 2014 reports on these methodological issues, which GM crops proponents do not take into account when making their claims about the past and potential future environmental benefits of GM crops.

as a powerful argument that presents the farming community and society at large as the benefactors of GM crop technology. Here, transgenic crops as an environmentally friendly agricultural technology is constructed as a public need which at the same time entails the potential for productivity gains. For instance, scientists cited by the industry suggest that the environmental benefits in terms of reduction of pesticide translate in substantial income increases on the farm level due to input cost savings and increased yields (Brookes & Barfoot, 2014; Kathage & Qaim, 2012; Qaim & Zilberman, 2003). EuropaBio representative Sarvaas also compliments environmental considerations with productivity arguments. In reference to insect-resistant (IR) traits he explains: "GM crops have the potential to increase GDP growth while reducing pesticide applications at the same time" (interview Sarvaas, 2012). CK Rao from FBAE agrees that reduced pesticide applications due to IR crops are both, environmentally friendly and economically beneficial at the same time:

> If the farmers use GM crops, they need not use the pesticide. It costs quite a lot. Pesticides are quite expensive. […] But if you take the economics of this pesticide use plus the seed cost, it is much smaller than the net gain, also for small farmers […] The farmer is saving a lot; there is labour saving. That means money saving. So a farmer does not see an expense isolated from the rest of the world. It's a total investment, it's a total return.
>
> (interview Rao, 2013)

Within the imaginary of environmentalism, GM crops are constructed as a solution rather than a risk. Scientists Padmanaban explains in regard to environmental issues that GM crops are widely misperceived: "The idea that (IR crops) endanger biodiversity? It is the other way around. It protects biodiversity because it protects the plant against insect infestation" (interview Padmanaban, 2012). In the same vein, Monsanto Company presents the risks of overusing pesticides and the development of resistance in weeds and insects not as a technological risk, but as problems of bad management practices at the farm level, such as planting non-GM refugia and adhering to safety distances between GM and non-GM crops to prevent gene-flow to related species (Monsanto, 2012b, pp. 104-105). These actors construct transgenic crops to benefit the environment through the technology's potential to reduce pesticide applications.[104] In that sense, the use of chemical pesticides in conventional farming is conceived as a risk in which can be mitigated by using transgenic crops; and reducing risks to the environment is constructed as a public need to which the sociotechnical imaginary of environmentalism responds.

Such issues have traditionally been the concern of environmental NGOs and civil society organisations. As studies on agricultural transnational corporations suggest however, *environmentalism* is a malleable concept, a set of ideas and guiding principles that corporations try to mobilise to convince buyers that their products are more environmentally friendly, in order to sustain and enlarge market shares of their products (Jansen, 2004; Jansen & Vellema, 2004).

[104] This counts for IR transgenic crops. In the case of HT crops, the argument usually goes that these preserve the soil through less ploughing of weed infested fields, which in turn also reduced greenhouse gas emissions and saves labour.

Most of the currently operating transnational GM seed producers entered the crop biotechnology market when growth in their core business in agri-chemicals (in particular pesticides) began to slow down in the early 1980s. At the same time, the environmental movement had grown to maturity and successfully invoked sympathy for their arguments about environmental risks of input-intensive farming among larger parts of the public (Schurman & Munro, 2010). It was at this point that transgenic seed technology allowed the industry to shape the image of their technologies as environmentally friendly. In reference to the yield and growth potential of the Green Revolution, industry actors tapped into a sociotechnical imaginary of environmentalism early on by rhetorically presenting GM crops as part of a biotechnology induced Evergreen Revolution (cf. Brooks, 2005). Connecting the sociotechnical imaginary of environmentalism to the actor's interpretation of the past, i.e. the Green Revolution, relates to the temporal construction of transgenic seed technology.

The proponents of GM crops understand the technology as a precise technological intervention that is complementary to, and an extension of the agricultural technologies of the Green Revolution. For instance, Monsanto presents transgenic crop seeds not to be much different from conventionally bred seeds (Monsanto, 2015b). Instead, biotechnologists describe GM to be a very "precise technology" with little risks, because it is more accurate and quicker in producing the desired traits in crops as compared to conventional breeding: "the main advantage is that nothing else is changed as only the desired characteristics are added" (Gheysen, n.d., p. 18). Accordingly, GM crops are constructed to not entail risks, but to be a precise technological solution to those risks that came about with the Green Revolution (interview Gheysen, 2012). STS describes the idea that problems caused by technological risks can be mitigated by adding more technology as the techno-fix (M. Smith & Marx, 1994; Weinberg, 1966, 1991). Indeed, transgenic crops are supposed to respond to environmental concerns related to the Green Revolution, foremost the excessive use of pesticides (Rao, 2013c). As an Indian industry representative contends: "in fact, the Green Revolution is the culprit, not GM technology" (interview Seetharama, 2013).

Still, in the sociotechnical imaginaries of productivity and environmentalism, a positive historical memory of the Green Revolution period remains the dominant interpretation of the past, projected onto the future by means of techno-scientific linearity and techno-fixes. A Mahyco representative explained at the 2013 *Doubling Food Production* conference in Delhi: "GM crops are the answer to the need for a second Green Revolution to increase food production". Indian biotechnology advocate Rao equally explains the need for GM crops by referring to future challenges in agriculture: "the Green Revolution has demonstrated that various barriers to food production can be overcome through technological intervention" (Rao, 2013c, p. 171). To Rao, agricultural biotechnology is an extension of previous technological improvements in agriculture, and therefore a continuation of the technological culture of the Green Revolution. From this perspective, transgenic modification merely constitutes an improved breeding technology with greater precision and speed – assuming a linear causality of improving society's condition from hunger, to economic growth, and environmental protection by technological intervention. This perspective that connects past, present and future through a suggested sociotechnical continuity leading towards more precision and control naturalises transgenic crops as the necessary outcome of the historical development

of agricultural technology. Rao explains his interpretation of the evolution of agriculture and the role of GM crops therein:

> All the ten thousand years of agriculture […] is genetic modification only. It was done initially by selecting natural mutations and then you induced mutations: first, natural hybridisation […] and later artificial hybridisation. In artificial hybridisation, you put two entire genomes. In mutation, it is hit and miss. You just don't know what is happening. […] In that way, genetic engineering is more precise. They are eliminating anything that is not acceptable.
>
> (interview Rao, 2013)

As Brooks (2005) comments, the construction of GM crops as inducing a second Green Revolution that will be as successful but environmentally more sustainable at the same time, serves to combine contradictory discursive elements: the idea of an Evergreen Revolution presents transgenic crops as natural, unavoidable, and logical technological fix leading up to a sociotechnical future in which GM crops technology solves not only hunger and growth issues, but environmental problems associated with agriculture, too. Indian activist Suman Sahai from Gene Campaign[105] explains this rhetorical labelling: "The industry is not stupid, it does not say 'biotechnology', it says 'second Green Revolution'; it does not say 'genetic engineering, but 'Evergreen Revolution'. It uses the same words that invoke the same images and reinforces the same positive believes" (interview Sahai, 2012).

However, those in opposition to GM crops, from Indian activists, to European transnational NGOs do not buy into the normativity and temporality constructed through the sociotechnical imaginaries of productivity and environmentalism. To them, the sociotechnical imaginary of environmentalism put forward by the technology's proponents is a chimera: "the camouflaged description of transgenic crops hides many of the ecological impacts of genetically engineered crops. The illusion of sustainability is manufactured" (Shiva, Barker, & Lockhart, 2011, p. 12). Moreover, they question the arguments about yield increases due to GM crops and the problem definition of productivity increases to solve problems of malnutrition and hunger (Kuruganti, 2009; Seervai, 2013). In constructing entirely different versions of a technological future and what is desirable for society, the opponents of GM crops invoke

[105] Dr. Suman Sahai is a geneticist, who is also an activist. In 1993, she founded Gene Campaign, a research and advocacy organisation that works on broader issues around agriculture, food and nutrition, including GM crops, biodiversity, farmers' rights, food security, and livelihood issues. Gene Campaign aims to bring together stakeholders like farmers, rural and adivasi communities, scientists, consumer and environmental groups, and economists in order to shape policy and laws on the ownership and use of bio-resources (GeneCampaign, 2014). There were anonymous allegations of plagiarism against Suman Sahei in 2013 concerning the *Habilitationsschrift* she wrote at the University of Heidelberg in 1986. In a personal communication with the author (2018) Dr. Sahai provided a copy of a letter from the University of Heidelberg which confirmed that no official proceedings regarding plagiarism were conducted by the University with respect to these allegations against Dr. Sahai. A press release stating that an investigation due to these allegations had taken place (UniversitätHeidelberg, 2013) has in the meantime been removed from the website of the University. Dr. Sahai suggested that the persistence of such accusations against her is probably an effort of biotech lobby groups who aim to discredit her scientific credentials as a dissenting scientist.

different sociotechnical imaginaries, based on different normative claims, and rooted in a different interpretation of our agricultural past. Instead of taking for granted the positive visions about the alleged benefits of GM crops paving the way to a great future, they construct the risks of this technology in a profoundly different way. Instead, they connect the meanings they associate with GM crops to a wider variety of issues and problem definitions. In the visions of the future they construct, transgenic seed technology is part of a horrific future in which the ecosystem is out of balance and where farmers lose control over their choice of seeds. Let me turn to these sociotechnical imaginaries next.

Complex Ecology

The imaginary of complex ecology envisions GM crops to lead to a horrific future in which the ecosystem will be brought out of balance. Indian environmental activist and writer Vandana Shiva is one of the most prominent spokespersons for the imaginary of complex ecology. Shiva leads the organic farming organisation Navdanya that concerns itself with biodiversity, seed preservation, and conservation issues (Navdanya, 2014). Having studied physics and earned a PhD degree in philosophy of science on quantum theory, she has been advocating organic farming and biodiversity since the 1980s.[106] Shiva has published extensively on such topics as livelihood and ecology (1988), the Green Revolution (1991), GM crops (2000), and the relationship between economy and ecology (2013). While some describe her as a "rock star" (Specter, 2014) and "anti-GMO celebrity" (Entine & Ryan, 2014) in the global fight against agricultural biotechnology, she frequently receives criticism for exaggerating her claims about GM crops (Herring, 2006). Although Indian grassroots activists question the legitimacy of her campaign as representative of India's civil society and farming community, she is frequently represented as "the voice leading the crusade against GMOs" (Frankman & Weinberger, 2014). Her notoriety makes her an important spokesperson in the global opposition to GM crops.

At a food conference in Wageningen, the Netherlands, Shiva explained the role of GM crops within a complex ecosystem as paving the way to a disastrous future: "If that system was allowed to spread […], a destroyed planet will give not food at all. Dead soils, disappearing waters, a totally chaotic climate, no seeds – it is a recipe for an absolute, not just disaster, but a recipe for human extinction (Shiva, 2014b). This catastrophic vision of the future relates to the notion of GM crops as an unpredictable large-scale intervention into the ecosystem, and the lack of knowledge and scientific certainty regarding the complex ecological interdependencies in and around the agricultural field. A report of a network of various environmental organisations from Africa, America, Asia, Europe, and Oceania titled *A Global Citizens Report on the State of GMOs – False Promises, Failed Technologies* (Shiva et al., 2011) provides the arguments for envisioning how GM crops could disrupt the ecosystem.[107] The report states for example: "GMOs

[106] Shiva herself explains that her education has helped her move "from a mechanistic paradigm to an ecological one" (Shiva, 2014a).

[107] Although the Citizen Report is lead authored by Shiva and coordinated by Navdanya International and the Centre for Food Safety (USA), several larger and smaller civil society organisations critical of GM crops

have failed to live up to the cure-all claims, and moreover this technology is a continuation of a global industrial agricultural model that has failed to feed the hungry and has contributed to environmental destruction" (Shiva et al., 2011, p. 27).

Arguments about how GM crops might disrupt the complexity of ecosystem interactions revolve around two issues: 1) questioning necessity of raising productivity for food security (and doubting the claims about yield increases due to GM crops); and 2) risks to the ecosystem in terms of resistance development, secondary pests, and non-target organisms. These two issues relate to these actors' view that GM crops are an extension of the intensification paradigm with its linear and deterministic thinking about the industrial intensification of agriculture that started with the Green Revolution and which marginalised indigenous knowledge about crop cultivation. As opposed to these issues, those constructing the sociotechnical imaginary of complex ecology draw on the complex interactions of a highly interdependent and volatile ecosystem. A quote from the Citizens Report sums up these issues:

> We have been repeatedly told that genetically engineered (GE) crops will save the world by increasing yields and producing more food. They will save the world by controlling pests and weeds. They will save the world by reducing chemical use in agriculture. They will save the world with GE drought tolerant seeds and other seed traits that will provide resilience in times of climate change. However, the GE emperor (Monsanto) has no clothes. All of these claims have been established as false over years of experience all across the world.
>
> (Shiva et al., 2011, p. 11)

First of all, anti-GM crops activists question the economic potential of GM crops. To them, the claims about yield increases, raised farm-level income, and reduced food insecurity are incorrect and not supported by scientific data. For instance, Suman Sahai, director of the Indian civil society organisation Gene Campaign, questions the paper by Qaim and Zilberman (2003) which is widely quoted by the proponents of transgenic crops as proof of increased productivity of Bt-cotton: "Qaim and Zilberman used data not from agricultural fields, but from Monsanto's trial fields. They gave evidence of an increase in production of Bt-cotton of 88 per cent. Science really trashed this." Sahai instead explains that her organisation Gene Campaign was the first to collect and analyse field level data at the time Bt-cotton was approved for market release in India in 2002/03: "We showed that Bt-cotton had in fact failed, because it was not even able to recover the costs" (interview Sahai, 2012). The *Global Citizens Report* equally debunks the industry's claims about productivity increases and food security. Although transgenic seeds have been on the market for two decades, "in this time hunger has reached epic numbers, with more than one billion people going hungry every day. […] The claim that GM crops produce higher yields and therefore will feed the hungry is false. This is well documented by empirical experiences and scientific studies" (Shiva et al., 2011, p. 27). European activists also doubt the claims about yield increases and reduced food

contributed to the report, amongst them Conféderation Paysanne/ La Via Campesina (France), Friends of the Earth (Africa), Gene Ethics (Australia), Save our Seeds (Germany) and many others.

insecurity due to transgenic crops (Antoniou et al., 2012, 2014; Greenpeace, 2015; Zacune, 2011).

To question the productivity claim, anti-GM crops activists draw on a variety of sources. Some NGOs produce their own data sets to evaluate the yield potential of transgenic seeds at the farm level in India (e.g. Qayum & Sakkhari, 2005; Sahai & Rhaman, 2003). Indian activist Kavitha Kuruganti reviewed existing studies on GM crop productivity in the US, India, and China and concluded that other factors than the transition to transgenic cotton explain raised yields (Kuruganti, 2009; cf. Stone, 2012).[108] European NGO reports such as by Friends of the Earth (e.g. Pispini et al., 2014; Zacune, 2011) draw on reviews of existing data by scientists from the Union of Concerned Scientists (Gurian-Sherman, 2009b) or the World Health Organisation (Labadarios et al., 2011) which question that transgenic crop technology has led and will lead to substantial productivity increases. Other NGOs also draw on the work of international organisations: the UK based Soil Association[109] cites reports by the United Nations Food and Agricultural Organisation (FAO) that indicate transgenic seeds have a reduced or equal yield potential compared to conventional varieties (FAO, 2004); and Greenpeace (Greenpeace, 2015; GreenpeaceNederland, 2012) cites data analysed by the United States Department of Agriculture (USDA) which show that genetic modification has not raised productivity; instead, yield potential depends on the cultivars which carry the transgenic trait (Fernandez-Cornejo & Caswell, 2006; Fernandez-Cornejo, Wechsler, Livingston, & Lorraine, 2014).[110] As Indian economists contend, estimating the benefits of GM crops in terms of yield potential neglects important socio-economic and ecological risks, particularly under the various agro-climatic conditions in which agriculture is practiced in India (Gaurav & Mishra, 2012; interview Gaurav & Misra 2012).

To activists, the future envisioned by the sociotechnical imaginary of productivity is merely industry publicity to invest transgenic crops with a favourable public image. According to the Soil Association: "In 2007, a major new public relations push began to convince European consumers to eat genetically modified crops by claiming they will be essential to feed the world" (Wallace, 2011). Grassroots level activists in India and Europe are particularly strong on criticising the idea of yield increases for raising food security. Working closely with local farmers, activist Sarangi from Living Farms, who works with farming communities in the Eastern Central Indian state of Odisha, describes hunger instead as a socio-economic problem, relating to access and ownership of the means of agricultural production:

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[108] As Stone and Kuruganti both note, yield increases in cotton production in the period 2002-2005 are unlikely due to the introduction of Bt-cotton in India in 2002, but rather due to an overall increase in cotton acreage and favourable climatic conditions such as good Monsoon rains.

[109] The Soil Association was founded by farmers, scientists, and nutrition specialists in 1946 to promote and certify organic farming practice and food production. The organisation also campaigns for wildlife preservation, nutritional food quality, and on issues of soil erosion and sustainable land use (SoilAssociation, 2017).

[110] Suman Sahai from Gene Campaign makes a similar argument about the actual working of IR Bt-cotton seeds in India. Since the Bt varieties available in India are a copy of the original Bt breeding varieties, they are inferior in expressing the IR trait, evident by the poor performance of the GM crop in repelling pest insects in India (Sahai, 2005).

> The crisis of agriculture is not a crisis of productivity. We have enough food to feed the whole population of the earth reasonably well. There is no shortage. Look at Orissa [Odisha], who is controlling the land? There is a possibility that you and I are from the same village, but you have 100 and I only have one hectare of land. It is a question of equitable distribution of productive resources.
>
> (interview Sarangi, 2012) [111]

So, these activists do not agree with the problem definition and the Malthusian rational the sociotechnical imaginary of productivity rests on.[112] A German ecological farmer's organisation representative agrees for instance that the narrative about GM crops as a solution to the world hunger problem was created by the developers of the technology though resting on a weak empirical foundation. Instead, he agrees with Sarangi that food security requires not better technology, but improved access for farmers to education, land, and seeds (interview Janssen, 2013). Indeed, as studies of GM producer Monsanto's business strategy have shown, the narrative about GM crops' potential to solve food security issues went hand in hand with the development of the technology. When agrochemical corporations moved into agricultural biotechnology, managers of these companies needed a coherent and rational narrative to justify these investments (Schurman & Munro, 2010; Scoones, 2002), despite little evidence of the relevance and effectiveness of transgenic seeds in achieving these ends (Glover, 2008, 2009, 2010). Still, the productivity discourse also provides an opportunity for activists in India, since the global food crisis of 2008 has stimulated new thinking about the relationship between food security and seed security, and the potential of conventional breeding techniques to deliver the necessary traits rather than transgenic seeds (Glover & Stone, 2011; McGuire & Sperling, 2011). Activist Kuruganti from the all Indian Alliance for Sustainable and Holistic Farming (ASHA) explains: "to say that when it comes to starvation and hunger, food safety issues are less of a concern, not as important as feeding people, we can examine that notion publicly: […] government might actually conceive that there are safety issues, but we have a larger responsibility to feed people" (interview Kuruganti, 2013).[113]

Yet, the alleged benefits of GM crops are less important to the actors in opposition to the technology than its risks. When criticising the paradigm of productivity, they emphasise the impact of intensive farming practice and transgenic crops on the ecosystem, which the agricultural field is part of. From the perspective of this sociotechnical imaginary of complex

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[111] Living Farms is a NGO placed in Buhbaneswar in the East Central Indian state of Odisha dealing with food sovereignty and sustainable management of natural resources. Debjeet Sarangi works with small-scale farmers, indigenous communities, and consumers to support sustainable farming and to preserve indigenous agricultural knowledge to protect farmers' autonomy from corporate influence on their cultivation practice (LivingFarms, 2008).

[112] Journalist Devinder Sharma, who writes on agriculture and politics is equally convinced foot shortages are not due to a lack of agricultural productivity: "you already produce twice the food for the population […] The problem is the distribution. You do not want to address distribution because there is no money in it. It is a political issue, as simple as that" (interview Sharma, 2013).

[113] ASHA is an alliance of several hundred agricultural NGOs, farming cooperatives, women's organisations, activists, and scientists from more than 20 of the Indian states. It concerns itself with alleviating the crisis of India's rural farming communities by promoting an ecologically sustainable agricultural economy based on principles of agro-ecology rather than modern input-intensive farming practices (ASHA, n.d.).

ecology, arguments about the environmental sustainability of GM crops are a chimera: "the camouflaged description of transgenic crops hides many of the ecological impacts of genetically engineered crops. The illusion of sustainability is manufactured" (Shiva et al., 2011, p. 12). Instead, social groups critical of the technology draw on complex ecosystem interactions in terms of insect and weed resistance, secondary pests, and the potential impact on non-target organisms to illustrate the risks GM crops pose to the ecosystem. The imaginary of complex ecology is constructed in both, India and Europe.

Environmental NGOs in unison point to the risk of resistance development of pests to the Bt-toxin produced by insect-resistant (IR) GM crops, and of weeds to the herbicides applied to herbicide tolerant (HT) GM crops (Antoniou et al., 2012, 2014; Greenpeace, 2015; GreenpeaceInternational, 2012; GreenpeaceNederland, 2012; Shiva et al., 2011; Zacune, 2011). Anti-GM activists argue that when pests and weeds develop resistance to the traits expressed by GM plants, this will make conventional pest controlling mechanisms useless in the future: "instead of controlling weeds and pests, GM crops have led to the emergence of super weeds and super pests" (Shiva et al., 2011, p. 12). The Global Citizen Report gives the example of outcrossing of GM traits into wild relatives of cultivated plants, e.g. the unintended pollination that occurred early on between GM sugar beets and weed beets, which undermines the efficacy of herbicide tolerance (Boudry, Morchen, Saumitoulaprade, Vernet, & Vandijk, 1993; for a more recent review of the literature, see Gurian-Sherman, 2009a). As an environmental scientists explained in an interview, there is increasing evidence of gene transfer from GM crops to wild relatives, while the scientific community abstains from discussing what effects this might have for assessing the safety-risk continuum of transgenic seed technology (interview Ganeshaia, 2013). Indeed, recent research suggests that weed resistance to the most widely used herbicide Glyphosate "can no longer be prevented, and therefore resistance must be managed" (Powles, 2010, p. 955). Since weeds develop resistance to glyphosate already, civil society actors foresee an increase in the overall use of various other herbicides, with its associated environmental consequences in the future (cf. Benbrook, 2012a; Benbrook, 2012b, 2016).[114] The *Citizen Report* for instance draws on a study by the US Environmental Protection Agency which confirms the use of HT crops has led to a tenfold increase of herbicide use in the period 1993 to 2007 in the US (Grube, Donaldson, Kiely, & Wu, 2011). Accordingly, the argument is that there will be an even greater increases of herbicide use if more acreage gets cultivated with HT transgenic crops in the future.

The *Citizen Report* also constructs an imaginary of the future in which resistant insect pests become the norm: "the question is not whether super-pests will be created, but when they will become dominant" (Shiva et al., 2011, p. 13).[115] Again, civil society actors draw on scientific studies that confirm the problem of pest resistance in GM IR crops: Western Corn

[114] Benbrook 2012a was a report commissioned by the NGO Greenpeace, the results of which later got published in a peer-reviewed scientific journal (Benbrook, 2012b).

[115] As policy-makers and scientists are aware, the emergence of pest resistance is unavoidable, and can only be delayed with careful crop management, crop rotation and resistance management practices (EFSA, 2011a; Gassmann et al., 2014; Gassmann, Petzold-Maxwell, Keweshan, & Dunbar, 2011). Whether in such diverse agrarian systems as that of India, such complex farm level management practices centred around GM crop technology alone are feasible and practicable remains open to debate. Studies of integrated pest management indicate that a larger variety of options is most practical in the Indian agricultural context (Quartz, 2011).

Rootworm has become resistant to Bt-maize in the US (Gassmann et al., 2014; Gassmann et al., 2011) and Cotton Bollworm has developed resistance to Cry1Ac and Cry2Ab Bt-toxins (Ranjith, Prabhuraj, & Srinivasa, 2010; interview Ganeshaia, 2013). More recently, Pink Bollworm developed resistance to Indian Bt-cotton varieties (Jadhav, 2017). In contrast, molecular biologist and GM crops proponent Padmanaban explains the possibility of resistance development to be dealt with by the means of adding more traits to IR GM crops: "We put two genes, or three. […] We come up with new things. That is what we do all the time. […] We can manage it, like with other problems. Why are the activists making it such a doomsday prediction?" (interview Padmanaban, 2012). Similarly, Monsanto suggests that HT crops can be modified to resist a wider range of herbicides (Hoffritz, 2009). Civil society activists, like Georg Janssen from the German farmers' association *Arbeitsgemeinschaft Bäuerliche Landwirtschaft* criticises exactly this way of thinking: "Input-intensive farming is reaching its limits. Soil, micronutrients, erosion, too much use of ground water. The idea is that if this does not work, we keep the system but add another component, another techno-fix" (interview Janssen, 2013). In contrast, the imaginary of complex ecology disregards techno-fixes as too simplistic. Instead, nature adapts quickly to such technological interventions. Dutch Greenpeace activist Bekkem explains the relationship between GM crops and the volatility of the ecosystem:

> They [HT and IR GM crops] pose specific environmental problems. For instance, the herbicide resistant crops improve the situation of farmers for two to three initial years, because it is easier to just spray Roundup. But the weeds develop a resistance to the pesticide that is constantly used. That is how nature, or evolution works. So what farmers do is that at first they spray much more Roundup. Secondly, they also use more toxic pesticides to kill the weeds.
>
> (interview Bekkem, 2012)

In reference to IR crops, he makes the same argument about the simplicity of GM crop technology vis-à-vis the adaptability of the complex and interdependent ecosystem:

> If you succeed in fighting one insect with a Bt-toxin, the ecological niche of this specific organism is taken over by a secondary pest, which maybe is not vulnerable to the Bt-toxin. So you still have to spay pesticides. And the insects which are dying from the Bt-toxins, some will survive and the population will develop resistance. In the end the farmer sprays more and more chemical pesticides.
>
> (interview Bekkem, 2012)

As this quote indicates, even if the Bt-toxin works on its target pest, a risk is that another, so-called secondary pest, will fill in the target pests' ecological niche, which in turn requires the application of more pesticides. Accordingly, a Greenpeace report foresees an increase in the use of insecticides, despite of the initial success of Bt-traits in GM crops: "even if successful at controlling a target pest species, other pests (called 'secondary pests') may then emerge as more prominent threats to the plants, resulting in crop loss and the need to apply additional pesticides" (E. Hammond, 2010, p. 2). Again, activists draw on scientific studies

indicating the development of resistance in pest populations, the emergence of secondary pests, and a decrease in the pesticide reducing effect of GM crops in China, Colombia, India, and the US (e.g. Dorhout & Rice, 2010; for more references, see Antoniou et al. 2012, 2014; Zhao, Ho, & Azadi, 2010). Though, agricultural activists often draw on their first-hand experiences. Activist Sarangi from Living Farms in India explains the ideas about the future benefits of transgenic crops are too simplistic. Crop cultivation must instead be understood as a complex activity within the highly interdependent ecosystem. GM crops rather create problems than solving them:

> It [brinjal] gets multiple pests. I have worked as a farmer myself. If you do proper management of your farm, then the pest attack will not be such a big problem as the companies are trying to tell us. You have to take care of many more things than the pests - soil, seeds, and the whole circle of growing crops. It is like you create a medicine first and then you create a disease.
>
> (interview Sarangi, 2012, cf. interview S. Misra, 2012)

The argument that allows constructing an imaginary of a disastrous future is one of ecological complexity that is difficult to control with very specific agricultural technologies, such as GM crops. Rather, GM crops themselves are constructed as a risk to the stability of the ecosystem, instead of being a solution to the risks of farming practice, since the latter depends on the former. The vision that GM crops disrupt the stability and integrity of the ecosystem can be illustrated not only by the foreseen increased pesticide use due to resistance development and secondary pests, but also by the question of the impact of the existing GM crop traits on non-target organisms (NTOs).

From this perspective, the transgenic Bt-toxins as well as increased herbicide applications that necessarily come along with HT GM crops affect insects and soil microorganisms not within the target range of these technologies.[116] Accordingly, the complex interdependencies of a multitude of organisms such as insects, soil microflora, and fauna affected by pesticides and herbicides will get out of balance. Shiva for instance states that: "the Bt-crop does not affect 'just one specific pest'. Beneficial insects like bees and ladybirds can be seriously affected. A Cornell study showed that the Bt-toxin affected the Monarch butterfly. Navdanya's studies have shown that soil microorganisms are negatively affected" (Shiva et al., 2011). Again, activists attempt to invest their arguments with scientific credibility. The Cornell study referred to by Shiva et al. was conducted by John Losey and colleagues (Losey, Rayor, & Carter, 1999), who found increased mortality rates of monarch butterfly larvae eating milkweed leaves dusted with Bt-maize pollen, compared with isogenic non-GM pollen dusted leaves and unexposed leaves. This study received a lot of media attention and led to considerable controversy in the scientific community at the time of its publication (Waltz, 2009). Several US Academy of Science papers concluded that most types of Bt-maize pollen are not

[116] Non-target organisms (NTOs) are living organisms that are present in the field but which do not reduce yield. NTOs can include soil micro-organisms, non-pest insects, birds, and other animals. Conventional agricultural methods (herbicide and pesticide application in particular) have large and well-documented non-target effects. While GM crops may have more specific target effects, non-target effects cannot be principally ruled out (Pilson & Prendeville, 2004; Snow et al., 2005).

toxic to the monarch butterfly in concentrations that occur under field conditions (Scriber, 2001). Yet, many NGO reports still refer to the study as a proof of the harmful effects of GM crops on non-target organisms (e.g. Antoniou et al., 2012, 2014). As there are numerous studies that suggest the current risk assessment frameworks for assessing NTO impact are insufficient , some entomologists believe that there is not only regulatory gaps, but also too much scientific uncertainty on this issue (Andow, 2010).[117]

The imaginary of complex ecology not only makes the normative claim about how transgenic crops pose a threat to the stability of the ecosystem, but it also shows the arena of sociotechnical imaginaries with(out) transgenic crops to be a contested epistemological terrain – all actors attempt to substantiate their claims by referring to science. However, as the previous chapter has shown, scientific findings that reveal potential risks of GM crops frequently become subject to fierce contestation (cf. Krimsky, 2015). Anthropologist Glen Davis Stone (2002) argues that both sides to the controversy about GM crops construct their own narratives about the technology and its risks, which rest on closed and mutually reinforcing "authentication loops", i.e. in constructing their visions of the wondrous or horrendous futures, opponents and proponents of the technology refer to their own empirical data, or commissioned studies that confirm their arguments.[118] So, constructing sociotechnical futures is not only a contestation of how to fulfil normative goals such as feeding the hungry or keeping the ecosystem intact, but they are also epistemic battlefields were the actors disagree over how to know about the risks of GM crops. Yet, as Suman Sahai explains, the scientific knowledge necessary to properly evaluate what could be the best technologies for future agriculture get marginalised. Instead, GM is being presented as the taken for granted and unavoidable route to the future:

> We have fine scientist who are plant breeders, soil scientists, entomologists, agronomists, who are doing very good work. Unfortunately, in this completely mad race for GM products, these sectors of agricultural science, which are the primary sectors, and which will continue to contribute to food security, get neglected in favour of this chimera called GM technology.
>
> (interview Sahai, 2012)

[117] The battle about the scientific reliability of Losey and colleagues resembles the dynamics of boundary making between science and politics I have described in the previous chapter. See, e.g. Minorsky (Minorsky, 2001, 2002), and Sears et al. (2002) for the debate, and Waltz (2009) for an analysis thereof. A more recent comparable case to that of Losey et al. (1999) is that of stream ecologist Rosi-Marshall and colleagues who found caddis-fly larvae to be negatively affected when fed with Bt-maize pollen, concluding that the transgenic maize may have negative effects on the biota of streams in agriculture areas implying there might be unexpected ecosystem-scale effects (Rosi-Marshall et al., 2007).

[118] While industry representatives and scientists in favour of GM crops frequently refer to their own studies and particularly the non-peer-reviewed reports by ISAAA, it is noteworthy that the opposition to GM crops not only cites its own data sets and references, but frequently mobilises studies conducted by United Nations agencies such as the Food and Agriculture Organisation and government agencies like the United States Department of Agriculture.

To better understand the construction of a disastrous future with GM crops and the meaning attached to transgenic seed technology, the GM crops opponents' interpretation of the interplay between modern agricultural technologies and the environment needs further explanation. While the proponents of the technology naturalise transgenic seeds as the logical continuation of the Green Revolution paradigm; i.e. the intensification of agriculture and the application of refined techno-fixes, the critics question the very causal determinism behind this reasoning. The opponents of transgenic crops rather interpret the interplay of technology and the environment since the Green Revolution differently. The imaginary of a future in which the ecosystem catastrophically collapses has been exemplified in the book *Silent Spring* by Rachel Carson (1962). Activists frequently refer to the book in which Carson described the harmful but unstudied effects of the pesticide DDT on the environment. The book draws a vision of a future in which birds die because they fed on insects contaminated with pesticides. This is a clear sign that agricultural chemicals disrupt the ecological equilibrium: "There was a strange stillness. The birds, for example, where had the gone? […] The few birds seen anywhere were moribund; they trembled violently and could not fly. It was a spring without voices" (Carson, 1962, p. 2).[119]

Within the imaginary of complex ecology, the Green Revolution does not have the meaning of a mere success in food production, but the interpretation assigned to it revolves around the devastating ecological consequences it has brought about. From this perspective, transgenic seed technology is a continuation of the simplicity and linearity of the thinking about the technological mastery of nature through techno-fixes (interview Ganguly, 2013; interview Kuruganti, 2013). As a commentator in the *Citizen Report* explicates, GM crops carry on the legacy of the Green Revolution with its narrow and causal outlook on agriculture (Berry, 2011, 2002, pp. 43-44). The Green Revolution intensification paradigm in turn is associated with its environmental and social costs (c.f. Shiva, 1991). In this interpretation of the agricultural past, the Green Revolution paradigm does not adhere to the contextual complexity of the agricultural field as part of the highly interdependent ecosystem. Instead, GM crops

[119] Current campaign efforts of environmental organisations about the ecological risks of pesticides revolve not anymore around DDT (Carson's choice of pesticide at the time), but the effect of neonicotinoid pesticides (currently the most widely used pesticide) on honey bees. Bees exemplify the interdependencies of the ecosystem as they are the most important pollinators globally (FriendsoftheEarth, 2014; Greenpeace, 2017). Recent research confirms the harmful effects of neonicotinoid pesticides on honey bees and bumblebees (Goulson, 2015; Rundlof et al., 2015), while other studies do not find such negative effects (Cutler, Scott-Dupree, Sultan, McFarlane, & Brewer, 2014; Dively, Embrey, Kamel, Hawthorne, & Pettis, 2017, note the author of the latter study received funding from Syngenta and Pioneer/duPont). See also Woodcock et al. (2017) for a review of the literature; and Suryanarayanan & Kleinman (2013) and Kleinman & Suryanarayanan (2013) for an analysis of scientific ignorance and the politics of expertise in the controversy about the role of neonicotinoids in honey bee Colony Collapse Disorder. Due to the scientific uncertainty regarding the potential risks of neonicotinoids on bee populations, the EU has implemented a moratorium on the use of the neonicotinoids Clothianidin, Thiamethoxam and Imidacloprid in 2013 (EC, 2013).

are a continuation of the industrialisation of agriculture that started with the Green Revolution. For instance, Ramanjaneyulu from the Centre for Sustainable Agriculture[120] in Hyderabad explains GM crops to exemplify a reductionist and determinist logic, yet contextual contingencies of gene expression are equally important for a crop to express its desired traits:

> Pro-GM arguments are often based on genetic determinism that says that the expression of certain characteristics is based on a gene sequence. The transfer of the sequence would also transfer the characteristic. However, this is very reductionist. The expression of a characteristic is not only dependent on genetics, but the environment inside and outside the plant. For example, Bt-cotton only works under ideal conditions with high inputs. This shows that gene expression depends to a large extent on the environment. It is not only about genes, but about much more. Ecosystem-based conceptions of agriculture have a much better understanding of this than the modern reductionist science of GM.
>
> (interview Ramanjaneyulu, 2012)

Despite criticising genetic determinism, opponents of the technology also set transgenic crops into a larger historical context. GM crops form this temporal perspective endanger biodiversity because they lead to monoculture cropping and the loss of biodiversity – as scientist MS Swaminathan explains, genetic homogeneity of monoculture leads to genetic erosion which in turn reduces biodiversity (interview Swaminathan, 2013). Activist Sahai explicates for instance IR traits to represent a linear thinking of technological intervention in agriculture, which is too simplistic for the complexity of agricultural cultivation, particularly in the tropics:

> If you do not have a lepidopteran pest attack, then it [IR trait] is useless. It does not protect from non-sucking pests, bacterial or fungal infection, or any other problem in crops. I have argued this over and over again, that in tropical countries the pest density and pest range will be much higher than in a temperate country. […] Suppose you have this one simple gene that confers disease resistance then you realise how idiotic argument it is and what the industry is taking you for.
>
> (interview Sahai, 2012)

Similarly, European grassroots activists see GM crops as too specific and its risks too unpredictable to function within the interdependent ecosystem. Two activists explain GM crop proponents do not take into account environmental risks associated with large-scale industrialised monocultures:

> The proponents of GM crops firmly believe in such a simple system. They explain how GM crops work in this linear perspective: We have a crop that is resistant, so management of that crop is easy in the field. You just apply herbicides, and all the weeds die

[120] The Centre for Sustainable Agriculture, Hyderabad, is a NGO that promotes ecologically and economically sustainable models of agriculture in order to improve the farming community's livelihood (CSA, 2014).

> while the crop survives and this safes cultivation input costs […] This way of thinking does not take into account the complexity of the agricultural system.
>
> (interview Brändle & Holloh, 2013)

Friends of the Earth representative Mute Schimpf argues in the same vein and instead emphasises ecological diversity to be the solution to the future problems of farming: "The idea that one trait can fit all conditions is simply wrong. We do not know the problems we will face in 30 years' time. Which crop diseases, new pests, micro climatic conditions? For this we need a lot of diversity in the plants. We need diversity and flexibility" (interview, Schimpf, 2012). Similarly, the *Global Citizens Report* not only constructs a negative future, but a positive one in which a large-scale transition to agro-ecological farming methods creates a world of "diversity, democracy, freedom, joy, culture, people celebrating their lives" (Shiva quoted in Specter, 2014). The notion of diversity as opposed to the uniformity of monocultures, as well as the temporal perspective on the Green Revolution connect the sociotechnical imaginary of complex ecology to another vision of the future, which the opponents of GM crops construct around the notion of seed sovereignty.

Seed Sovereignty

Leo Saldanha from Environmental Support Group (ESG) in Bangalore stipulates: "a pluralistic view of this technology is not just about human health and the environment, it is also about seed sovereignty" (interview Saldanha, 2012).[121] The sociotechnical imaginary of seed sovereignty revolves around questions of rural autonomy, control over seed germplasm, and issues of corporate-driven neoliberal globalisation. In this vision of the future, GM crops pave the way to the loss of farmers' control over seeds because of the proprietary character of GM seeds and the monopolistic tendencies of agricultural input markets. As Savvy Misra from the Centre for Science and Environment (CSE) in New Delhi explains, the future thus imagined is one where monopolistic markets reduce the diversity of seed germplasm and thus the sovereignty of farmers to make their own cultivation choices (interview S. Misra, 2012).[122] In this imaginary, GM seeds are "a commercial proprietary resource, a commercial item owned by someone, separating farmers and their crops from the seeds they require for planting" (Kuruganti & Prasad, 2013, p. 70). From this view, the loss of farmers' sovereignty

[121] ESG is a non-profit NGO placed in Bangalore. It works with various Indian groups dedicated to issues of environment and social justice to support research, education and campaigns on environmental issues. ESG describes its ethos as "to be sensitive to contextual complexities so the solutions are environmentally and social just, and deeply democratic" (ESG, n.d.).

[122] CSE is a public interest research and advocacy organisation that deals with issues of sustainable and equitable development. The organisation engages in communication and awareness raising, research and advocacy, and education and training activities. CSE receives funding from several international development aid organisations, the World Bank, the Bill & Melinda Gates Foundation, as well as the Government of India. CSE's chair person is eminent Indian scientist MS Swaminathan. Numerous Indian scientists, writers and activists are members of CSE (CSE, 2018).

is aggravated by GM crops being part of an agricultural system that favours large-scale monocultures and economies of scale. A look at the *Global Citizens Report* shows how arguments from the sociotechnical imaginary of complex ecology provide an entry point to the slightly more complicated notion of seed sovereignty:

> The fable that GMOs are feeding the world has already led to large-scale destruction of biodiversity and farmers' livelihoods. It is threatening the very basis of our freedom to know what we eat and to choose what we eat. Our biodiversity and our seed freedom are in peril. Our food freedom, food democracy and food sovereignty are at stake.
>
> (Shiva et al., 2011, p. 7)

Seed sovereignty in its simplest can be defined as keeping control over seeds in the hands of the farming community (Kuruganti & Prasad, 2013, p. 69). To civil society activists in India and Europe, GM crops are however part of a global techno-scientific transformation of agriculture towards industrial and chemical input-intensive farming dominated by transnational corporations; GM crops accordingly are merely "the tip of the iceberg of this agricultural model" (interview Sanchez, 2013). The opponents fear this transformation will inevitably lead to market concentration with limited choices for farmers: "commodification/ commercialisation of seed, its corporatisation/ monopolisation and its alienation from farmers" (Kuruganti & Prasad, 2013, p. 70). For instance, Suman Sahai explains GM crops to fit the industry's need for growth. HT GM crops require the application of herbicides produced by the same corporations that sell transgenic seeds. When transnational agrochemical producers invested in biotechnology in the 1980s, they created seeds to complement existing agricultural technologies to secure their market shares by selling agricultural technology packages combining seeds and pesticides: "There are no hidden logics but economic facts. […] When patents started running out, the chemical sector was becoming less viable and the biological sector more viable, the sector of the future. […] Even if the patents run out, herbicide tolerance means you still have to use Roundup. It is complementary" (interview Sahai, 2012).[123] The fear of civil society is that transnational corporations, by dominating the seed market, will impose a certain way of doing agriculture and deprive farmers of the choice which seeds to cultivate. Mute Schmipf from Friends of the Earth, Europe explains:

> Food production starts with seeds. The idea that a few multinationals control what happens to seeds is a nightmare for everyone with an understanding of agriculture. […] If you cannot decide yourself on what happens to seeds, if the whole cultivation process is prescribed, including seeds, fertilisers. Every farmer understands this, in Spain or in India. […] The fear is that food production will be taken out of the hands of the farmers.
>
> (interview Schimpf, 2012)

[123] For an in-depth analysis of how transnational chemical industries moved into biotechnology since the late 1970s, thus becoming a new cultural economic actor within the context of the ideological and political turn towards neo-liberal globalisation, see Schurman & Munro (2010).

The *Global Citizen Report* equally identifies the dominance of transnational corporations in the food and agricultural sectors as a risk. Such a system driven by market imperatives aims primarily for profits and shareholder value while it marginalises indigenous knowledge about seed reproduction and cultivation practices:

> Enormous profits can be made from crops that feed into an industrialized model of agriculture. Small-scale, agro-ecological farm systems that grow food locally for local consumption are systems of self-sufficiency and do not fit into an industrial, market-based paradigm.
>
> (Shiva et al., 2011, p. 28)

To better understand the imaginary that foresees a future in which few globally operating companies determine the fate of agriculture, it makes sense to look at the seed industry's development and structure: With the invention of gene splicing technique in the 1980s, many agrochemicals producers moved into a life sciences business model. In the 1970s, when biotechnology was still in its infancy, Monsanto Corporation was the first large chemical company that recognized the commercial opportunities of rDNA research and bought up small molecular biology start-ups. No other company invested as much resources in establishing its position in the newly developing business branch, and it remains the industry's leader till date. Monsanto brought Bt-cotton Bolgard I™ and Bolgard II™ to India, as well as Bt-brinjal.[124] The only cultivated GM crop in Europe, Bt-maize MON810 is also a product of Monsanto.

Much of anti-GM crops activism has focused on the company's technologies and activities, and a range of popular culture books (e.g. Louv, 2013; Wilcox, 2013) and documentary films (e.g. Kenner, 2008; Robin, 2008) on the topic depict Monsanto as the epitome of transnational corporations' efforts to market GM crops technology worldwide. As Schurman and Munro explain: "if there was one company whose name became virtually synonymous around the world with the term GMO, that firm was unquestionably Monsanto" (Schurman & Munro, 2010, p. 18).[125] Yet, to better understand the opponents' fear of monopolisation,

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[124] Monsanto operates in India through sub-licensing agreements. Mahyco Monsanto Biotech, a 50:50 joint venture between Mahyco and Monsanto Holdings Pvt. Ltd., has sub-licensed the Bt-cotton transgene Bollgard II™ and Bollgard I™ to dozens of Indian seed companies, each of whom have introduced the transgenic technologies into their own germplasm. This resulted in the availability of 800 Bt-cotton varieties on the Indian seeds market (Monsanto, 2015a). Although plants are not eligible for patent protection under India's Patents Act, microbiological processes (such as the transgenic technique) and microorganisms (inventive transgenes and their products) are patentable. Monsanto's patents cover these components, although there is debate about excessive pricing policies and about which intellectual property regime applies under India's legal provisions (cf. Basheer, 2016).

[125] Since 2013, there is a campaign for an annual demonstration against GM crops called "March against Monsanto", which exemplifies the name Monsanto as representative for transnational corporations' involvement with the technology. It addresses risks to health and the environment, legislative issues, and the ties between corporations and regulatory authorities that apply to the whole biotech industry rather than to Monsanto alone. The campaign was initiated by a US citizen after a failed ballot initiative to introduce GMO labelling on food products in California, which was heavily lobbied against by the biotech industry, in particular Monsanto. The campaign spread quickly through social media and the internet to other countries. Since

it makes sense to look at the development of the global market for agrochemicals and seeds over the last decades more broadly.

According to a 2008 report titled *Who Owns Nature* by the Action Group on Technology, Erosion, Concentration (ETCGroup, 2008)[126], 82 per cent of the global commercial seed market was in proprietary seeds (i.e. brand named seed subject to intellectual property protection). In 2007, this segment was worth 22 billion US$ in sales while the total commercial seeds sales were worth 26,7 billion US$ in the same year. ETC group estimates that the top ten seed producing companies accounted for more than half (55,4 per cent) of the global commercial seed market, and for two thirds (67 per cent) of the global proprietary seed market; and only three companies accounted for almost half (47 per cent) of the market in proprietary seeds: Monsanto as the market leader with 23 per cent, followed by Du Pont with 15 per cent, and Syngenta with 9 per cent market share (ETCGroup, 2008).[127] This trend towards market concentration and monopolization of the commercial and proprietary seed markets had developed over the three preceding decades, and it intensified further after 2007.

A new study by ETC group (2015) found that the biggest three companies, Monsanto, Du Pont, and Syngenta, account for 60 per cent of the market share in field crops, i.e. major commercial grain, forage, sugar, oil, and fibre crops (together these crops accounted for 86 per cent of total global seed market in 2013). By 2014, it was not anymore ten, but only seven companies which together dominated two thirds (69 per cent) of the global market in field crops. Amongst these, Monsanto had a share of 29 per cent, Du Pont 21 per cent, and Syngenta ten per cent.[128] ETC Group warned that the further concentration of the seed industry had already led to higher seed prices, but there was more to come. According to their analysis based on figures from 2013, there are six big companies that together dominate not only seeds, but agrochemicals too: BASF, Bayer, Dow, DuPont, Monsanto, and Syngenta together control 75 per cent of the global agrochemical market, 63 per cent of the global commercial seed market, and 75 per cent of all private sector research in seeds and pesticides (ETCGroup, 2015).

This concentration of the seeds and agrochemical markets will intensify in the future. In 2017, several corporate mergers were about to happen, intertwining both industries even closer: European and US regulators have cleared ChemChina's (China's biggest agrochemical producer) acquisition of Swiss seed producer Syngenta (EC, 2017b; FinancialTimes, 2017),

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2013, 'March against Monsanto' demonstrations happen annually in hundreds of cities worldwide (MaM, 2017).

[126] ETC Group is a Canadian civil society organisation that investigates processes of corporate concentration relevant to issues of biodiversity, sustainable development, climate change, technology assessment and corporate monopolisation (cf. ETCGroup, 2014). In its reports, ETC group bases its calculations of relative market shares on figures provided by companies themselves, and on analysts' estimations. E.g., for the fiscal year 2007, Monsanto self-reported its sales amounting to five billion US$ with a gross profit of three billion US$ (Monsanto, 2007).

[127] ETC group conservatively estimated the top three proprietary seed producers controlled two thirds of the global market in maize seed, and more than half of the soybean seed market in 2008. For each of the biggest three, GM crop seeds accounted for a steadily growing proportion of its revenues. Monsanto's GM seeds and traits, including those licensed to other seed companies accounted for 87 per cent of the global acreage under GM seed cultivation (ETCGroup, 2008, pp. 12-13).

[128] Other notable companies amongst the top seven are Group Limagrain (5 per cent), and Dow (4 per cent).

and the merger between agrochemicals and seed producers Dow Chemical Co. and Du Pont (Bartz, 2017; EC, 2017a). Also, German chemical giant Bayer is planning to take over Monsanto, thus creating the world's largest integrated pesticides and seeds corporation. While this merger was still under scrutiny of regulatory authorities based on anti-competition regulations (Bray, 2017; Vestager, 2017), the European Commission, as well as the US Department of Justice approved the merger between Bayer and Monsanto in spring of 2018 (Kendall & Bunge, 2018; ZeitOnline, 2018). These mergers and acquisitions, ETC group predicts, will concentrate two thirds of the global seed and pesticide markets in the hands of just three companies: DuPont-Dow, Syngenta-ChemChina, and Bayer-Monsanto, which will collectively control 65 per cent of global pesticides sales and 61 per cent of commercial seed sales. Market concentration and the close integration of these industries is predicted to have a negative impact on the availability and quality of commercial seeds. Corporate monopolies can determine seed prices, and the direction of seed technology innovation, i.e. it is in the industry's interest to engineer commodity crops such as corn, cotton, and soybean to tolerate proprietary chemicals, as is already the case for herbicide tolerant transgenic seeds such as Roundup Ready™ crops (ETCGroup, 2016). With an eye on the power concentrated in the hands of a few transnational corporations, Suman Sahai asks: "If these technologies are completely controlled by the private sector, what happens then to our seed sovereignty issue?" (interview Sahai, 2012).

The vision of a few corporations controlling the seed market has already become a reality in India where since the introduction of Bt-cotton, non-GM cotton seeds have disappeared from commercial seed stores (Herring & Rao, 2012). As Greenpeace activist Bekkem explains: "Monsanto, and all seed producing companies in India provide Bt-seeds. It is the only thing they sell. There is no choice anymore" (interview Bekkem, 2012). This, the opponents argue, is symbolic of a more general transition of the agricultural relations of production and social organisation of labour in the farming sector. Dr. Babu from the Institute for Cultural Research and Action (ICRA)[129] in Bangalore explains: "The problem is that farmers become enslaved to the market. The farmer has been transformed into a consumer of agricultural inputs" (Interview Babu, 2013); and Kavitha Kuruganti from ASHA alludes that when farmers use GM seeds, they buy into the entire model of input-intensive farming, which on the one hand induces a circle of increased input costs, and on the other deprives farmers of the knowledge and ecological resources necessary for other ways of farming: "the productivity of farmers' resources is constantly being eroded" (Kuruganti, 2009). In the same vein, Sarangi from Living Farms explains how the discourse of technological modernisation and economic growth depoliticises the technology, while questions about the political economy of agricultural inputs should become more prominent in the critique of GM crops: "Agriculture is being treated as an entirely technological subject, this is presented as apolitical. But it has a political economy, we need to ask: who controls the technology, who decides, and what are the interests at work?" (interview, Sarangi, 2012).

[129] The Institute for Cultural Research and Action (ICRA) in Bangalore engages in action research to promote organic agriculture. It works directly with farmers in the state of Karnataka and explicitly criticises the dominant paradigm of development. ICRA scrutinises the impacts of globalisation on agriculture and livelihoods and it wants to empower marginalised communities with the aim of empowering farmers, and enhancing social justice and sustainability (ICRA, n.d.; interview P. Babu, 2013).

The debate about Indian farmers committing suicide in large numbers is exemplary of the argument that once they join the paradigm of input-intensive farming, they are deprived of alternatives. This is because expensive modern agricultural technologies such as GM crops are much more expensive than conventional seeds. The argument goes that when farmers use GM seeds and their complementary technologies, they get bound in a vicious circle of indebtedness. Many civil society actors see farmer suicides as a sign of an agrarian crisis that they associate with the political economy of agrarian change elevated by the advent of neoliberal globalisation. Shiva has made the claim that suicides and the corporate monopolisation of agricultural inputs go hand in hand: "Farmers' suicides are concentrated in the regions where corporations like Monsanto have established a seed monopoly, selling costly and unreliable hybrid and GM seeds like Bt-cotton" (Shiva, cited in Herring, 2006, p. 472).[130]

Within the imaginary of seed sovereignty GM crops acquire the meaning of a technology that benefits transnational corporations in their efforts to centralise agricultural input markets in order to raise their profits. As a consequence, farmers lose autonomy over their cultivation decisions. Since GM seeds is a proprietary technology which farmers need to purchase every season anew, the monopolising tendencies on the seed market lead to the farming community's loss of control over seed germplasm; and this will restrict the autonomy of the farming community's access to productive resources. The argument is that once farmers invest in the technology (prices for GM seeds are up to ten times higher than conventional seeds), they get bound to the systemic logic of input-intensive farming, which once begun is difficult to escape because GM seeds and agrochemicals are complementary technologies. This will marginalise alternative agricultural practices not based on market principles, such as the free exchange of seeds amongst farmers (e.g., interview Sanchez, 2012; interview Brändle & Holloh, 2013).

Activists in Europe and India suggest that GM crops are a tool of global economic elites to capture the markets of developing countries for maximising profit. David Sanchez from CEO explains GM crops to be a stepping stone for transnationals to determine the development of the entire agricultural model in order for them to sell their technology packages from seeds to agrochemicals (interview Sanchez, 2012). Leo Saldanha from Environment Support

[130] For the focus of this chapter lies elsewhere, I cannot extensively cover the issue of agrarian crisis and farmer suicides here. Yet, it is important to note that various civil society actors link Indian farmer suicides to the introduction of Bt-cotton by claiming the adoption of transgenic crops drives farmers into depth because of high prices for transgenic seeds and agronomic failure of the technology (Kuruganti, 2012; D. Sharma, 2011, 2014; Shiva, Jafri, Emani, & Pande, 2000). As Herring and Rao suggest however, the Indian story of farmer suicides has become a global narrative of the catastrophic impacts of GM crops for the farming community, despite the difficulties with empirically verifying these claims (Herring & Rao, 2012). While there is doubt in the distinctiveness of suicides in the farming community and its connection to the introduction of GM seeds (Economist, 2014; EuropaBio, n.d.-a; Gruère & Sengupta, 2011; Sheridan, 2009), the issue has reached popular discourse and media. There is a Hindi speaking movie (Tatari, 2008) and the English speaking documentary *Nero's Guests* by prominent Indian journalists and filmmakers (Sainath & Bhatia, 2009) alerting a wider public to the agrarian distress supposedly aggravated by GM crops. Even international public figures such as Prince Charles make this connection (Malone, 2008). See Mishra (2006) and Shah (2012) for alternative explanations of farmer suicides based on socio-economic and cultural grounds, respectively.

Group in Bangalore (ESG) makes the critique more explicit by explaining that after decolonisation, the actors of globalisation, as well as innovative agricultural technologies, such as GM crops represent relations of domination: "The structures are the same. Capitalism has adopted the colonial structures. It is imperialism. What is Monsanto but a wing of the United States?" (interview Saldanha, 2012); and to S. Kannayan from the Indian Coordination Committee of Farmers Movements[131], these mechanisms are a form of "neo-colonialism" (interview Kannayan, 2013).[132] Eminent Indian scientist and molecular biologist PM Bhargava agrees with such an explanation from the broader perspective of market segments: "It [seeds for food production] is the single biggest business in the world and whoever controls food business is master of the planet" (interview Bhargava, 2012). How is this vision of the future rooted in the past?

The sociotechnical imaginary of seed sovereignty also has a temporal perspective that takes the Green Revolution period central. Indian opponents to GM crops regard GM crops as a risk to the sovereignty of the farming community. In particular activists link this meaning to the processes of globalisation that they see to disproportionally benefit transnational corporations through the privatisation of agricultural inputs and the monopolisation of markets. What results a loss of diversity and the associated disruption of the social organisation of rural labour, due to the transformation to large-scale monocultures that make input-intensive farming economically viable. The activists' discourse is framed by a postcolonial understanding of the global power relations they see inscribed in the techno-scientific modernisation of agriculture that began with the Green Revolution and resulted in the commodification of previously freely available resources such as seeds. This project, they argue, is carried on and intensified by the dissemination of transgenic crops to farmers in developing countries. As Ramanjaneyulu from CSA explains: "GM is not entirely new, it is part of an agricultural system that got established with the Green Revolution – that is also when notions of modernity began to be colonised by visions of science and technology" (interview Ramanjaneyulu, 2012); and Kavitha Kuruganti agrees that GM crops are an extension of the past: "First, it is the same set of players who want to make money with the old and new technology; and second, in terms of basic science of crop ecosystems, things seem not to have changed. Agroecology that is supposed to drive newer understandings, it is missing" (interview Kuruganti, 2013).

Yet, there is also a difference to the Green Revolution as to how and by whom GM crops are developed. Suman Sahai explains that during the Green Revolution period, publicly funded research was central in inventing and marketing improved seed technology: "The Green Revolution came out of public labs; therefore there was a sense that there could not be a conflict of interest. Everyone in science was working for the public interest". Yet, Sahai

[131] The Indian Coordination Committee of Famers Movements brings together large farmer organisations from the North and South of India, such as BKU and KRRS.

[132] Suman Sahai from Gene Campaign explains the structures and institutions of globalisation have benefited the creation of markets for agricultural inputs that fit large-scale monoculture farming. Since India's liberalisation in the 1990s, private corporations took over research that had previously been funded publicly. "When that began to happen, they [transnational corporations] imposed this model on the rest of the world through agencies like WTO and its agreement on agriculture, etc. They were not satisfied with just the European market; they wanted to look at the global market" (interview Sahai, 2012).

explains things changed with the liberalisation of India in the 1990s: "Everything began to go wrong with the privatisation of science […] who was benefiting from the science – not the people". Instead she argues, "When governments began to invest less, industry began to take control. Now there is complete control. There is no small government seeds store left in the US or in Europe". To Sahai, the power of corporations intensified with the disinvestment of public sector research in agricultural technologies, which paved the way for transnational corporations to take control over research and development in the seed sector. This allowed them to capture seed innovation completely in order to only offer a limited, yet profit-making set of technologies (interview Sahai, 2012).

This interpretation of the Green Revolution constructs a symbolism in which the GM crops entail not only the risk of destroying ecological diversity, but also the autonomy over cultivation choices and thus the political sovereignty of the farming community, too. The meaning this imaginary attaches to GM crops is as part of a system in which a few corporations strive for controlling the markets for agricultural inputs. Once markets are concentrated, these corporations have the power to determine what kinds of technologies will be available at what price, which ultimately reduces the diversity of seeds and famers' choices over which seed technology to use. As seed diversity is reduced, a central productive resource that farmers have cultivated over thousands of years erodes and finally vanishes. This follows a certain logic that eventually leads to farmers losing control over their means of production, and to a loss of indigenous seed germplasm and knowledge about non-industrial farming practice. Suman Sahai alludes in this regard: "when you provide this simple, silly solution […] which you present to the farmers as a one-stop-shop, then the farmer will just watch it grow believing it will take care of itself. So this is what leads to the erosion of knowledge" (interview Sahai, 2012). Anthropologist Shiv Visvanathan notes the Green Revolution has infused agriculture with a language of productivity and techno-fixes, which "represents an extension of accountancy and instrumental reason to agriculture" (Visvanathan, 1997, p. 74), from which follows that ever more technology, such as GM crops, become perceived as logical and inevitable.

To resist these developments, activists oppose the centralising tendencies of the seed market with the notion of ecological and political diversity: "diversity is key in technology and the political system" (interview Ramanjaneyulu, 2012). Connecting ecological diversity to political sovereignty, grassroots activist asks Sarangi asks: "to take the future of organic agriculture, which empowerment it contributes to farmers, what it takes to mother earth?" (interview Sarangi, 2012). Farmer leader Yudhvir Singh from the farmer union *Bhartiya Kisan Union* (BKU) also emphasises the value of diversity for agriculture and prompts to ask which technology benefits whom with an eye on the long-term implications:

> Agriculture depends on diversity, not technological interventions. We need technology but we need to consider what kind of technology. We therefore need to ask some broader questions about GM crops: When and how does technology benefit or damage whom? What is the long-term perspective? What are the alternative technologies to GM seeds?
>
> (interview Singh, 2013)

From this perspective, the concept of diversity means more than genetic or ecological variety, but it represents a multidimensionality of natural processes, of agriculture as a way of life, and it ascribes political agency to the farming community. Opposing GM crops to a political notion of diversity therefore opens the debate about GM crops to issues of livelihood, democracy, and justice. Babloo Ganguly from the ecological farming organisation Timbaktu collective explains: "The central issue is sovereignty, if people lose the capacity to make autonomous decisions, this leads to homogenising agriculture and society" (interview Ganguly, 2013).[133] This perspective, that opposes the power of transnational corporations to the sovereignty of the farming community, defies the universalising reductionism and economic rationalisation of Green Revolution style input-intensive agriculture, which renders farmers mere recipients and consumers of agricultural technology and deprived of agency. Instead, the concept of diversity constructs the normative vision that the farming community ought to be able to choose what technologies to use, independent of transnational corporations and the forces of globalisation– and this requires opposing GM crops as such. For transnational corporations strive to monopolise and therefore to control markets, farmers will be deprived of making such choices in the long run, essentially leaving them at the hands of a few powerful economic actors whose primary interest is in increasing profits. As Ashlesha Khardse from the NGO La Via Campesina, which works closely with farmers' organisations in India explains: the struggle against GM crops and for the free availability of diverse seeds for the farming community is essentially about ownership rights, which should be just and democratic instead of centralised (interview Khadse, 2013).[134] In Visvanathan's words (1997), diversity becomes a resource of agricultural and political resistance. How do these activists envision a different agricultural system?

Kavitha Kuruganti explains that the history of industrialised farming has prompted to re-examine the Green Revolution period: "now, it is crossroads time, we are at the point to make decisions based on the last 50 years of experience in agriculture" (interview Kuruganti, 2012).[135] Despite the doomsday predictions activists put forth, they also construct a counter model in which ecological diversity and the availability of seeds equals political sovereignty of the farming community: "We have the confidence that we can still live differently, and this is important when talking about taking a different course on a broader scale" (interview

[133] Ganguly is the founder of the grassroots organisation Timbaktu collective, which is a non-profit organisation that works in the Anantapur district of Andhra Pradesh to establish sustainable ecological farming practices, alternative banking systems, and ecological restoration. Timbaktu collective aims to support the livelihood of marginalised rural communities and small farmers based on principle of local self-governance (TimbaktuCollective, 2018).

[134] *La Via Campesina* (LVC), founded in 1993, describes itself as the international voice of peasants to protect small-scale family-based agriculture, food sovereignty, indigenous seed germplasm, peasants' rights, and social justice. LVC can be understood as an umbrella organisation that unites farmers' organisations from Africa, America, Asia, the Caribbean, and Europe (LVC, 2018).

[135] Suman Sahai from *Gene Campaign* explained in an interview that NGOs are often unaware of the powerful cultural meaning the Green Revolution has in the history of India's political development towards an independent state. Through the Green Revolution, "India was able to become independent of food imports; for the political leadership this meant sovereignty", while those trashing the Green Revolution "do not have half an idea of what impact it has. I am not saying it did not have its drawbacks, it certainly had, but the impact of the Green Revolution on politics and political economy of India was so powerful that it still stands" (interview Sahai, 2012).

Ramanjaneyulu, 2012). To Leo Saldanha from ESG; striving for freedom from dominance by transnationals also means more democracy: "Our whole philosophy is that we should not become corporatized. We should become supportive of a deeper democratization" (interview Saldanha, 2012). Generally, European and Indian activists, from grassroots activists to campaigners at larger NGOs such as Greenpeace, all envision a broader systemic change away from industrialised farming towards agricultural practice based on principles of agro-ecology and ecological diversity. As Greenpeace campaigner Bekkem explains: "We think that it is better to try to change the system itself than only focus on one aspect of the system" (interview Bekkem, 2012). Though an Indian grassroots activist thinks there is a difference between Europe and India in imagining and working towards such an alternative vision of the future: "People of Europe and America, I think they are lacking a dream […] they should have an idea of what could be different" (interview Sarangi, 2012).[136]

I encountered one such example of an alternative vision for the future of agriculture that defies the dominance of transnational biotechnology corporations and pledges for seed sovereignty at the inauguration of the farmers' university Amritha Bhoomi in the Biligiri Ranga Hills, close to Mysore in the South Indian state of Karnataka in February, 2013. The place was founded by KRRS leader MD Nanjundaswamy in 2002, who forged a national alliance of farmers' movements already at the time of India's liberalisation in the 1990s.[137] Since that time, KRRS has been explicitly criticising the neoliberal model of globalisation, its institutions such as the WTO, and the power of transnational corporations in transforming agriculture. KRRS protestors are notorious for their use of violence against symbols of globalisation, such as the rioting of Kentucky Fried Chicken restaurants and the head office of agribusiness Cargill Seeds Company in Bangalore in the 1990s (cf. Akhil Gupta, 1998; Khadse & Bhattacharya, 2013).[138] After Nanjundaswamy's death in 2004, the lack of central leadership divided the farmers' movements and consequently weakened the alliance's collective bargaining power. So, Nanjundaswamy's daughter Chukki continued the project of reuniting India's farmers in their struggle against the dominance of transnational corporations in the farming sector. She continued to build Amritha Bhoomi as an agro-ecology farm, indigenous seed bank, and training centre to educate farmers, women, and youth from all

[136] Debjeet reminded me of the role of such writers as Arundhati Roy (e.g. Roy, 2004, 2009) in questioning the political economy of India's transformation to modernity by means of technological innovation; and the inspiration such writing can give for constructing better visions of the future.

[137] The Karnataka Raiya Raitha Sangha (KRRS) is the Karnataka State Farmers' Association. It was founded in 1980 with the Gandhian objective of Swadeshi (home economy) to realise a village republic, i.e. "a form of social, political, and economic organisation based on direct democracy, economic and political autonomy and self-reliance"(Khadse & Bhattacharya, 2013). Although this farmers' movement is Gandhian in principle, it resorts to direct action against inanimate objects and confrontational politics against unfair socioeconomic systems. From its inception onwards, the organisation has opposed the policies and institutions of neoliberal globalisation.

[138] Due to the movement's history of engaging in violent protest, Indian authorities are up to this date wary about any KRRS assembly. I witnessed myself how hundreds of armed riot police kettled a peaceful congregation of KRRS farmers in Bangalore in February, 2012 for the fear of their assembly turning into a violent protest. European farmers also use means of direct action to produce media coverage for their protests, such as the spraying of milk at police and European Union buildings and the erection and burning of barricades during demonstrations in Brussels (see, e.g. Ruddick, 2015).

over India about seed sovereignty and rural autonomy (interview Khadse, 2013; interview Kannayan, 2013). In February 2013, hundreds of farmers, farmer leaders, activists, journalist, politicians and other supporters of the movement attended the inauguration of the farmer's university (see figures 7&8, below) to celebrate their "struggle for biodiversity conservation and against agribusiness's plans of total domination through seed patents" (AmrithaBhoomi, 2017). At the inauguration, several leaders from the farmers' organisation KRRS and BKU were present, and speakers from all over the country presented their visons of the future of farming.

Figure 7: Journalist Devinder Sharma, politician Yogandra Yadav[139], South Indian Coordination Committee Convener S Kannayan, La Via Campesina activist Ashlesha Khadse, local journalist, and researcher (from left to right) at Amritha Bhoomi (source: author, 2013).

[139] Yogendra Yadav was the National Executive of the Aam Aadmi Party (AAP) that emerged from the India Against Corruption Movement in 2012. After getting expulsed from the party, he was one of the founding members of another anti-corruption movement Swaraj Abhijan and the farmers' groups coordination movement Jai Kissan Adolan in 2015.

Figure 8: Assembly of BKU and KRRS farmer leaders at Amritha Bhoomi (source: author, 2013)

One speaker at the inauguration, Babloo Ganguly from the Timbaktu Collective, warned the audience consisting of farmers and farmer leaders that modern agricultural technologies and the institutions of the global market deprive Indian farmers of control, of autonomy, and freedom: "if we are not careful, then there is no future" (interview Ganguly, 2013). Instead, he prompted that concerns about the future of India's farming community should revolve around questions of sovereignty and control over land, seeds, and the marketing of agricultural produce: "Farmers are losing their autonomy, which means they lose the sense of control over their own lives; it's a loss of farmers' sovereignty, seed sovereignty, food security […] Loss of autonomy is loss of freedom!". Ganguly suggested to his audience that they should take matters into their own hands. Instead of succumbing to the forces of global markets or refraining from them, they should form collectives to build direct producer-to-consumer chains for their produce.[140] Since added value is generated when food is sold to consumers, "as farmers we must take that space in the market" to get better prices and to reclaim autonomy: "It is time to accept that we have to engage with the market and that we have to do business […] to assert ourselves and to get the right price for our products" (Ganguly, 2013). The events at Amritha Bhoomi are just one example of the farming community organising itself to assert more sovereignty over the way they do farming. All over India, civil society organisations organise autonomous seed banks and alternative marketing systems for their produce. Although in Europe only a marginal part of the population engages in agriculture (in India up to 70 per cent of the population is directly or indirectly involved in farming), there are numerous movements that promote agro-ecological farming

[140] P. Babu (ICRA) agrees: "The gap between producers and end-users of agricultural produce is a sign of a lack of democracy in the food production system" (interview Babu, 2013). To Indian grassroots activists, GM crops therefore directly relate to issues of autonomy, democracy, and justice.

and cooperative-based market models such as Community Supported Agriculture, calling for a future of "good food and good farming" (interview Brändle & Holloh, 2013; see figure 9 below).

Figure 9: Decorated tractor at Good Food March, Brussels, September 2012 (source: author, 2012)

Conclusion: sociotechnical imaginaries and publics

This chapter looks at the arena of publicly circulating visions of the future that the actors of the GM crops debate construct in the controversy. I employ Jasanoff's and Kim's (2015) concept of sociotechnical imaginaries to capture these collectively held and publicly performed of a desirable future with or without GM crops (see also table 2, below). The sociotechnical imaginary of productivity presents GM crops as the necessary and logical technological intervention into agricultural practice to increase productivity by enhancing yields, reducing input costs, and stimulating economic growth and competitiveness; necessary because of the Malthusian rationale that assumes only productivity increases in agriculture can feed the world population, and logical because transgenic seeds are seen as an imperative to remain competitive in global markets for agricultural produce. In this imaginary, the potential benefits outweigh the risks associated with GM crops. Actors constructing such a vision of the future elevate the normative imperatives of feeding the hungry and of enhancing economic growth and competitiveness above possible concerns about the technology's risks.

I show the sociotechnical imaginary of environmentalism to respond to the changing societal context that demands agricultural technologies to be more environmentally friendly. Actors in favour of GM crops point to the pesticide reducing potential of insect-resistant crops and the benefits of no-tillage farming with herbicide-tolerant GM crops. If risks arise, these will be solved by adding more techno-fixes, or by better farm management practices, e.g. through improved crop rotation and pesticide application techniques, the technology's proponents argue. The normative underpinning of this sociotechnical imaginary is to protect the environment with better seed technology. The biotech industries' attempt to brand transgenic crops as more environmentally friendly than previous agricultural technologies is evident in the branding of GM crops as an Evergreen Revolution. However, civil society groups, transnational NGOs and grassroots farmers' organisations fiercely question the visions GM crops proponents construct for the future.

The imaginary of complex ecology questions the necessity for yield increases and the effectiveness of GM crops in reaching this goal. The problem definition put forth in this imaginary is of hunger and malnutrition not being caused by a lack of productivity. Instead, these actors argue that the complex web of interdependent and vulnerable ecological mechanisms the agricultural field is part of, is insufficiently understood. This imaginary emphasises ecological risks of GM crops: transgenic crop technology leads to an increase in pesticide applications due to resistance development in insects and weeds, and due to secondary pests that GM crops do not target. Moreover, they illustrate ecological complexity by the risks transgenic crop technology poses to non-target organisms. To its critics, the logic behind GM crops is too simplistic and does not adhere to the requirements of the ecological interdependencies of which the agricultural field is an intrinsic part. The normativity of the sociotechnical imaginary of complex ecology pertains to maintaining the integrity of the ecosystem and preserving biodiversity, both as vital elements for sustainable food production and the survival of humanity.

Finally, the sociotechnical imaginary of seed sovereignty takes the centralising tendencies of transnational corporations in the seeds and agrochemical markets as its starting point. From this view, GM crops acquire the meaning of paving the way to monopolisation and

the control of transnational corporations such as Monsanto over agricultural inputs, and the quality and availability of seeds. This, the opponents of transgenic crops argue, will deprive farmers of their choice which sort of crops to cultivate, and bind them to a system of input-intensive monoculture cropping systems. The risks ascribed to GM crops within the socio-technical imaginary of seed sovereignty are reduced choices for farmers and loss of biodiversity due to monopolistic markets, and therefore a loss for the farming community's sovereignty over its productive resources. If farmers are not free to choose the varieties most suitable to the various agro-climatic and ecological conditions of their fields, and if they have no choice but to buy GM seeds, this sociotechnical imaginary foresees agriculture to be unable to cope with the challenges of the future. The meaning of seed sovereignty is therefore linked not only to sovereignty over the means of production in agriculture, but also to livelihood and ecology. Autonomy of farmers and diversity of seed germplasm are central normative underpinnings of the imaginary of seed sovereignty. Diversity acquires the meaning of not only being important for ecosystem stability, but for the farming community's political sovereignty, and therefore for democracy and justice, too.

What connects these competing, conflicting, and contested imaginaries is their temporality: The various visions of a sociotechnical future with or without GM crops that symbolise diverging meanings attributed to GM crops. The normative underpinnings underlying these are stabilised and consolidated by actors' interpretations of past agricultural development since the Green Revolution. The linearity with which proponents of the imaginary of productivity and environmentalism envision GM crops to function is rooted in their interpretation of the Green Revolution as an unproblematic technological boost to agriculture. From this perspective, GM crops constitute a linear continuation of sociotechnical project of the intensification of agriculture through technological innovation. In this interpretation of the history of agricultural development, transgenic seed technology acquires the meaning of the mastery over nature. If risks materialise, further techno-fixes will solve ensuing problems. This becomes most obvious in the rhetorical presentation of GM crops as 'a second Green Revolution' and the construction of GM technology as a logical continuation of traditional breeding with more precision; and in the construction of GM crops as environmentally friendly and therefore enabling a future 'Evergreen Revolution' that maintains past intensity but without future negative environmental effects. However, the instrumental reason such interpretations of the Green Revolution represent are opposed by those relevant social groups who construct the imaginaries of complex ecology and seed sovereignty, which ascribe a different meaning to the Green Revolution period.

Civil society groups, environmental NGOs, and farmers' organisations all emphasise the environmental and social costs associated with input-intensive farming practices of the Green Revolution. To them, transgenic crop technology is a continuation of the system of industrial agriculture which has led to ecological destruction, the loss of biodiversity, and agrarian crisis. The Green Revolution bound farmers to a technological regime of input-intensive farming practice: high yielding crops, agrochemicals, and monoculture cropping systems. Also, the associated ecological impact destroyed biodiversity resources and ecological integrity; and the necessary transformation of the social organisation of rural labour has led to the loss of knowledge about alternative farming methods. In this imaginary, GM crops will only intensify these developments. At the same time, GM crops are qualitatively different

from Green Revolution technologies because they extend the proprietary logic to the molecular level which individual farmers will be unable to detect and have an impact upon. Instead, the dependency of farmers on producers of agricultural technologies that started with the Green Revolution will intensify, meaning farmers will be at the mercy of monopolistic markets dominated by a few transnational corporations that determine seed technology innovation and prices.

This temporal perspective emphasises the long-term perspective not only of ecosystem evolution, where negative ecological consequences of monocultures and chemical farming only show over the course of decades, but also of postcolonial dependencies that date back to the industrialisation of agriculture in the Green Revolution period. To some actors, GM crops are a technological project of domination by the structures of neoliberal globalisation that will deprive the farming community of its autonomy over cultivation choices and make them dependent on transnational corporations for seed germplasm. The sociotechnical imaginaries of complex ecology and seed sovereignty foresee a future with GM crops lead to worsening ecological consequences and to the perpetuation of unjust post-colonial relations of dependency. Despite these negative interpretations of the past and predictions for the future, the opponents of GM crops also construct a productive break with this temporal continuity: their positive vision of the future relates to a systemic change of agricultural systems to principles of agro-ecology with ecological and political diversity, free choice, and fair access to markets for farmers.

As much as futures are constructed in sociotechnical imaginaries, the past is equally imagined, interpreted, and appropriated by the actors in the debate. A focus on role and construction of time can help to better grasp conflicting, competing, and contested sociotechnical imaginaries in debates about technological risks. Temporalities can alert us to unacknowledged political and normative implications (S. Sharma, 2013). The analysis of the temporal dimension of sociotechnical imaginaries indicates that different interpretations of the past entail different perspectives of time which in turn inform the normativity of the actors' arguments, i.e. how they relate to the past shapes the construction of their imaginaries of the future. Historian Barbara Adam (2006) infers that naturalised machine time invented in the West now spans the globe and imposes a timeframe marked by invariability, standardisation, quantification, and universalisation. The sociotechnical imaginaries of productivity and environmentalism embody these dimensions in accounting for benefits of transgenic crops in terms of yield, in reacting to environmental concerns by means of universal technofixes, and through the suggested linearity of technological development. Although naturalised machine time has benefited the global span of the mode of capitalist production and the logic of markets, it fails to take into account the temporality of ecological and socio-economic perspectives on time, thus leaving "other temporal orientations and structures de-legitimised" (Adam, 2006, p. 124).

The sociotechnical imaginaries of complex ecology and seed sovereignty in contrast reveal that certain actors have a different temporal perspective on the dominance of industrialisation and globalisation as processes that colonise both nature and society. While the proponents of GM crops envision the technology as part of an invariable course of human and technological progress, the sociotechnical imaginaries of complex ecology and seed sovereignty suggest different temporal frames. By developing counter imaginations based on the

perspective of longer time spans of ecosystem development and postcolonial relations of domination, these imaginaries shift the temporal perspective towards the *longue durée* of socio-historical time: society stretches over long and short periods of time. Not only material, but also mental and environmental structures shape the long-term course of events in human history beyond the immediate consciousness of the actors involved (Hall, 1980). The temporal perspective of the sociotechnical imaginaries of complex ecology and seed sovereignty regard ecological, cultural, and social structures (ecosystem, industrialisation, colonial dependencies) to evolve over considerably longer time frames than capitalist techno-scientific innovation.

The concept of sociotechnical imaginaries helps to show how past, present and future interrelated in the GM crops debate. As such, the concept is future oriented, but also constrained by present conditions, as well as historical, political, and cultural contingencies (Marcus, 1995b). Temporality is what connects the normativity of the various contested and competing sociotechnical imaginaries at play in the controversy. Proponents and opponents of the debate place their conflicting views of the future with and without GM crops within different interpretations of the history of agricultural development since the Green Revolution. The multiplicity of competing imaginaries as visions of the future aim at shaping the present and yet are framed by various interpretations of the past. This means imaginaries are temporal, i.e. how it is or was, and how it ought to be, are intertwined.

Taking such a perspective into account allows us to see the normativity of the respective sociotechnical imaginaries vis-à-vis other perspectives on the history of sociotechnical development, i.e. in technological controversies, the actors' deep-seated background understandings and interpretations of the past inform their imaginaries of the future. The relation between past and future finds expression in the shared meanings of imaginaries. This shows how the actors in the debate understand their present social reality and the futures GM crops might entail. Conceptually, the focus on temporality implies that sociotechnical imaginaries relate to wider issues such as ecology, the evolution of agriculture, capitalism, and globalisation. Also, the notion of linearity and universality that underlies the normative arguments of the sociotechnical imaginaries of productivity and environmentalism stands in contrast to the norms of interdependency and diversity which are the basis for the sociotechnical imaginaries of complex ecology and seed sovereignty.

Finally, the normativity and temporality of sociotechnical imaginaries speak to and from different publics. This means that sociotechnical imaginaries address specific audiences, but they equally construct such publics. As Jasanoff and Kim argue, sociotechnical imaginaries are collectively held visions of the future that construct publics in the sense of representing and performing notions of what is good and desirable for societal development and the political community. The sociotechnical imaginary of productivity constructs consumer publics as being interested in cheaper commodity prices resulting from more productive agricultural technology, and farmer publics as being interested in increasing yields, lowering input costs, and employing cutting-edge technological innovation. The corresponding public therefore is constructed as based on the normative assumption that risks should be taken if technological innovation leads to increases in agricultural productivity, economic growth, and competitiveness. Both are seen as serving the public good and therefore catering to publics.

The sociotechnical imaginary of environmentalism in contrast constructs a societal need for agricultural technologies that are less harmful to the environment. The relevant publics thus constructed are consumers and farmers who wish for more environmentally friendly agricultural technologies. Although the normative underpinnings and their corresponding publics are generally agreed upon (feeding the hungry, stimulating economic growth, protecting the environment), the construction of publics differs fundamentally in the opponents' visions of the future. The sociotechnical imaginary of complex ecology emphasises the need for ecosystem stability and biodiversity in order to keep agriculture sustainable, affordable, and productive. The corresponding normative claim that ecosystem complexity is to be accounted for therefore constructs entire humanity as its public, which depends for its survival on maintaining biodiversity and respecting the interdependencies of the ecosystem. Finally, the sociotechnical imaginary of seed sovereignty constructs yet another farmer public. Farmers in this vision affirm their political agency by retaining the autonomy over seeds, and they resist the imposition of a system of techno-political domination of their relations of production and the social organisation of labour, in short, their livelihood and culture. Along with their respective publics, the sociotechnical imaginaries at play in the GM crops controversy also construct respective targets for policy action, such as more or less stringent regulatory requirements. Accordingly, sociotechnical imaginaries pertain to the political regulation of transgenic crop technology. How these play out in policy-making will be subject to the case study I look at in the following chapter.

Table 2: Overview of the sociotechnical imaginaries in the GM crops debate (source: author, 2018)

STI	GM crops, meaning	Risk	Normativity	Temporality
Productivity	Increase productivity: yield, GDP growth	Benefits outweigh risks	Feeding the hungry, economic growth	A second Green Revolution: linear continuation GR
Environmentalism	Environmental friendly technology	To be solved by techno-fixes	Environmental protection	Evergreen Revolution: improved GR
Complex Ecology	Threat to ecosystem stability	Impact on ecosystem unpredictable	Ecological integrity, interdependence & stability; biodiversity	Ecological effects of GR, GMOs; continuation
Seed Sovereignty	Threat to farmer's autonomy	Seed monopoly, loss of diversity, reduced choice, political sovereignty	Diversity: farmers' sovereignty over cultivation decisions	Social and political effects of GR: postcolonial dependency

Chapter 4

The Bt-brinjal Consultations - Publics in the Arena of GM crop Policy-Making

Introduction: publics of Bt-brinjal?

On February 9, 2010, Indian Minister of Environment and Forests Jairam Ramesh overruled the recommendation of the Genetic Engineering Approval Committee (GEAC), India's government body responsible for the authorisation of GMOs, for the commercial release of Bt-brinjal.[141] Ramesh instead imposed a moratorium on India's first GM food crop, just before it had reached marketing stage. In a 19-page document explaining his decision, Ramesh announced:

> It is my duty to adopt a cautious, precautionary principle-based approach and impose a moratorium on the release of Bt-brinjal, till such time independent scientific studies establish, to the satisfaction of both the public and professionals, the safety of the product from the point of view of its long-term impact on human health and environment, including the rich genetic wealth existing in brinjal in our country.
>
> (Ramesh, 2010, p. 17)

Ramesh's moratorium announcement is a remarkable event in Indian science and technology policy-making that has not been studied in depth yet. I will highlight three aspects of the controversy about Bt-brinjal that merit an investigation of this case in order to scrutinise the democratisation of techno-scientific development.

First, the moratorium decision followed extensive public participation and engagement: In October 2009, after several expert committee reports on Bt-brinjal and continued societal controversy about its approval process, Ramesh decided to hold public consultations throughout India. The Minister reasoned this would help to arrive at a "careful, considered decision in the public and national interest" (Ramesh, 2009). This participatory process came to be known as the Bt-brinjal consultations, a globally recognized event of engaging the public in Indian policy-making on GM crops. These consultations were unique since experiences with public participation in India's GM crop biosafety regulation had been non-existent up to that point (Aarti Gupta, 2011). Public engagement allows citizens' participation in controversial matters in which decision-making is usually delegated to unelected experts. It is therefore thought to enhance the legitimacy and efficacy of policy decision-making in the democratic process (Hamlett, 2003; Thayyil, 2014). The Centre for Environment Education (CEE) based in Ahmedabad organised the Bt-brinjal consultations in seven Indian cities in January and February 2010, shortly after which the Minister announced the moratorium.

Second, Ramesh's reasoning for his decision reverberated with issues Indian civil society actors had tried to bring to the attention of policy-makers for a long time: Debates about the lack of scientific certainty regarding long-term consequences for human health and the environment; concerns about the increasing concentration of the seed market in the hands of transnational companies; and topics such as the value of genetic diversity for agricultural livelihoods; the independence of scientific advice; and how consumers can make informed choices, reverberated with the decision to impose this drastic policy measure (Ramesh, 2014).

[141] Brinjal is the Indian term for aubergine or eggplant (*Solanum melongena*).

The Bt-brinjal consultations are special because they opened up the controversy about this specific technology to wider issues and debates about GM crops: the nature of decision-making and institutional design, and the role of ecology, markets, and publics in techno-scientific development for agriculture.

Finally, the decision for a moratorium is outstanding because by drawing on the Bt-brinjal consultations, Ramesh put 'the public' on par with experts. Both experts and the public needed to be convinced of the safety and necessity of Bt-brinjal before it would be allowed to reach marketing stage. Accordingly, both science-based risk assessment, and societal concerns seem to have shaped the Minister's decision. However, while public participation can be considered an institutional response to address concerns about representational and democratic deficits, public engagement meant different things to the actors involved. Civil society and some scientists saw the consultations and the resulting moratorium as a sign of democratization of policy-making on technology. Yet, industry representatives and other scientists criticized the consultations as orchestrated and the Minister's decision as populist. While a broad array of actors from civil society, the corporate sector, the farming community, and science had participated in the Bt-brinjal consultations, it remains a question which 'public' Minister Ramesh referred to in his moratorium decision. The Bt-brinjal consultations provided a space for interactions and associations between various actors that had previously not existed in institutional policy-making. In the following, I will therefore ask which publics emerged in India's policy arena in the context of the Bt-brinjal consultations.

The current chapter enters the arena of policy-making to study how publics had an impact on the regulation of genetically modified Bt-brinjal in India. I ask what conditions made the Indian Minister of Environment and Forests impose a moratorium, a unique, unprecedented, and unanticipated decision in Indian policy-making.[142] I try to understand the relationship between policy-making and public engagement by reconstructing the Bt-brinjal consultations with a specific focus on how different publics got constructed in that process, and how publics co-constructed the regulation of Bt-brinjal. Therefore, my central concern here is with the question: Which notions of the 'public' got constructed in the Bt-brinjal consultations and how did these 'publics' shape the moratorium decision?

At the centre of the ensuing analysis will be the various issues around which publics formed, as well as the varying conceptions of 'publics' that inform the understandings of the actors involved in the debate. Studying the Bt-brinjal consultations as part of the policy process allows me to identify what sort of associations and relations arose amongst the actors involved (cf. Marres, 2007). Vice versa, I suggest that the notion of a plurality of heterogeneous 'publics', and the attempts to harness, enrol, and engage such publics, played a decisive role in actor's attempts to shape the policy process. I will show that such issue-based constructions of the public root in the interpretative flexibility of Bt-brinjal and its risks, as well as wider conceptions of the role of science, the market, and the structure of the agricultural system. Different conceptions of how publics emerge from public engagement carry implicit

[142] Note that in Europe, there is no such legally imposed moratorium on GM crops. Only a marginal acreage in a few countries (e.g. Bt maize in Spain) is under GM crop cultivation in Europe. However, in the literature we find references to a 'de facto moratorium' on cultivating GM crops because of widespread public opposition to GM seed technology that has resulted in most members states banning cultivation on their territory (Thayyil, 2014).

normative ideas about the character and role of publics in democracy (Bucchi & Neresini, 2008) and underlying notions of political order (Chilvers, 2008; Durant, 2011; Hamlett, 2003). For understanding public issues and problems, Wynne advises STS scholarship to engage closely with concepts that help us grasping "the deeper forces shaping scientific understandings and normative representational performances of its 'democratic' publics" (Wynne, 2007, p. 99). Investigating the meanings actors attached to the process of the Bt-brinjal consultations, and the issues they raised therein, helps to explain how heterogeneous publics emerged in the arena of Indian GM policy-making. Scrutinising the construction of publics through the lens of issue-based publics and object-oriented politics therefore provides a different perspective on how social problems get redefined towards workable solutions in the policy process (cf. Hajer, 1995; Marres, 2007).

The following examines the case of the Bt-brinjal consultations and Ramesh's moratorium decision chronologically. I will show specifically how new associations and relations between Bt-brinjal, its risks, and actors such as activists, farmers' organisations, industry representatives, policy-makers, public intellectuals, and scientists allowed for the construction of heterogeneous issue-based publics. The different meanings relevant social groups attributed to Bt-brinjal and to the issues raised through public engagement allowed them to speak to and from different publics. First, I reconstruct the controversy starting with the events that preceded Ramesh's decision for public consultations and the reasons for doing so from the perspective of democratic theory. I will then zoom into the consultations, how public engagement was organised, the actors' arguments and the issues they raised, what meanings relevant social groups attached to the consultations, and how three sorts of heterogeneous publics emerged from the Bt-brinjal consultations. Next, I will explain the moratorium decision and discuss the most crucial reasons that motivated the minister's decision in response to the public consultations. Finally, the various meanings the moratorium had in the aftermath of the Minister's decision will allow me to explain the construction of issue publics in the wider controversy about GM crops in more depth. I will explain how publics got constructed through which meanings and symbolic issue articulations the relevant social groups invoked. These issue publics at the same time unravelled the wider social, political, and economic issues that regulating GM crop technology in India is entangled with, such as questions of problem framing, institutional design, and legitimate expertise, or wider concerns with the role of science, markets, and agricultural development. Before I commence with reconstructing the events around the Bt-brinjal consultations, let me explain how to study such processes from a STS perspective.

STS and the Study of Public Policy: a case for constructivist analysis

Involving the public through engagement exercises is widely conceived of as democratising science and technology decision-making. Yet, constructivist approaches in STS that study the democratising potential of such procedures have received criticism for a supposed lack of theoretical clarity. Durant (2011) argues there are diverging conceptions of democracy in STS theorising; Lövbrand et al. (2011) question whether there is enough empirical support for calls for public engagement based on deliberative models of democracy; Brown criticises STS empirical studies for insufficiently conceptualising the notions of 'publics' (2009) and

'politics' (2015); and Wynne (2007) suggests that STS work on public engagement has entered a reductionist impasse by asking primarily for the *qualification* of publics to engage in expert discourses about techno-science, while leaving more fundamental questions aside.[143]

Nonetheless, the last decade of STS research has yielded a much deeper understanding of the role of technology in democracy than these critics suggest (Bijker et al., 2009; Jasanoff, 2005a, 2005b; Marres, 2005). There are, for instance, empirical investigations of non-Western contexts that emphasise the influence of publics on styles of governance (Beumer, 2016), the role of civic engagement in techno-scientific development (Höffken, 2012), and the impact of bottom-up creative dissent in shaping agrarian alternatives (Quartz, 2011), and conceptions of technological citizenship (e.g. Valkenburg, 2012). There are also inquiries into the various conceptions of publics in the co-construction of technology and politics (e.g. de Saille, 2015; Marres, 2007; Mukherjee, 2016; Varughese, 2012). By studying the meanings attached to the Bt-brinjal consultations and the publics emerging in the debate, my approach follows the calls to engage with relevant political science concepts for understanding the construction of publics and public problems in matters pertaining to techno-scientific development (Brown, 2015; Thorpe, 2008). The Bt-brinjal consultations provide a fruitful ground for studying how the relationships between the state, science and technology, and society were subject to renegotiation through competing conceptions of the various publics affected by Bt-brinjal. Such a constructivist approach can help to better understand the impact of publics on policy-making.

A constructivist understanding of policy as a process of social change that involves meaning-making can unravel the discourses and politics of policy-making (cf. Hajer, 1995). It can help to characterise the changing forms of governance and regimes of power reflected in techno-scientific development (Hackett, Amsterdamska, Lynch, & Wajcman, 2007, p. 5). While conventional rational choice models assume policy to be a neutral and legal-rational way of getting things done, the constructivist approach suggests to study policy-making processes as complex interactions of institutions, power relations, meanings, and interpretations of the actors involved. This approach only found entry into policy studies about two decades ago (Shore & Wright, 1997; Wedel, Shore, Feldman, & Lathrop, 2005). Instead of understanding policy-making as linear, such an 'anthropology of policy' considers the complexity of processes of meaning-making as full of politics (Wedel, 2008; Wright, 2006). STS offers the ethnographic sensitivity in the study of the policy process as an arena in which various actors construct different meanings with regard to technology. STS allows to better grasp the mutual shaping of technology and its publics in attempts to democratise policy-making by symmetrically considering the co-construction of the politics of policy-making and the interpretative flexibility of technology.

The Bt-brinjal consultations constitute an empirically intriguing case of publics engaging in the democratic regulation of techno-science in the global South that has not been empirically investigated so far. To study this case, I draw upon qualitative interviews I conducted

[143] The 'third wave' debate in STS between Collins and Evans (Collins & Evans, 2002, 2003) on the one hand, and Jasanoff (2003) and Wynne (2003) on the other, is exemplary of the debate about the reasons and parameters for accepting public involvement in techno-scientific development. For a further discussion, e.g. of the models of democracy, or conceptions of lay actors' agency underlying such conceptions in STS, see also Durant (Durant, 2008, 2011), Rip (2003), Wynne (2008), and the .introduction to this dissertation.

with key actors who were involved in the Bt-brinjal consultations: activists such as Suman Sahai from Gene Campaign and Leo Saldanha from Environmental Support Group (ESG); farmers' and industry representatives like Judhvir Singh and CK Rao, respectively; journalists like Devinder Sharma; and Indian scientists such as G Padmanaban, PM Bhargava and MS Swaminathan; as well as other activists, industry representatives, and scientists. To reconstruct the Bt-brinjal consultations, I also studied textual documents about the events, such as the more than 500 page summary report of the public hearings provided by the organiser of the consultations (CEE, 2010a).[144] Further, I scrutinise reactions to the consultations and the moratorium in the form of advocacy material, weblog entries, essays, opinion pieces and news articles in various public media, scientific and government reports. The time-frame of my investigation of the Bt-brinjal debate spans from 2009, when the Minister decided to consult the public, up to his decision for a moratorium. The Bt-brinjal consultations opened up the debate about GM crops in Indian agriculture, which reflects in other Indian policy moments involving public participation after the moratorium was imposed.[145]

Although the Bt-brinjal consultations are about Indian policy-making, the entanglements, associations, and issues of the debate reach beyond the Indian sub-continent. International experts and civil society actors from outside India formed discourse coalitions (Hajer, 1995) that had an impact on the consultations, too. I also include the contributions to and interpretations of the Bt-brinjal consultations by non-Indian actors, such as scientists, activists, and industry representatives from the global North. In Europe, engagement exercises on GM crops took place a decade earlier, such as the British *GM nation* or the Dutch *Eten en Genen* debates, which both yielded mixed results.[146] Although none of the European experiences with public participation in GM crops policy-making resulted in outcomes comparable to the moratorium implemented by India's Union Minister of Environment and Forests in 2010, actors often compare the Indian developments to European public policies on GM crops. Despite the contingency and uniqueness of the Bt-brinjal case, similarities with the construction of issue-publics in Europe exist, for instance with regard to the regulatory principles the actors of the contestation invoked in the debate. Yet, as Sheila Jasanoff (2011) notes for the United States, the focus on public engagement as a remedy to the shortcomings of liberal pluralist democracy should be sensitive to context, culture, the contingent traditions

[144] Pages in the final CEE report on the Bt-brinjal consultations are not consistently numbered. For this reason, direct quotations from the report are not referenced with a specific page number, but with sufficient detail (text section, speaker, and the type of document) for the reader to trace the source back to its origin in the summary report.

[145] Such as for instance the *Lok Sabha's* (the lower house of India's bicameral Parliament) Committee on Agriculture, which consulted farmers from all over India for their report on GM crops in 2012 (CoA, 2012).

[146] The British *GM nation* debate revealed consumers' general uneasiness about GM crops. It showed there was little support for early commercialisation, and severe mistrust of government, regulatory authorities, and transnationals (TheGuardian, 2003); the Dutch case showed the public to be sceptical of, but not entirely opposed to GM crops: Dutch consumers saw information and choice, and independent research on biosafety as most important (NRC, 2002).

of deliberation of other democratic cultures.[147] Next, let me reconstruct the events leading up to the consultations.

From Conventional Policy-Making to Public Engagement

Maharashtra Hybrid Seeds Company (Mahyco) started genetically modifying brinjal, India's first vegetable GM food crop, in the year 2000.[148] Bt-brinjal was engineered to express the event EE1 (licensed by Monsanto) to make the plant resistant against lepidopteran insects such as the Fruit and Shoot Borer.[149] The transgenic insertion of the gene Cry1Ac from the bacterium *Bacillus thuringiensis* (Bt) makes the brinjal plant produce an insecticidal protein in each of its cells throughout its lifetime. The Fruit and Shoot Borer dies when it feeds on any part of the plant, but other insects, animals, and humans are supposed to remain unaffected by the Bt-toxin in Bt-brinjal. Bt-cotton, India's only other commercialised GM crop that was introduced in 2002, works with a similar Bt-insertion (the toxic proteins expressed in Bt-cotton are different and so is the target pest). Bt-brinjal however, is India's first GM crop for human consumption.

Bt-brinjal was developed following a technology transfer agreement of a US-Indian public-private partnership under the Agriculture Biotechnology Support Project (ABSP) of Cornell University in the United States, and funded by the United States Agency for International Development (USAID) (Choudhary & Gaur, 2009). This programme allowed Mahyco to collaborate with Indian public agricultural research institutions. When Mahyco had transferred EE1 into its own brinjal varieties, the University of Agricultural Sciences (UAS) in Dharwad and Tamil Nadu Agricultural University (TNAU) in Coimbatore back-crossed event EE-1 into locally adapted open-pollinated varieties of brinjal. The Indian Institute of Vegetable Research (IIVR) in Varanasi was responsible for conducting open field trials. Between 2002 and 2004, Mahyco conducted confined field tests and submitted data from these trials to the Review Committee on Genetic Modification (RCGM).[150] Based on a review of

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147 Amartya Sen (2005) describes a long history of dialogic tradition and the acceptance of discursive and argumentative heterodoxy in India, which he depicts as vital for democracy and public reason. It is from this non-Western democratic context this chapter aims to expand our understanding of the construction of publics.

148 On the Monsanto website, Mahyco Monsanto Biotech (MMB) is depicted as a 50:50 joint venture between Maharashtra Hybrid Seeds Company and Monsanto Holdings Pvt. In turn, 26 per cent of Mahyco is owned by Monsanto (Abdelgawad, 2012; CorporateWatch, 2005). MMB has sub-licensed the Bt-cotton varieties Bolgard I™ and Bolgard II™ to 28 Indian seed companies which further crossed these varieties into their own germplasm summing up to 300 Bt-cotton hybrids available on the Indian market (Monsanto, 2015a). In 2015, the anti-monopoly Competition Commission of India (CCI) has found MMB to have violated anticompetitive agreements and to have abused its dominant market position (TheEconomicTimes, 2016).

149 The Fruit and Shoot Borer *Leucinodes orbnalis* and the Fruit Borer *Helicoverpa armigera* are tropical insects that feed predominantly on brinjal and few other vegetable crops throughout the plants' life cycle. Conventional breeding of resistant brinjal has failed, resulting in a high number of annual pesticide sprays in cultivation (Shelton, 2010). Industry-sponsored studies describe non-GM pest management as labour and pesticide intensive and present the Bt-gene expression as the only viable solution "to protect the crop and get good yields" (Choudhary & Gaur, 2009, p. 42).

150 The RCGM is an apex body under the Department of Biotechnology (DBT). Its regulatory role concerns the approval and review of GMOs in research and small-scale field experiments. RCGM also authorises

these data, RCGM recommended India's Genetic Engineering Approval Committee (GEAC)[151] to grant authorisation for large-scale field trials of Bt-brinjal. In 2006, Mahyco submitted its biosafety data to GEAC, the regulatory body for large-scale production and release into the environment of GM technology in India, to apply for the permission to conduct such large-scale open field trials. This however, did not remain uncontested.

Civil society concerns found expression in the filing of a Public Interest Litigation (PIL) as early as 2005.[152] The PIL questioned the GEAC's independence and the reliability of the existing scientific risk assessment, stating that field trials should only commence if "comprehensive, scientific, reliable and transparent bio-safety tests have been carried out" (Sreelata, 2006). Reacting to the PIL, India's Supreme Court banned all field trials with Bt-brinjal and constituted an expert committee (ECI) to review all safety data. In 2007, ECI came up with a report that lifted the ban on the open field trials, but requested seven more biosafety studies and socio-economic evaluations to be carried out. Accordingly, the Indian Institute of Vegetable Research (IIVR) commenced large-scale field trials in ten locations across India in 2007 and eleven in 2008 (GEAC, 2006). ECI's verdict and commencing the field trials did not stop the controversy though.[153]

In a separate move to the Supreme Court, Greenpeace India and NGO Gene Campaign requested all biosafety data on Bt-brinjal to be made publicly accessible, which had until then been denied by the Department of Biotechnology because of confidentiality concerns (Sahai, 2010). In 2008, India's Supreme Court finally ordered the Government to release Mahyco's biosafety data under the Right to Information (RTI) Act.[154] At the same time as IIVR submitted the results of the large-scale field trials to GEAC in 2009, several Indian and international scientists submitted their reassessments of Mahyco's biosafety data to the Ministry of Environment and Forests to which the GEAC reports. These scientists' investigations pointed to deficiencies in the applicant's data generation, analysis, and interpretation, as well

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imports of GMOs for research purposes. Earlier, RCGM had been authorised to grant approval for multi-location research field trials, but in May 2006, India's Supreme Court ordered that all such approvals need to be made by the Genetic Engineering Approval Committee (GEAC) (CEE, 2010a, pp. 60-61).

151 The GEAC is the apex body under the Ministry of Environment and Forest (MoEF). It was set up in May 1990 under the Environment Protection Act (EPA) of 1986 which gives the GEAC statutory authority to grant approval for large-scale field trials and the environmental release of genetically modified organisms. The GEAC has the power to authorise the commercialisation, i.e. large-scale production and release of GMOs into the environment (CEE, 2010a, p. 60; Ramesh, 2010). At the time of the Bt-brinjal controversy and just before Minister Ramesh initiated the public consultations, GEAC's name was changed from Genetic Engineering *Approval* Committee to Genetic Engineering *Appraisal* Committee (Aarti Gupta, 2011).

152 Writ Petition (Civil) No. 260 of 2005 by Aruna Rodigues, Devinder Sharma, PV Satheesh and Rajeev Baruah.

153 Besides various government sources provided by MoEF, civil society organisations (e.g. Sahai, 2010) and industry-sponsored advocacy groups (e.g. Choudhary & Gaur, 2009, an ISAAA publication) also provide accounts of the course of events. The descriptions in these documents carry implicit interpretations, for instance regarding the legitimacy of such committees as ECI. I therefore triangulated various textual and interview sources to reconstruct the events.

154 How biosafety data were treated confidential, thus preventing further analysis by other actors in the Bt-brinjal case, shows striking resemblance to the story about risk assessment data on GM maize MON863 that I describe in chapter two. Similar to India's Supreme Court decision, an Appeal Court decision initiated by Greenpeace in Germany legally obliged Monsanto to make public the biosafety data on MON863 in 2005.

as insufficient molecular characterisations in the biosafety tests (e.g. Séralini, 2009). As Shah (2011) notes, only 8 out of 18 submissions by international experts supported the release of Bt-brinjal, and only 16 out of 26 submissions by Indian scientists supported marketization at that point.

As a reaction to the fierce debate and the doubts raised about Mahyco's risk assessment, India's Supreme Court then constituted a second expert committee (ECII) to review the field study data and consider civil society's criticism of the biosafety tests. ECII submitted its report (2009) at the 97th meeting of the GEAC in October 2009. Although the GEAC subsequently recommended the commercial release of Bt-brinjal, it left the final verdict to the Ministry of Environment and Forests because of the "major policy implications" (GEAC, 2009, p. 7) of that decision. In the face of the strong views on Bt-brinjal, Jairam Ramesh then decided to make the ECII report publicly available to receive further comments. The decision about Bt-brinjal could have been taken within GEAC's and MoEF's scientific-technocratic nexus of expertise despite public contestation. Instead however, the Minister decided to deviate from conventional technocratic course and engage the public: Ramesh asked the Centre for Environment Education (CEE) to hold a nationwide "series of consultations in different places with scientists, agriculture experts, farmers' organisations, consumer groups and NGOs […] to arrive at a careful, considered decision in the public and national interest" (Ramesh, 2009).[155] The Bt-brinjal consultations accordingly opened up policy-making to societal criticism and public deliberation.

Ramesh's decision to hold public consultations was contested. On the one hand, scientists like biotechnologist Padmanaban lamented that it was "not clear how this consultation process would help" since safety study reviews like Séralini's were commissioned by Greenpeace to "oppose anyway". Instead, Bt-crop modifications had a history of safe use in other countries (Padmanaban, 2009). On the other hand, the Committee on Agriculture of the *Lok Sabha*, India's directly elected lower house of Parliament, welcomed broad consultations between the state, science, and society (CEE, 2010a, annexure II). NGOs, grassroots organisations, and farmers' unions also welcomed the consultation process. As several activists explained in interviews, they regarded the consultations as the institutional reply to the failure of the regulatory system to mediate controversy. The consultations therefore provided another route to influence opinion-formation of policy-makers and to construct the publics of the Bt-brinjal debate anew: "The debate brought together a variety of groups that otherwise would not have come together" (interview Saldanha, 2012).[156] The Minister's call for public engagement can be understood in this procedural sense, but also more pragmatically as an

[155] The Centre for Environment Education is based in Ahmedabad and engages with cross-generational and cross-sectoral education about environmental issues such as climate change and biodiversity conservation. Its aim is to support environmentally sustainable, economically viable, and socially beneficial development. It is a Centre of Excellence supported by the Ministry of Environment and Forest, GoI (CEE, n.d.).

[156] Saldanha expressed his deep appreciation for Ramesh's decision to hold public consultations as "a framework of progressive politics" that would contribute to transparency, accountability, and ultimately democracy: "We cannot allow an elite minority to decide for the majority. Be it scientists, businessmen or technocrats […] It should be a norm to have consultations" (interview Saldanha, 2012).

attempt to harness an overflowing public debate. Before I continue reconstructing the consultations, let me explain why policy-makers seek public engagement and how the actors in the Bt-brinjal debate conceived of Ramesh's decision to hold the Bt-brinjal consultations.

Public Participation, Displaced Politics, and Democracy

Public participation refers to the various situations and activities "more or less spontaneous, organized and structured, whereby non-experts become involved, and provide their own input to agenda setting, decision-making, policy forming, and knowledge production processes" (Bucchi & Neresini, 2008, p. 449; see also Rowe & Frewer, 2005). Several scholars point out that the terms 'public participation' and 'public engagement' are often used concurrently (Delgado, Kjolberg, & Wickson, 2011; Rowe & Frewer, 2005). I follow these researchers in using both terms simultaneously, a tendency they point out to reflect indistinctive use of these terms in policy documents (e.g. Wynne & Felt, 2007) and academic texts (e.g. Nowotny et al., 2001) alike, while public engagement appears to be the more fashionable term recently.

Public participation can be thought of as a reaction to the shortcomings of liberal pluralist democracy, i.e. traditional policy-making's incapacity to accommodate the various conflicts around sociotechnical development in its institutional arrangements and procedures (Bucchi & Neresini, 2008; Jasanoff, 2011; Offe, 2011). Due to the radical uncertainties in regard of the risks of techno-science, policy-makers have difficulties anticipating all possible future scenarios that might result from new technologies. As Callon, Latour and Barthe (2001) have shown, policy-makers thus seek the perspective of potentially affected parts of the population, the public. Public participation conveys legitimacy to decision-making on technological development beyond science-based risk concerns (Aarti Gupta, 2011) and it is supposed to enable citizens to build an informed opinion about the common good (Held, 2006a). Both, STS analysis and insights from deliberative democratic theory share the view that public problems are not pre-given, an assumption that seems to dominate perspectives such as pluralism or rational choice theory. Rather, constructivist scholarship suggest that definitions of public problems and the very publics involved with the political regulation of techno-science are contingent, constructed, and subject to transformation. Assumptions, knowledge, preferences, and values can change over time, in particular if different relevant social groups come together to allow for the reciprocal formation of informed and considered public opinion in a process of deliberation (Dryzek, 1990; Hamlett, 2003, pp. 121-123; Offe, 2011, p. 459). In that sense, the Bt-brinjal consultations constitute a strategic site for studying the construction of publics in the arena of GM crop policy-making.

Public engagement can be understood as an answer to the problem of "displaced politics" (Marres, 2005). Displacement refers to the symbolic meaning of the risks of techno-science becoming a catalyst to conflicts traditionally addressed in different settings – the solutions worked out in the closed circles of experts and policy-makers are contested by various actors who problematize the issues affecting them differently. As Valkenburg notes, displacement of politics is also a displacement of power "whenever the context in which decisions are made is not clearly connected to the context in which those decisions matter" (Valkenburg,

2012, p. 472). Often, techno-scientific development intertwines with broader socio-political considerations and questions about the public good. In other words, politics shifts from technocratic decision-making toward issues about science, economy, and society subject to contestation and deliberation in the public realm. Displacement not only refers to the institutional and social setting in which politics about techno-science are played out, but it also refers to the spatial entanglements between the local, the national, and the global.[157]

The idea of displacement reveals politics in the risk societies of late modernity to be fragmented and multiple (Beck, 1986, 1992; Giddens, 1990). Beck has described such displacement as leading to a complex web of sub-politics, which refers to actors' strive for the democratisation of social criticism and political decision-making from outside established institutional arrangements (Beck, 1998, p. 37). In STS, sub-politics refers to the complex, expert knowledge intensive, and distributed political issues arising in a techno-scientific culture (de Vries, 2007). Drawing on public engagement, policy-makers aim to connect displaced politics back to the arena of institutional democratic procedures. By systematically including stakeholders in the formulation of policy responses to public problems, publics re-enter the arena of policy-making beyond the electoral vote for political representation. We may assume that different publics are constructed through such engagement exercises. Exposing and capitalising the displacement of politics allows actors whose preferences were not considered in political decision-making before to influence policy decisions. Through public engagement, the arena of policy-making therefore opens up to society and its concerns by allowing various actors affected by a problem to problematize techno-scientific issues and to re-articulate problem definitions and solutions, and hence to re-shape the object of politics.

In the case at hand, a variety of actors engaged in discursive and legal action to gain a public voice in the regulation of Bt-brinjal, e.g. through filing Public Interest Litigations (PILs), writing letters to the Minister, reinterpreting scientific data, and engaging in the consultations. Such expressions of concern are a clear sign of processes of sub-politicisation that aim to reshape problem definitions and agenda-setting issues in policy-making. Public engagement constitutes a response to this sub-politicisation: In theory, citizens disconnected from the political process can reconnect to political debate and will-formation through deliberative engagement in which they become 'a public' (Habermas, 1996a). By allowing non-expert citizens "to participate effectively and meaningfully in developing policy responses to identified problems" (Hamlett, 2003, p. 118), the Minister of Environment and Forests wanted to improve the quality of decision-making on Bt-brinjal (Ramesh, 2014). In principle, public engagement increases openness, transparency and reflexivity and therefore enriches traditional policy-making procedures to potentially enhance the democratic process and its legitimacy (Dryzek, 1990; Held, 2006a). Principle 10 of the UN Rio Declaration on Environment and Development (UnitedNations, 1992) refers to public participation as a right of members of the public to get involved in decisions that affect the environment. This pertains

[157] It must be noted here, that displacement of politics is not entirely undesirable. As Valkenburg explains, representative democracy institutionalises displacement in parliamentary procedures, which allows citizens to spend less time on getting involved in politics directly. However, "it becomes problematic if there is no democratic mechanism to legitimize and control both the content of displaced decisions and the displacement itself" (Valkenburg, 2012, p. 472). The Bt-brinjal consultations can be said to constitute an attempt to address this very problem.

to the right to access to information, participation in decision-making, as well as access to justice in reviewing policy-decisions (Duvic-Paoli, 2012).

The Bt-brinjal consultations provided a para-institutional route of political preference formation, and therefore were thought of as an ailment to the displacement of politics. From this perspective, we can understand the organisers' description of the Bt-brinjal consultations as "a landmark […] in democratic and transparent decision-making" (CEE, 2010a, p. 5). Indian public intellectual Shiv Visvanathan welcomed the Minister's decision to consult the public on the issues around Bt-brinjal as a "breakthrough in the relation between science and democracy" (2014) because it allowed citizens a say in decision-making formerly contained to experts and technocrats. Professor Swaminathan, eminent Indian scientist who spent his lifetime working on plant genetics explained that the consultations opened up policy-making to wider framings beyond techno-scientific definitions of risk: "The public was overwhelmingly against it, so we have to look at the reasons, discussing technical matters only will not do it" (interview Swaminathan, 2013). To civil society actors, the consultations meant a chance to democratise decision-making by overcoming the dominance of experts in informing policy-makers. For instance, Leo Saldanha from Environmental Support Group (ESG) welcomed public engagement as democratising opinion formation and decision-making in the policy process: "the deeper the democratisation of a decision, the better the choice" (Interview, 2012).

By initiating the Bt-brinjal consultations, Ramesh created a chance to realise what deliberative democratic theory suggests public engagement to achieve: improving the quality of decision-making by examining and testing arguments; exposing how these are linked to sectional interests or ideological positions; allowing actors to consider the preferences of others; and subsequently arriving at the most reasonable argument in a process of political debate (Habermas, 1996b; Held, 2006a; Horlick-Jones et al., 2007). Ramesh fulfilled the obligation inscribed in the Rio Declaration to include the public in the political regulation of Bt-brinjal as an issue affecting the environment. However, as Stirling points out, the recognition of social agency through public engagement is often countered by notions of the epistemic supremacy of science and deterministic notions of technological progress (Stirling, 2008). The question remains what conceptions of publics emerged from the engagement around Bt-brinjal. I suggest that in the Bt-brinjal consultations various heterogeneous publics got constructed along with the issues and meanings actors attached to Bt-brinjal, its risks, and the consultation process itself while at the same time there was an epistemic hierarchy at play that privileged certain arguments over others.

By providing a space to present collective and deliberative opinions beyond interest formation through periodic voting, public engagement in principle strengthens discursive and communicative rationality vis-à-vis market rationalities that underlie liberal conceptions of interest aggregation through the ballot (Dryzek, 1990; Habermas, 1986, 1996a; Held, 2006a). In that sense, the decision for the consultations can be understood as the minister's attempt to open up policy-making by fathoming the interests of the wider public. Nevertheless, Ramesh later reflected on the Bt-brinjal consultations not as a democratic exchange of rational arguments, but instead lamented: "the extreme intolerance on the part of the civil society activists as well as the disdainful arrogance on the part of the scientists were on full

display" (Ramesh, 2014). So, how were the Bt-brinjal consultations organised, which arguments did the participants make, and what sort of publics emerged from this process of public engagement? Let me continue the story of the consultations.

The Bt-brinjal Consultations

The public hearings on Bt-brinjal took place between January 13 and February 6, 2010 "as a platform for a wide variety of stakeholders" (CEE, 2010a, p. 2) in Kolkata, Bhubaneswar, Ahmedabad, Nagpur, Chandigarh, Hyderabad and Bangalore. Kolkata and Bhubaneswar were chosen because West Bengal and Odisha together account for 50 per cent of Indian brinjal production; Ahmedabad because of the success of Bt-cotton in Gujarat; Nagpur because the Central Institute for Cotton Research (CICR) is based there; Chandigarh as the capital of an agriculturally advanced state that had been at the centre of the Green Revolution; and Hyderabad and Bangalore as the most important centres for Indian agricultural biotechnology research and development. Requests by civil society to include more states such as Kerala, Tamil Nadu, Bihar and Madhya Pradesh were turned down by CEE because of limited resources and time to organise more public hearings (CEE, 2010a, p. 8).

Preceding the consultations, primary information material was issued in 11 languages (CEE, 2010b). It explained the situation of Indian brinjal farming, the technology of genetic modification, as well as arguments for and against Bt-brinjal, ranging from environmental and biodiversity issues, to questions of human health, and socio-economic considerations. Some actors were invited to contribute while in principle each meeting, announced in newspaper advertisements in the respective states ahead of the consultations, was open to all members of the public. All consultations were chaired by Jairam Ramesh himself and held in the local language, Hindi, and English. Each of the public hearings lasted three to four hours. The events were documented in writing, photography and film. Videotaped material was made available on the MoEF website. Outside the venues, various groups were free to demonstrate: "at each consultation, stakeholders shouting slogans and protesting were seen outside the auditoriums" (CEE, 2010a, p. 10). The consultations accordingly became a kaleidoscope of publicity for opinion and protest.

Quoting from Amartya Sen's *The Idea of Justice* (2009), organiser CEE stated the major objectives of the consultations were creating public awareness and understanding different local and regional perspectives on Bt-brinjal, thus to improve decision-making on the technology (CEE, 2010a, pp. 4-5). The consultations were thought to account for and categorise the cacophony of arguments that revolved around Bt-brinjal in the public debate. CEE presented its final report (CEE, 2010a) as an annexure to Ramesh's moratorium decision (Ramesh, 2010). The document summarises the seven consultation meetings with contributions of more than 6000 registered participants, 2000 demonstrators outside the venues, and collects samples from 9000 written submissions by state governments, scientists, and civil society.[158] In that sense, the report succeeds in listing, categorising, and ordering arguments.

[158] Written submissions were collected at the venues or were submitted to MoeF, or CEE directly. These included letters to the Minister, published studies and research papers, books, handouts, and opinion pieces (CEE, 2010a).

Before I analyse this document in more depth, let me explain what the Bt-brinjal consultations as such meant to the actors involved, and who came to the hearings.

Activists attended the consultations with high hopes to influence regulation by questioning the necessity of Bt-brinjal and by pointing to arguments about biosafety. They also emphasised alternatives in pest management, and drew attention to wider issues they saw implicated with the technology. Activist and researcher Ramanjaneyulu from the Centre for Sustainable Agriculture (CSA) in Hyderabad saw the public hearings as an opportunity to discuss not only technology and policy of Bt-brinjal, but also institutions and markets of contemporary and future Indian agriculture. Public engagement allowed reflecting on technological development in its social, economic, and cultural contexts (interview Ramanjaneyulu, 2012). Persistent civil society pressure enabled public engagement, which in turn opened up Bt-brinjal policy-making new associations of actors and issues previously not on the agenda. To activists, the consultations in themselves formed a unique opportunity "to celebrate the diversity of opinions" (interview Saldanha, 2012). Public participation thus carried the meaning of democratic participation in the Indian polity because the consultations stimulated pluralistic engagement: "You should have seen the kinds of people who walked into these auditoriums […] people from all sorts of backgrounds and for the first time these people were given the opportunity to be heard" (interview Kuruganti, 2013). Activist Sarangi from Living Farms Bhubaneswar explained: "Farmers, scientists, researchers, corporations, academics, everybody conveyed what they felt about it. And none of us knew which way the decision would go. So at least that was a space to let your opinion be heard" (interview Sarangi, 2012).

So, to gain a voice as members of the public was an important idea about the consultations; it was a chance for those marginalised from conventional policy-making, such as tribal farmers (interview Babu, 2013) or youth (interview Isaac, 2013) to get heard by the Minister. To the activists, the consultations provided a chance to increase the diversity of arguments and open up perspectives in the policy process. Ramanjaneyulu from CSA described the democratic openness to a diversity of arguments vital for sustaining a range of technology options in a democratic polity because "diversity is key in technology and the political system" (interview, 2012). Similarly, Leo Saldanha, from Environment Support Group (ESG) opined that the Minister had to hold the consultations in the face of enduring public controversy and the persistent work of civil society to challenge the approval of Bt-brinjal in order for his decision to be democratically legitimate: "It is irrational thinking for minsters who think they do not have to care about public opinion once they are elected – if they think an election is enough to represent the public" (interview Saldanha, 2012). This shows that civil society actors appreciated Ramesh's attempt to go beyond his electoral mandate in order to gain legitimacy for the decision on Bt-brinjal. The consultations opened up the debate beyond science-based considerations of risk to include societal concerns through public participation in the institutional structures and practices of GM crop biosafety regulation. As public media reported, even spiritual figures got involved in the debate and voiced their appreciation for Ramesh's decision for public consultations: prominent Indian gurus such as Sri Sri Ravi Shankar and Baba Ramdev not only welcomed public engagement, but also explicitly agitated against Bt-brinjal (Chouhan, 2010; IndiaToday, 2010).

Yet, many in favour of Bt-brinjal and GM crops did not attend the consultations because to them, such engagement meant providing a stage for activists' populist propaganda and

not a genuine expression of public interest (interview Padmanaban, 2012). Others conceived of the consultations to have breached established regulatory norms and procedures which allowed "misinformation" and "fear" to "demonize" public opinion on GM crop technology; instead of consulting the public, the issue should have been left to experts (P. K. Gupta, Choudhary, & Gheysen, 2015). Such arguments for technocratic decision-making and against public engagement construct the consultations as opening a Pandora's Box of non-science by those unqualified to engage in expert discourses on the complex technical matter of Bt-brinjal. From this perspective, the public got constructed as a threat to the techno-scientific project of Bt-brinjal because of its alleged lack of knowledge and expertise on the issue. GMO advocate Rao (interview, 2013) and scientist Padmanaban (interview, 2012) described the public to suffer from knowledge deficits, specifically in agricultural and toxicological science. Also a former member of the GEAC stated that "the public, the NGOs, the environmentalists do not know anything about science, they do not speak in the scientific temper but in emotional resentment", insisting that "we require trust in science, in the technology, and in the analysis for its need" at the same time (interview former GEAC member, 2013).[159] Such meanings are rooted in what STS scholarship has termed the classical deficit model of public (mis-) understanding of science theories which present publics as ill-informed and irrational. The deficit model characterises the public as having inadequate knowledge about the complexity of techno-science (Irwin & Wynne, 1996; Wynne, 1995), or suffering from a deficit of trust in experts (Breeman, 2006; Chilvers, 2008; Wynne, 2006), or both (Bucchi & Neresini, 2008).[160] Those opposing public engagement per-se saw the Minister's decision to invite unnecessary public drama and publicity for emotional and political, rather than technical and science-based arguments. To them, the public, and by that implication civil society groups, are not qualified to participate in the discussion of technical and scientific problems because of their lack of expertise. From the perspective of the deficit model, experts of techno-science have ultimate legitimacy to give policy-makers advice based on their epistemic authority vis-à-vis an unknowing, ignorant, and emotional public. Accordingly, members of the public simply should not be invited to deliberate on a level playing field. However, the Bt-brinjal consultations enabled exactly that.

The consultations unfolded as a drama in which invited and uninvited engagement went hand in hand, appearing as a colourful carnival of protest and ideology (Visvanathan, 2014). Public demonstrations took place outside each of the venues as illustrated in text and photographs of CEE's document that summarises the consultations (2010a, pp. 6, 7, 10, 14-17) and news coverage of the events (e.g. TheHindu, 2010), owing to the need for civil society groups to reach wider audiences with the issues they raised. While participants of the consultations needed to register on site in six interest group categories of either (1) farmers, (2) industry representatives, (3) NGOs/activists/farmers' organisations, (4) scientists/experts, (5) researchers/students, or (6) government members, outside the consultation venues civil society beat the drum of protest against Bt-brinjal (CEE, 2010a, pp. 10-11). So, the scientific

[159] The former GEAC member preferred to provide information anonymously because of "the highly politicised debate about GM crops and Bt-brinjal" (interview, 2013).

[160] All the authors referenced here criticise the deficit model of public understanding of science for its empirical, normative, and practical inadequacies.

citizen publics and quasi-publics of political society (Chatterjee, 2004; Varughese, 2012) both appeared in the arena of the Bt-brinjal consultations.

The display of protest banners and the chanting of slogans, people dressed as brinjal, rallies by activists and farmers, or the presentation of brinjal varieties on site ensured media coverage of the events. Media attentive to these representations of Bt-brinjal in turn was decisive for informing larger parts of India's population about the consultations (interview Saldanha, 2012). Several researchers have suggested to consider the materiality of such forms of political engagement as part of an "object oriented democracy" (Latour & Weibel, 2005) in which "ontologically heterogeneous publics" (Bennett, 2010) consist of humans and non-humans, such as the brinjal itself.[161] Indian scientist Padamanaban is not convinced that such publicly enacted diversity including non-human elements contributed to better decision-making. For Bt-brinjal, he would have preferred small expert-based consultations, and he lamented that he did not attend the consultations because activist agitation was intimidating: "There were just too many activists […] they would have chopped you down. There was a huge drama enacted, but for what?" (interview Padmanaban, 2012). Indeed, the consultations did not always proceed smoothly and peacefully and as planned by CEE. Political society rose its head in the form of uninvited participation.

Uninvited participation is spontaneous and autonomous, as opposed to structured and organised engagement. It allows actors to voice alternative framings and to question implicit, yet dominant normative commitments built into structured forms of public engagement such as consultations (Wynne, 2007). Uninvited participation may take unusual forms. The CEE document reports of clashes between protestors in Hyderabad, where conflicts between opposing parties resulted in broken auditorium equipment (CEE, 2010a, p. 13). An informant who attended the consultations in Bangalore explained in an interview that farmers physically fought others to prevent them from gaining access to the consultation venue, revealing the conflictual nature of invited and uninvited engagement. Grassroots farmer activist P Babu from the Institute for Cultural Research and Action (ICRA) alleged that such actions show how those who would usually not have access to policy-makers, desperately fought to be heard by the Minister, while denying that same opportunity to others (see figure 10, below). The violent clashes revealed the differentials of power and resistance in the controversy about Bt-brinjal, despite the democratising ambitions of structured engagement through public consultations (interview Babu, 2013). Blurring the lines between invited and uninvited participation accordingly provided an opportunity for farmers to balance out the industry's privileged access to decision-makers in institutional policy-making processes. Uninvited participation in the context of the Bt-brinjal consultations can consequently be understood as a strategy of political society's unruly "quasi-publics" of techno-science who engage in para-legal activities to gain a voice vis-à-vis economy and science (Varughese, 2012). Why would they resort to such tactics?

[161] In a recent article on the campaign actions by survivors of the Bhopal gas accident in 1984, Mukherjee suggests that in the issue-based controversy about long-term toxicity of the chemicals from the industrial disaster, non-humans in the form of toxic chemicals became part in the survivor's construction of a political collective, a "chemical public" (Mukherjee, 2016). In the Bt-brinjal consultations, brinjal itself became equally part of the associations of political actors on the arena of GM crops policy-making to form a quasi-public.

Figure 10: Minister Ramesh discussing with protestors at a consultation venue (CEE, 2010a, p.13)

Head of NGO Gene Campaign Suman Sahai explained that the industrial producers of agricultural technology have direct connections to the policy-making circles of the state, whereas the interests of small-scale and subsistence farmers usually get side-lined in Indian policy-making on agricultural technologies: "It is agri-business, contract-farming, the industry, but it is not the farming community that is being heard [by policy-makers]. It is industry that has priority and when agriculture links to industry that will have priority" (interview Sahai, 2012). This made participation the Bt-brinjal consultations particularly important for farmers. BKU representative Yudhvir Singh agreed that the consultations meant access and empowerment for the farming community in the policy process. In the face of strong ties between state and agri-business, the consultations created an opportunity to express farmers' concerns with questions of livelihood and survival connected to Bt-brinjal and GM crops, constituting a unique and essential opportunity for famers' groups (interview Singh, 2013). Some of the farmers defended even physically the access to policy-makers, thus creating a parallel set of entry requirements for participation in the consultations. These farmers' groups accordingly formed a quasi-public which negotiated conflict differently from what was envisioned by the organisers of the consultations. Their actions can be interpreted as opposing forms of dominance they saw imposed onto them through the implicit normativity of the way the consultations were organised, such as the categorisation of speakers into industry, farmers, NGOs, or science (interview anonymous participant Hyderabad consultations, 2013).

As figure 11 below shows, farmers and their representatives made for the largest group in all public hearings except the meeting in Kolkata. In Bangalore in contrast, one out of five participants registered as industry and business representative, owing to the city's status as an Indian biotech hub. In general, industry voices were not as prominent during the consultations, which might be due to strong agitation by famers' groups, the mobilisation and protest actions of other civil society groups, or the lack of willingness of industry representatives to engage in public debate, as described above. In terms of the relationship between science, the

state and publics, public intellectual Shiv Visvanathan contended in his reflections on the consultations that Ramesh's engagement of the public created a space in which the Indian debate about Bt-brinjal was reconstituted as "a drama of a new reciprocity": citizens critically reflected on science, while the state, experts, and industry in turn were faced with the argumentative power and direct action of the subjects of policy-making (Visvanathan, 2010). It is consequently not only important who attended the consultations, but also what arguments were brought forward, how they were accounted for, and around which issues various publics got constructed in the consultations. So far, I have shown the meanings the actors attached to public engagement. Let me continue with what publics got constructed around which issues in the Bt-brinjal consultations. For this, I analyse the extensive report on the consultations by CEE, interview data, and reactions to the consultations in various documents.

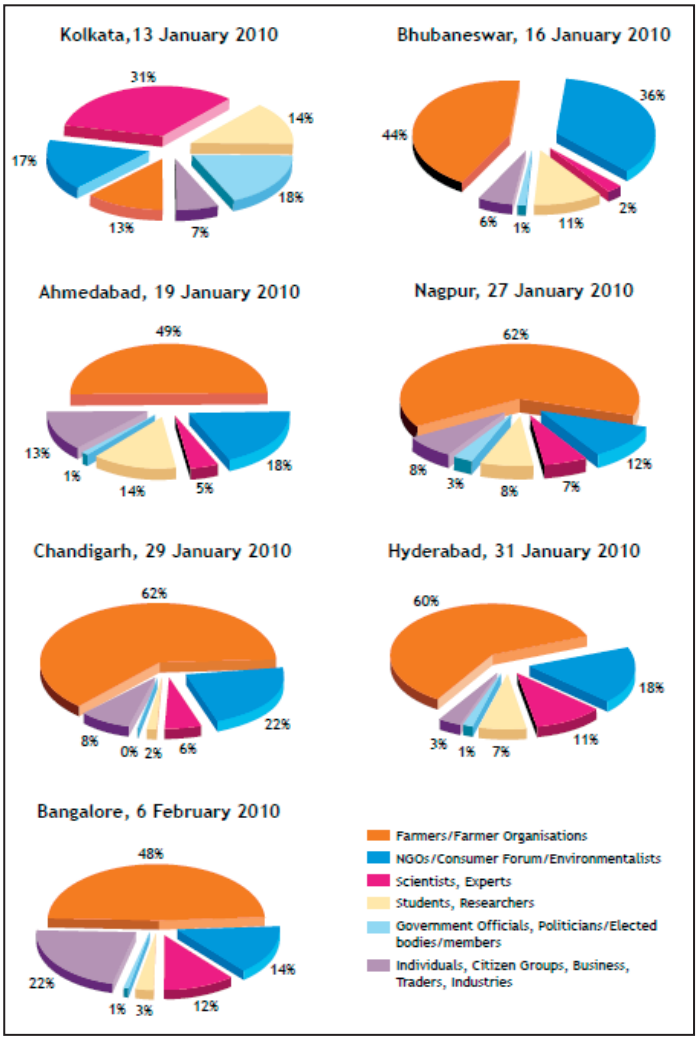

Figure 11: Attendance at the consultations per venue and by category (CEE, 2010a, p. 12)

The CEE Report

CEE's final report (2010a) on the Bt-brinjal consultations, in total 532 pages long, was published as an annexure to Jairam Ramesh's final decision on Bt-brinjal (Ramesh, 2010) on February 9, 2010. Despite its division into four sections, the CEE report is difficult to access due to its sheer bulk of material. Biotechnology advocate CK Rao from FBAE described it at the time as impossible "even to scan through this massive material, let alone analyse it" (Rao, 2010). Only the 101 pages of annex I are numbered and it is difficult or impossible to identify those who spoke. There are also inconsistencies with the order and completeness of materials, particularly in annexure IIIa/b, likely due to the short timeframe in which the report was produced.

In annex I, the document provides a summary of the public consultations and the arguments participants brought forward in the form of 544 'propositions'. These are ordered in categories: biodiversity and environment (60), pest management (61), economy and livelihoods (106), consumer concerns (38), human health and biosafety (189), approval process for Bt-brinjal (91), and regulatory process for GMOs (87).[162] The sheer number of issues listed in annexure I point to the interpretative flexibility of Bt-brinjal. Despite Jairam Ramesh's announcement to include issues pertaining to Bt-brinjal alone (2010, p. 7), many arguments go beyond classical risk considerations about human health and the environment and included comments on other Gm crops, foremost Bt-cotton. The participants also voiced larger issues about consumer rights, ecology, livelihood, markets, and the regulatory process for GM crops. The CEE report not only lists the participants' arguments in the consultations, but it also contains written submissions by India's Federal State Ministers, scientists, and civil society.

On 10 November 2009, Ramesh had asked the Chief Ministers of the Indian Union States to express their views on the commercialisation of Bt-brinjal.[163] Annexure II of the CEE report lists their letters to the MoEF: Kerala, Karnataka, Gujarat, Maharashtra, Bihar, West Bengal, and Andhra Pradesh submitted their views, as well as Odisha's Minister of Agriculture, and the leader of the *Lok Sabha's* Committee on Agriculture (CoA). All these submissions explicitly opposed the introduction of Bt-brinjal, some of which based their judgement on consultation processes in their own states (Andhra Pradesh, Bihar, and Kerala), out of which Kerala's ban of all GM crops after such public engagement in 2008 is most outstanding. Only the Chief Minister of West Bengal gave no explicit recommendation whether to commercialise Bt-brinjal or not, but his comments were in line with the arguments raised by

[162] Despite listing, ordering, and categorizing the issues raised during the consultations, the CEE report dissociates the actors from the arguments they made. Most propositions cannot be traced back to the speaker who made them. Accordingly, neither the CEE report's categorizations, nor the obvious division of arguments for and against the GEAC decision for the commercialisation of Bt-brinjal reflect the publics that got constructed during the consultations directly. Instead, I follow the issues actors raised and the interpretative flexibility of Bt-brinjal therein to identify which publics emerged and how these had an influence on the moratorium decision. This section reconstructs the CEE report to understand how arguments were accounted for and how various publics got constructed in the consultations.

[163] India is a federal republic comprising of 29 states and seven union territories. A Chief Minister is the elected head of government of a state or union territory who has the *de facto* executive authority.

the other Ministers of State.[164] After identifying the issues raised in the Bt-brinjal consultations, I will zoom into the State Ministers' submissions further below. Let us first look in more detail at the CEE report again: Many of the propositions in annexures I and II made claims that could not be verified by existing scientific knowledge. CEE noted that this opened up an agenda for more research because scientific data, for example about long-term and intergenerational biosafety studies, or experiments on gene-flow through outcrossing and its potential environmental effects, did not exist in sufficient detail to make definite conclusions about the risks of Bt-brinjal (CEE, 2010a) (note the sociotechnical imaginary of complex ecology reverberating with these issues). With science being so central to the arguments raised during the consultations, the 39 written submissions by Indian and international scientists, listed in annexes IIIa and IIIb respectively, gain particular importance.

These two sections of annex III constitute the main bulk of the CEE report with more than 300 pages in total. Scientists from various disciplines submitted their views: endocrinology, entomology, environmental sciences, epidemiology, medical science, immunology, molecular and neuro-biology, plant pathology, and toxicology. The scientists submitted extensive reviews and argumentations, including lists of references, research papers, reports, and opinion pieces previously published (e.g. Gowrishankar, 2009; Grover & Pental, 2003; Gurian-Sherman, 2009b; Padmanaban, 2009); and they took effort in constructing their epistemic authority by referring to their expertise, experience, institutional affiliations, board positions, publications, and research in the fields relevant to GM crop risk assessment. It seems that as if the sheer quantity and sort of material submitted by these scientists invested them with credibility about their arguments – a material manifestation of their epistemic authority in the public consultations. Out of 23 submissions by Indian scientists, eleven argued in favour, nine against, and three did not make a direct recommendation either for or against commercialising Bt-brinjal; and out of 16 contributions by international scientists, seven argued in favour and eight against commercialising Bt-brinjal, while one letter remained inconclusive.

However, as the previous chapters have shown, the category of science is highly contested in the field of GM crop risk assessment, with institutional and financial commitments and dependencies complicating the idea of trustworthy and reliable science; and with mutually reinforcing authentication loops vesting claims with empirical data and scientific authority. CEE's labelling of scientists who submitted their opinions to the MoEF therefore cannot be taken at face value, but their affiliations and backgrounds need closer inspection: Most of the scientist hold PhDs and professorships, and work in research institutions and universities. Amongst them were on the one hand high-ranking and widely recognised figures of Indian science, such as PM Bhargava, P Padmanaban, and MS Swaminathan, all of them

[164] I listed the states in the order in which the CEE report, annexure II presents them. The letters were sent by Chief Minister V.S. Achuthanadan (Bihar), Chief Minister B.S. Yeddyurappa (Karntaka), Chief Minister Narenda Modi (Gujarat), Chief minister Ashok Chavan (Maharashtra), Chief Minister Nitish Kumar (Bihar), Chief Minister Buddhadeb Bhattacharjee (West Benga), Minister of Agriculture, Co-operation, Fisheries & Animal Resources Development Damodar Rout (Odisha), Chief Minister K. Rosaiah (Andhra Pradesh) and member of Parliament (*Lok Sabha*) Basudep Acharia, leader of Committee on Agriculture (CoA). The letters from the Chief Ministers of Gujarat and Maharashtra only contain a confirmation of Jairam Ramesh's request to explain their views, with further information from these states pending. However, it seems both state ministers did not hand in their comments before they could be included in CEE's final report.

being known for having outspoken opinions on Bt-brinjal and GM crops. Also, experts from India's Central Institute of Cotton Research (CICR), biologists and entomologists from Cornell University and other international universities, a member of the Union of Concerned Scientist, and self-proclaimed 'independent scientists' submitted their opinions.[165] On the other hand, some of those listed as 'scientists' worked for NGOs, advocacy groups, or in the corporate sector. Several contributions were authored by scientists who turned activists, such as Suman Sahai from Gene Campaign, or Mira Shiva (sister of Vandana Shiva) who submitted a co-authored letter by Doctors for Food and Biosafety, an association of medical professionals which argues for moratoria on GM crops due to health concerns (GMO-freeEurope, 2009; GMwatch, 2008). Gilles-Eric Séralini, the highly contested scientist who was at the centre of the controversy I analysed in chapter two, followed Ramesh's call to review the ECII report and the GEAC decision, too. Yet, other submissions were written by scientists who work for the GM industry or its advocacy organisations, such as CK Rao from the Foundation for Biotechnology Awareness and Education (FBAE); the vice president of Indian seed company Ankur Seeds; the chairman of the Association of Biotech Led Enterprises (ABLE); the global science policy leader of Dow Agro-Sciences; or Professor Richard Goodman from the University of Nebraska who had worked for the tobacco industry and for Monsanto before (cf. Godman's role in questioning Séralini's scientific integrity in chapter two). As the background of these scientists suggests, their verdicts on Bt-brinjal, the ECII report and GEAC's decision were in disagreement. For instance, those arguing against commercialisation questioned the reliability and soundness of the existing biosafety studies on Bt-brinjal, while those in favour were convinced the safety of the product for human health and the environment had been proven sufficiently. Further below, I will show that continuing scientific debate and uncertainty indeed were decisive arguments that convinced Jairam Ramesh to impose the moratorium. Still, there was more than the scientific risk framing.

In annexure IV, the CEE report lists a sample of 17 additional written submissions by "civil society groups, research institutes, and concerned individuals", mostly from India. Most of these opposed the GEAC verdict. Amongst the contributors are Aruna Rodrigues, who was amongst those filing the PIL against GEAC in 2005; Kavitha Kuruganti from the Alliance for Sustainable and Holistic Agriculture (ASHA); and anti-GMO activist Vandana Shiva. Also a pro-GM famer's association[166] submitted its opinion, and a letter submitted by "concerned citizens" was signed by film director Mahesh Bhatt (director of the documentary 'Poison on the Platter', see Bhatt & Kanchan, 2009, and further below) and Vandana Shiva, amongst others. An Indian Member of Parliament and a United Kingdom Member of Parliament and former Minister for Environment Michael Mearcher submitted their opinions in

[165] Mind that Bt-brinjal was developed in a public-private partnership under the Agriculture Biotechnology Support Project (ABSP) of Cornell University which was funded by the United States Agency for International Development (USAID). The scientists from Cornell University who submitted their opinion to Ramesh were directly involved in the development of Bt-brinjal in the public-private partnership with Mayhco and Indian public research institutions. Therefore, their positions cannot be considered disinterred in the outcome of the GEAC evaluation of the ECII report and must be scrutinised with this context in mind.
[166] The Consortium of Indian Farmers Associations (CIFA) is known to have received funding from GM producing transnational corporations. Chengal Reddy, the secretary general of the CIFA appears to represent the interests of large agricultural technology producers, such as Monsanto (Powerbase, 2009c; Reddy, 2012).

writing, too. In annexure IV, we also find scientists from Jarwahalal Nehru University and the Agribusiness Management University in Hyderabad.[167]

As this section's short overview suggest, although the CEE report provides a structure to the arguments and documents of the Bt-brinjal consultations, the way it categorises issues and actors does not answer the question which publics got constructed in the debate. Let me approach this question by looking at the shared meanings relevant social groups attached to the contentious issues of Bt-brinjal next.

Constructing Publics: consumers, farmers, citizens

In the Bt-Brinjal consultations, two sorts of consumer publics were constructed. Two intertwined issues were central in this regard: the question of Bt-brinjal's risk to human health and the question of choice. According to journalist Devinder Sharma, who was involved the campaign against Bt-brinjal from early stages of societal opposition to the technology, the high number of arguments about human health was due to civil society's unprecedented campaigning strategy that aimed to mobilise India's urban middle class. Instead of primarily addressing the farming community, "it was a consumer campaign" (interview Sharma, 2013) that involved the support of public figures from the Indian film industry. Together with Bollywood director Mahesh Bhatt, Sharma initiated the production of the film *Poison on the Platter*, a 30 minute documentary that features concerns about the potential health risks of Bt-brinjal voiced by members of the urban middle class (Bhatt & Kanchan, 2009). Sharma contended that addressing consumers' anxieties about food safety with the help of people from the entertainment industry was a unique and successful strategy, which created sensitivity towards the question of biosafety assessment of Bt-brinjal: "I wanted you to be hit by fear. I wanted shock and awe. He [Mahesh Bhatt] did it, he did it well, that effect delivered" (interview Sharma, 2013). Drawing on the risk perceptions of a consumer public accordingly prompted the question of consumer choice.

CEE's report contains a separate section with 38 propositions on consumer concerns (2010a, pp. 35-37) amongst which the violation of the consumers' right to an informed choice features most prominently (16 propositions). The absence of a labelling system for Indian agricultural products would deprive consumers of "the fundamental right to choose" (ibid, p.36) whether to eat genetically modified brinjal or not, irrespective of its risk assessment.[168] The issue of potential health risks accordingly merged with the question whether consumers could ultimately decide for themselves whether to eat Bt-brinjal or not (interviews Bhargava, 2012 & Kuruganti, 2013). Civil society actors repeatedly emphasised that the absence of a labelling system for Indian agricultural products would make "the choice of eating which food completely choiceless" (interview Kannaiyan, 2013). From the analyst's point of view, the emphasis on *choice* constructs the public as rational but passive market agents concerned with consumption decisions. Yet, the intertwined issue of labelling constructs the

[167] It remains unclear why these scientists' contributions were not listed in appendix III.

[168] For instance, proposition 262 suggests that the right to an educated choice is vested in India's Consumer Protection Act of 1986, therefore requiring labelling of GM foods.

consumer public also as assertive political agents who claim their *right* to know. Both ideas however hinge on a liberal conception of the public as market participants, rather than as republican idea of citizens involving themselves in politics.

Still, the central issue pertaining to consumers was the question about Bt-brinjal's potential impact on human health. Since the ECII report and the GEAC verdict primarily hinged on evaluating the scientific risk assessment provided by Mahyco, it is not surprising that the health risk assessment was discussed by almost all actors in the consultations. The CEE report lists 189 propositions related to this issue, which are mostly concerned with the reliability and adequacy of the health impact studies on Bt-brinjal. Since risk assessment involves complex science, the contributions by scientists primarily dealt with evaluating the biosafety data reviewed in the ECII report. Not only Indian scientists reacted to Ramesh's request for review of the data, but scientists from Australia, Europe, the Philippines, and the United States also submitted their comments.

Those arguing in favour of commercialising Bt-brinjal all insisted the biosafety studies produced by Mahyco and checked by GEAC and ECII were scientifically sound. For instance, medical biotechnologist Padmanaban attached an article to his written submission in which he listed the extensive efforts to guarantee the biosafety of Bt-brinjal which had involved more than 150 scientists who had conducted a dozen risk assessment studies over a duration of seven years. Padmanaban secured Ramesh of the sound work of science for the public interest: "after all, least of all scientists would want to compromise on food safety" (Padmanaban, 2009). Two entomologists from the US, Richard Hellmich, working for the US Department of Agriculture, and Professor Shelton from Cornell University agreed that animal feeding and allergenicity studies had shown Bt-brinjal's safety, and prompted the MoEF to subsequently "base its decision on science and the public good for India" (CEE, 2010a, annex IIIb).

Those arguing that human health was not an issue drew on a variety of data to prove their point. For instance, Richard Goodman from the University of Nebraska, Lincoln (cf. Goodman's fast-track appointment as Associate Director for Biotechnology at the journal *Food and Chemical Toxicology* and his history of working for Monsanto Corporation, that I describe in chapter two) reviewed the ECII report with the help of data produced by the industry-sponsored organisation International Service for the Acquisition of Agri-biotech Applications (ISAAA) to confirm the toxicological safety of Bt-brinjal. Those scientists argued the work of EC II and the GEAC decision in terms of human health risks were of high scientific quality; they accordingly presented risk assessment as sufficient to approve the safety Bt-brinjal for human health. These arguments therefore constructed not the public, but science to provide the legitimate judgement about Bt-brinjal's potential risks. While the opponent's arguments for more rigorous testing were certainly "intended to help protect consumer concerns" (CEE, 2010a, appex IIIb), they also warned that more safety tests would significantly decelerate innovation in seed technology, and therefore impact India's competitiveness on global agricultural markets, which would ultimately bear negative consequences

for Indian consumers, too (cf. the sociotechnical imaginary of productivity I describe in chapter three).[169]

The chairman of industry advocacy organisation ABLE, VR Kaundinya insisted Bt-brinjal's safety had been proven. He emphasised the benefits for consumers in terms of cheaper commodity prices for Bt-brinjal. Bt-cotton, India's only other GM crop, served as the prime example for the success and safety of GM crops. Scientist Padmanaban argued, along with agri-biotech consultant Manjunath and Deepak Pental, then vice chancellor of the University of Delhi, that India's experience with Bt-cotton, a crop with the same insect-resistance trait producing a similar Bt-protein, was proof of a history of safe use of Bt-technology. Their argument was that the experience with Bt-cotton showed that Bt-brinjal was as safe as its non-GM counterpart. In the same vein, CK Rao from biotechnology advocacy organisation FBAE invoked the principle of substantial equivalence, stating that safety tests had shown Bt-brinjal to be as safe as non-GM brinjal.[170]

The consumer public that accordingly got constructed was one that was to trust science. This trust would rest in the scientific community's adherence to international standards for quality scientific risk assessment. Trusting the rigour of such standards, MK Bhan from the Department of Biotechnology (MoST, GoI) hailed the professionalism of the GEAC, calling for the need to "show faith in our scientists who participated in this assessment" (CEE, 2010a, annex IIIa). Also, Dr. Hautea from the University of the Philippines argued that adherence to scientific standards was more than sticking to the rules: MoEF had "fulfilled all legal and moral requirements of risk assessment": Indian's safety tests on Bt-brinjal were also used for regulatory decisions on large-scale field trials and commercialisation of the technology in the Philippines and Bangladesh (see also proposition 459, CEE 2010, p.51). By pointing to Bt-brinjal's, "potential to help improve the lives particularly of […] consumers not only in India but in other parts of the world", Hautea argued that trust in scientific risk assessment carried the responsibility of bringing Bt-brinjal's benefits to consumers globally.

In contrast to the assurances of Bt-brinjal's safety for human health, prominent Indian scientists pointed to deficiencies in Mahyco's risk assessment: Suman Sahai, Director of the NGO Gene Campaign criticised the risk assessment studies for too many uncertainties and omissions regarding molecular changes and metabolic consequences in Bt-brinjal, the use of a substitute protein in the toxicity studies, and statistical uncertainties. Sahai alleged that the proponents of Bt-brinjal were falsely invoking the principle of substantial equivalence when they referred to a history of safe use of Bt-cotton. Instead, a case-by-case investigation of each GM crop was necessary to rule out unintended side effects of the genetic insertions. Eminent Indian molecular biologist PM Bhargava raised many similar points in his detailed review of the EC II report.[171] Bhargava alleged that such studies need to be "scientifically

[169] Striking resemblances exist between the arguments made for the toxicological safety of Bt-brinjal and its necessity for economic competitiveness and food security, and the arenas I have studied in the previous two chapters.

[170] A recent study by Séralini and colleagues (Mesnage et al., 2016) suggests that in toxicity tests with laboratory animals, control feed is not substantially equivalent. Therefore, the existing toxicological risk assessments produced by industry are unreliable.

[171] In his detailed letter, Bhargava refers to specific page numbers and sections of the ECII report, e.g. on authenticity of samples to check the alkaloid content of Bt-brinjal, or on the lack of experimental data to

sound and valid" whereas Mahyco's safety tests showed too many statistical uncertainties to be considered reliable. Others like molecular biologist Jack Heinemann (University of Canterbury, New Zealand), known to be quoted by civil society groups in opposition to GM crops, stated in his submission to Ramesh that the safety studies on Bt-brinjal did not satisfy international risk assessment standards such as the *Codex Alimentarius* guidelines; specifically molecular data and its analysis "were too poorly conducted to make a definitive claim that the product is safe" (CEE, 2010a, annex IIIb).[172]

Concerns about the adequacy of health risk assessment were not a new topic that came up with the ECII report. PM Bhargava complained in his submission that ECII had not reacted to concerns about biosafety he had raised earlier when reviewing the ECI report. Bhargava alluded that GEAC had not properly reviewed the risk assessment data of Bt-brinjal, but that the Genetic Engineering Appraisal Committee (GEAC) had shown a tendency to uncritically wave through biosafety studies that had been labelled sufficient by Review Committee on Genetic Engineering (RCGM) in the past. The latter, "operating under Department of Biotechnology has not functioned as a regulator, but as a vendor; rubber stamping". Bhargava alleged that "the Department of Biotechnology today […] it is a vendor of the [GM crop] technology" (interview Bhargava, 2012). The consumer public that got constructed in these arguments would not trust GEAC's and ECII's risk assessment evaluation, despite of claims about the alleged adherence to international risk assessment standards. Even more so, scientists opposing the ECII verdict not only commented on uncertainties about acute toxicity, and difficulties with the reliability of the existing risk assessment studies, but they also argued international standards for long-term health impacts comparable to acute toxicity testing did not exist and therefore Bt-brinjal's potential long-term effects on human health could not be safely assessed.

A letter by Doctors for Food and Biosafety equally warned that the literature on health risks of GM crops did not cover questions on consequences of long-term human consumption, an issue that deserved attention since brinjal is widely consumed in India.[173] Bt-brinjal being part of a life-long diet could therefore bear unanticipated long-term consequences of ingesting the Bt-toxin. Renowned geneticist MS Swaminathan equally pointed to the need to know about chronic health effects. He made specific suggestions which Indian scientific bodies could investigate these issues with particular regard to scrutinising questions of chronic toxicity of Bt-brinjal that none of the risk assessment studies had answered so far. Swaminathan stated such additional biosafety research to be "in the national interest" and compared the importance of health impact studies on Bt-brinjal's potential long-term effects

study the effect of Bt-toxins on the synthesis of other proteins in the plant. Bhargava asked in his letter "why is there such a reluctance to do such studies?" More interestingly, the CEE report does not include Bhargava's full letter, but only parts of it. In a personal interview, Bhargava alleged that there was a similar strategy at work to exclude him from participating in a review by the National Academy of Medical Sciences: "I was carefully selected out" (interview Bhargava, 2012).

172 Heinemann later also communicated his review of the Indian Bt-brinjal risk assessment to the government of the Philippines, prompting its regulatory authority not to rely on the Indian health risk assessment (Heinemann, 2010).

173 As early as 2008, Doctors for Food and Biosafety had called for a moratorium on Bt-brinjal due to inadequacies in its biosafety assessment (cf. GMwatch, 2008).

to "the studies carried out on the impact of tobacco smoking on the incidence of lung cancer in human beings" (CEE, 2010a, annex IIIa). International scientist equally drew the Bt-brinjal health risk assessment into question.

Professor Séralini, the French scientists known for notoriously questioning GM crop toxicological studies (see chapter two), and a letter by "independent scientists" stated that the findings on the absence of health risks were too uncertain to allow commercialising Bt-brinjal.[174] Séralini provided an extensive review of the ECII report. Similar to what I show in chapter two, he identified signs of chronic health effects of Bt-brinjal. Judy Carman, epidemiologist and director of the Australian non-profit Institute of Health and Environmental Research, similarly pointed to errors in risk assessment methodology, data reporting, and analysis, which ECII had not addressed.[175] Séralini and Carman explained in their letters to Ramesh that statistical difficulties, deficiencies in the experimental set up (particularly the use of a surrogate toxin and length of feeding trials), the lack of data, and a potential bias in how the applicant had interpreted test results, made Mahyco's tests unreliable. Signs of endocrine disruption, carcinogenesis, and immune replies in the feeding trials had not been followed up by GEAC and ECII. These omissions emphasised the need to scrutinise chronic toxicity in prolonged feeding trials. Referring to the historical cases of tobacco, asbestos and pharmaceuticals, Carman argued along with PM Bhargava and Séralini that "contradictory independent expertise is highly necessary" (CEE, 2010a, annex IIIb).

The issue of health risks and the scientific evaluation thereof gave rise to the construction of two consumer publics, one trusting scientific risk assessment, and the other critical of it: On the one hand, a consumer public interested in the benefits of cheaper commodity prices and India's competitiveness on global agricultural markets was constructed as to trust the rigour and reliability of the existing health risk assessment. This trust was thought to extend to the professionalism of GEAC and ECII which had evaluated Mahyco's risk assessment by international scientific standards. On the other hand, a consumer public was constructed by questioning the very reliability of the existing biosafety studies and the non-adherence to international risk assessment standards. These studies were criticised based on their scientific uncertainty and deficiencies in data collection, reporting, and interpretation. Also, as several scientists had pointed out, risk assessment had not sufficiently answered consumers' concerns about Bt-brinjal's potential long-term impact on human health. Associated with these uncertainties, such a critical consumer public was constructed to insist on the right to choose between GM and non-GM brinjal, an impossibility regarding the absence of a labelling system for agricultural produce in India.

A remarkable paradox in the construction of consumer publics is the role of science though. Beyond civil society's strategy of addressing consumers with the help of popular

[174] Amongst the signatories to this letter are some of the scientists who also send letter to Ramesh individually, such as Jack Heinemann, Gilles-Eric Séralini, and David Schubert, all argued against commercialising Bt-brinjal. Others, who later became involved in the debate about Séralini's long-term toxicological risk assessment study (cf. chapter two), also signed the letter. Amongst them are Angelika Hilbeck from the European Network of Scientists for Social and Environmental Responsibility (ENSSER), and Michel Antoniou, who publishes scientific reports on GM crop biosafety together with anti-GM activists (e.g. Antoniou et al., 2014; Meyer & Hilbeck, 2013).

[175] Carman later published an article in which she extensively reviewed the toxicological risk assessment on Bt-brinjal. Note that it was published and advertised on a prominent anti-GM website (Carman, 2010).

media, such as exemplified by journalist Devinder Sharma, and the arguments about consumer issues raised during the consultations, scientists presented themselves as central in the construction of both consumer publics. These were depicted as either trusting the existing risk assessment, or as insisting on the need for more rigorous, peer-reviewed, or long-term scientific studies. This renders the idea of the consumer a passive political subject, primarily concerned with healthy food consumption, an issue of concern to India's rising middle class (interview Khadse, 2013). The legitimate knowledge about health concerns however was ultimately to be decided by risk assessment science, if done right. Science accordingly reclaimed the space a critical consumer public had drawn into question in order to retain its epistemic authority – either by insisting on the reliability of risk assessment or by pointing to its deficiencies and possibilities for its improvement. At the same time, the construction of the consumer public followed the deficit model: A former GEAC member explained the concern with health impacts had been due to emotional resentment, fear of technology, and ultimately a misunderstanding of the scientific enterprise: "if you do not understand it, you will resent it" (interview former GEAC member, 2013). Scientist Padmanaban was also convinced that "anything negative captures the public more easily than positive things" (interview Padmanaban, 2012) and even activist Sahai argued that the inner workings of risk assessment science were almost inaccessible to the public, so only independent expertise could answer the questions of a critical consumer public (interview Sahai, 2012). As a consequence, what went hand in hand with the construction of consumer publics around the issues of health risk assessment is the construction of the scientific community as the ultimate guardian of reliable knowledge about the potential health impacts of Bt-brinjal. Science, as we will see below, played a central role in the construction of other publics in the Bt-brinjal debate, too. The issues and the divergent meanings that gave rise to consumer publics are however remarkably different from the farmer publics that were constructed in the consultations, to which I will turn next.

In the Bt-brinjal consultations, farmer publics were constructed through three interrelated issues: the environmental safety of Bt-brinjal, its potential impact on the socio-economic conditions of farmers, as well as the question of seed sovereignty. The CEE report lists 60 propositions in relation to 'biodiversity and environment'. Most of these point to the potential outcrossing of the Bt-genes into wild and cultivated brinjal relatives, its consequent impact on the natural variability of India's indigenous brinjal germplasm, and on biodiversity more generally. Other arguments about environmental safety revolved around the possibility of transgene mutation, the development of insect resistance to the Bt-gene, as well as the lack of scientific studies on Bt-brinjal's impact on non-target organisms (NTOs) like honey bees and soil micro-organisms. Another argument was that the land holding structure of small-scale farming would make refuge placement and safety distance to prevent contamination between GM and non-GM brinjal fields impossible.[176] These arguments resemble those made from within the sociotechnical imaginary of complex ecology that I have described in chapter three. For instance, proposition 49 explains the unpredictability and uncertainty associated with introducing GM crops into India's environment: "The complexity as well as inter-relatedness

[176] Refuge placement implies that a certain area of a field planted with Bt-crops needs to grow non-Bt-crops to control resistance development. Providing such a refuge area exists, insects that have developed resistance can mate with non-resistant insects to produce non-resistant offspring (UCSD, n.d.).

of species within ecosystems is such that the prediction of impacts from human interventions cannot be made with certainty, nor can the time frame within which the impact will escalate be predicted" (CEE, 2010a, p. 22).

While potential effects on human health were much more prominent issues (twice as many propositions) than environmental safety concerns during the public hearings, it was the States' Chief Ministers' submissions that emphasised Bt-brinjal's risks to the environment and its impact on farmers much more forcefully (CEE, 2010a, annex II). Their letters not only questioned the adequacy and reliability of Mahyco's environmental risk assessment (henceforth ERA), but they also pointed to the lack of scientific data concerning socio-economic implications. With agriculture being a policy subject of the Indian Union states, it is not surprising the potential impacts on farmers were issues mentioned in almost all letters by the Chief Ministers: the contributions from Andhra Pradesh, Kerala, and West Bengal listed the potential risks of gene-flow through outcrossing of the transgene to biodiversity and ecosystem stability, and its possible consequences for farming. Karnataka's Chief Minister expressed concerns about the lack of scientific certainty regarding Bt-brinjal's impact on NTOs, and Bihar's Chief Minister remarked the lack of data on Bt-brinjal's performance in different agro-climatic zones which would be necessary to estimate its benefits in the various contexts of Indian agriculture. Again, the meanings attached to environmental and socio-economic risks called upon scientific evaluation.

However, the scientists' contributions on matters of environmental safety were as much in disagreement as they were on issues of health risk assessment. The scientists arguing in favour of commercialising Bt-brinjal all insisted the ERA produced by Mahyco and checked by GEAC were scientifically sound, and that the technology was needed to increase production and reduce pesticide use – clear socio-economic benefits for farmers. These arguments mobilised the imaginaries of environmentalism and productivity (cf. chapter three). CK Rao from FBAE, Kreshav Kranti from CICR, KS Varaprasad from the National Bureau of Plant Genetic Resources in Hyderabad, and MK Bhan from the Ministry of Science and Technology all insisted outcrossing and therefore Bt-brinjal's impact on genetic diversity was unlikely. Instead, farmers would benefit because of lower input costs and higher yields. Yet, there were also more cautious notes on the biosafety of Bt-brinjal amongst the supporters of commercialisation. The Global Science Policy Leader of Dow Agro Sciences, Dr. Nicolas Storer advised to implement Insect Resistance Management (IRM) strategies to delay resistance in pests. Although he evaluated Mahyco's data to confirm the environmental safety of Bt-brinjal, he remarked that small farms would benefit less from non-Bt refuge placement than larger land holders. Accordingly, more Bt-brinjal varieties were needed to delay resistance. Storer regarded outcrossing improbable, yet he alluded that even if it occurred, "the consequences of this is likely to be insignificant" (CEE, 2010a, annex IIIb). The meaning attached to Bt-brinjal by its proponents was that it was a technological innovation which Indian farmers wanted and needed access to (Consortium of Indian Farmers Associations, CEE, 2010, annex IV) and that it was necessary to alleviate India's food crisis. With these benefits in mind, they considered the ERA sufficient.

However, other scientists disagreed. For instance, entomologist David Andow[177], S Parasuraman from Tata Institute of Social Sciences in Mumbai, cellular neurobiologist David Schubert, and toxicologist Séralini warned that Mahyco's ERA was incomplete and unreliable. Professor Gurian-Sherman, plant pathologist from Union of Concerned Scientists and Robin Shoen, director of the Board on Agricultural Resources at the National Research Council in Washington both criticised ECII (ExpertCommitteeII, 2009) for ignoring flaws in gene-flow assessment, the existence of studies indicating the possibility of horizontal gene transfer, and the lack of evidence on the absence of environmental effects through outcrossing (Gurian-Sherman, 2009a).[178] Indian molecular scientists PM Bhargava further remarked the absence of studies confirming the socio-economic necessity of Bt-brinjal, and activist Suman Sahai warned the co-existence of GM and non-GM brinjal was impossible because of the uncertainties in ERA. These issues entailed the meaning of Bt-brinjal putting ecosystem stability and therefore the very foundation of farming and agricultural livelihood at risk.[179]

The Chief Ministers' contributions were even more explicit on this. The Chief Ministers of Bihar, Odisha, Kerala, Karnataka, and West Bengal all argued environmental risks, specifically the potentially decreasing availability of indigenous germplasm in the case of outcrossing (reduction of biodiversity), and the development of insect resistance would entail adverse socio-economic effects on small and marginal farmers: decreasing food security, the sustained use of pesticide sprays, and rising input costs. Basudeb Acharia from the *Lo* Committee on Agriculture (CoA) also warned of potential crop failure. With no liability mechanism in place, farmers' interests were at risk. These arguments about socio-economic impacts were intertwined with the fact that Bt-brinjal was a technology produced by a transnational consortium. India's more than 1000 cultivated and wild varieties of brinjal and with it its volatile ecosystem on which farming practice depends, would be at danger of corporate endeavours for profit irrespective of its potential environmental risks.[180] These arguments entailed another problem: putting India's seed sovereignty at risk, which turned out to be a central issue in the construction of farmer publics.

Activist Suman Sahai explained the crucial question about Bt-brinjal to be about who controls the technology and which impact this will have on Indian farming: "India should evaluate whether this is really a technology that makes sense. If technologies are completely controlled by the private sector, what happens then to our seed sovereignty issue? […] So

[177] Andow later published an extensive report in which he reviewed the inadequacies of GEAC's environmental risk assessment in detail (Andow, 2010).

[178] Here, Gurian-Sherman (2009a), summarises recent studies on outcrossing from transgenes that suggested mating between wild and GM brinjal could produce fertile progeny, an issue that needed further scientific investigation in light of its possible consequences for biodiversity.

[179] Article 26.1 of the Cartagena Protocol on Biosafety explicitly mentions the inclusion of socio-economic considerations into food and feed, and environmental safety risk assessment to support decision-making. Some argue the legal text lacks specificity as to how, when, and under what decision-making rules the requirement for socio-economic evaluation applies. This is complicated by the existence of additional international guidance documents with regard to risk assessment of GMOs, such as the *Codex Alimentarius* (Falck-Zepeda, 2009).

[180] Specifications on the total number of Indian brinjal varieties varies significantly and range up to more than 3500 accessions of cultivated varieties (see e.g. Choudhary & Gaur, 2009; Ramesh, 2010).

the question is 'what does this technology offer'?" (interview Sahai, 2012). The Chief Ministers of Odisha, Karnataka, and West Bengal, and the *Lok Sabha's* Committee of Agriculture leader had an answer to this question: By emphasising India's experience with Bt-cotton, they warned of a seed monopoly to emerge which would lead to rising costs of transgenic seeds and the decreasing availability of non-proprietary alternatives. Also, if insects developed resistance to the Bt-toxin, farmers might not reduce pesticide sprays to protect their investment in the costly GM seeds, an experience NGOs had documented in the case of Bt-cotton (e.g. Shiva et al., 2011). Instead, Acharia argued along with the ministers of Kerala and Odisha that indigenous crop varieties and local farming practices might be better suited to India's agriculture than Bt-brinjal produced by a transnational corporation – and that farmers should be able to decide themselves which seeds to cultivate. However, making farmers dependent on restrictive trade practices and monopolising tendencies of transnational seed companies would gravely endanger the autonomy and self-reliance of Indian agriculture. Scientist PM Bhargava formulated this concern in relation to the unreliability of ERA provided by the producers of GM seeds: "Monsanto has strong vested interests and it has an extremely derogatory record in respect of honesty, integrity, and following the law" (CEE, 2010a, annex IIIa) and in an interview, he warned that safety tests done by the applicant could not be relied upon since "these also have been done by the company, a company that is known to give false information, which is known to lie and bribe. And we accept these results?" (interview Bhargava, 2012).

The question of seed sovereignty is an argument that cut across all actor groups that participated in the Bt-brinjal consultations. Farmers, civil society groups, and scientists like MS Swaminathan argued the intrinsic relation between environmental integrity and farmers livelihoods was put at risk by transnational corporations' attempts to capture Indian market shares and to establish seed monopolies with proprietary GM seeds. India's farmers would end up with no choice but to buy Bt-brinjal seeds.[181] Scientist MS Swaminathan suggested in an interview that one of the central problems with GM crop technology was that it is controlled by transnational corporations through intellectual property rights. He asked: "Can this technology help small farmers? Or only make the rich richer and the companies richer?" (interview Swaminathan, 2013); and activist Suman Sahai suggested "there are no hidden logics but economic facts" (interview Sahai, 2012). Yet, these arguments were most forcefully expressed by those working closely with farmers. S. Kannaiyan from the South Indian Coordination Committee of Famers' Movements (SICCFM) explained Bt-brinjal was essentially about the attempts of transnational corporations to control the productive resources in agriculture: "Control over seeds is going to the hands of the companies – it is a question about control over natural resources […] if the control over seed goes to the corporate, the cost of production will go up" (interview Kannayan, 2013). Sarangi from Living Farms, a grassroots NGO working with marginal farmers in Odisha, explained "a technology cannot exist in isolation of society. It also has a context. Who controls the technology? Who benefits

[181] By asking what kind of seeds commercial seed companies offered on the market, Suman Sahai explained the case Bt-cotton to be exemplary of market control that needs to be avoided with other GM crops: "India needs a policy for producing true breeding varieties, and not hybrids. How come all the 350 Bt-cotton varieties, which itself is a ridiculous number for any country to release, how come they are all hybrids?" (interview Sahai, 2012).

from the technology?" While seed technology was traditionally considered common property, Bt-brinjal would signify a move towards allowing food crops to be commodified and controlled by powerful transnational corporations: "I am not questioning technology per se, but I am questioning who is in control and for what purpose […] GM technology is part of a larger package, of a larger design to ensure that agriculture is being taken over and food is being taken over" (interview Sarangi, 2012). Ashlesha Khadse from the international peasant movement LaVia Campesina agreed that ownership questions are essential for small and marginal farmers since they are most vulnerable to seed price fluctuations (interview Khadse, 2013).

As way of example, farmer representatives frequently refer to the experience with Bt-cotton seeds for which the price rose sharply as compared to the non-GM seeds while at the same time, the latter disappeared from Indian seed stores.[182] Activist Kannayan suggested that while Bt- cotton "was forcibly imposed on farmers because there is no market for non-Bt anymore"; subsequently, Bt-brinjal was the next step in the attempt "to completely control the Indian seeds and seed companies" not only in cash crops, but in food crops, too (interview Kannayan, 2013).[183] During the consultations, it was Leo Saldanha from Environmental Support Group (ESG) who attempted to provide a legal perspective on the seed sovereignty issue. He argued that the development of Bt-brinjal was an act of bio-piracy, because Mahyco is partly owned by Monsanto.[184] Since no official permissions had been obtained to develop GM crops using indigenous brinjal varieties, the development of Bt-brinjal was illegal under India's Biological Diversity Act, an argument that was swiftly dismissed as an "wholly unjustified controversy" by Ramesh (2010, p. 2).[185]

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[182] S. Kannaiyan explained that since the liberalisation of the Indian market in the 1990s, a large number of indigenous seed producers have been bought up by transnational corporations. In the case of Mahyco, "very well an Indian company which has grown with the support of small and marginal farmers" he alludes, "they have sold themselves shamelessly to Monsanto and they have become its agent" (interview Kannayan, 2013).

[183] Bablu Ganguly, founder of Timbaktu collective, a grassroots organisation working to establish organic farming in Andhra Pradesh, expressed the concern of corporate control much more drastically: "Control over food means control over a state" (interview Ganguly, 2013). Leo Saldanha from ESG shares this perspective. He explained GM crops to be a tool of capitalist domination by US corporates: "The structures are all the same. Capitalism has just adopted the colonial structures. It is imperialism. What is Monsanto but a wing of the US?" (interview Saldanha, 2012).

[184] Bio-piracy refers to illegal appropriation of biological diversity and the traditional knowledge of local communities from developing countries by transnational corporations and research institutions for commercial utilisation (Abdelgawad, 2012). In anti-GMO activism, the argument about bio-piracy is not new. Already in the late 1990s, Activist Vandana Shiva described patented biotechnology seeds as a way to appropriate resources and knowledge from indigenous communities of developing countries for corporate profit. Describing bio-piracy as a form of colonialism, she explained: "Through patents and genetic engineering, new colonies are being carved out […] Capital now has to look for new colonies to invade and exploit for its further accumulation" (Shiva, 1997, p. 5). As CK Rao from FBAE remarks, bio-piracy is not an officially recognised term in the United Nations' Convention of Biodiversity, but instead prefers to use the term "benefit sharing" (personal communication with the author, 2018).

[185] In August 2011, India's National Biodiversity Authority (NBA), that regulates access to and use of biological resources under the Biological Diversity Act, announced after a yearlong investigation into ESG's formal complaint, that the development of Bt-brinjal was indeed a case of bio-piracy. Although the NBA does not use the term bio-piracy, it confirmed that Monsanto and its Indian partner Mahyco had not obtained

As this section shows, farmers got constructed as a twofold public. Those in favour of commercialisation presented farmers to be in need of Bt-brinjal to deal with pest pressure, and to reduce pesticide sprays and input costs – arguments that spring from the imaginaries of productivity and environmentalism I described in chapter three. The farmer public that got constructed through these issues would accordingly want access to Bt-brinjal as a cutting-edge innovation and trust the scientific evaluation of its environmental risks. On the other hand, scientists, farmer activists, and civil society groups questioned the ERA and the socio-economic necessity of Bt-brinjal. These voices constructed Bt-brinjal to put biosafety and India's indigenous brinjal germplasm at risk while cheaper and less risky alternatives for pest control existed (e.g. letter by independent scientists, CEE, 2010, annex IV). Another issue intrinsically related to a critical evaluation of ERA was the fear of monopolising tendencies of powerful transnational corporations that seek market shares and profit at the expense of environmental integrity and farmer's free choice over seeds. The experience of Bt-cotton pushing aside non-Bt seeds in India's seed stores was seen as a warning sign that the same might happen with brinjal. Bt-brinjal was thus constructed as a tool of domination and control, something entirely opposed to the idea of farmers' sovereignty to freely chose, exchange, and store seeds – once Bt-brinjal would enter the market, this freedom would disappear and prices for GM seeds would rise. Accordingly, Bt-brinjal not only put the environment, but seed sovereignty and therefore farmers' autonomy and livelihoods at risk. The construction of this farmer public emerged from issues that pertain to the sociotechnical imaginaries of complex ecology and seed sovereignty that I described in the previous chapter.

However, as Yudhvir Singh, leader of the Indian farmer union BKU explained: "the category of 'farmers' gets abused for many purposes by many actors" (interview Singh, 2013). Here, I do not mean to suggest there are only two farmer publics in regard of Bt-brinjal. I am aware of the diversity of India's farming communities that Sarangi from Living Farms explained to me: "farmers are not a homogeneous group […] There are different farmers, different areas, and different interests. Different costs, crops, climatic conditions. Also the crises are different." (interview Sarangi, 2012). Yet, I suggest that in the Bt-brinjal consultations, farmers either got constructed as a public that aspires to using the latest seed technology for productivity gains and input cost reduction, and by implication trusts ERA and socio-economic evaluations; or farmers got constructed as a public unwilling to accept Bt-brinjal since it constitutes a threat to environmental integrity and instead gets ascribed the meaning of a tool of domination and control of the means of agricultural production in the form of seeds. It appears that the construction of a farmer public of the latter sort entered the stage of policy-making only via the issues of ERA and socio-economic evaluations, which ultimately rests on scientific evaluation. So, the political question of control gained credibility in the policy arena by discussing the science about Bt-brinjal's environmental and socio-economic implications. While the political concern of seed sovereignty forcefully entered the

permission from the NBA or the relevant State and local biodiversity boards to use nine Indian brinjal varieties (TheHindu, 2011). The NBA decided to initiate legal proceedings against Monsanto/Mahyco, UAS Dharwad, and Sathguru Management Consultants Ltd. which acted as coordinator on behalf of USAID and Cornell University (Abdelgawad, 2012). This step was fiercely opposed by biotechnology advocates (e.g. Rao, 2013a). The decision in this case is still pending but is expected to have repercussions with the development of other GM crops by Monsanto in India, such as onion and maize.

policy-making arena, it was not primarily farmers' concerns about the relations of agricultural production and questions of control, dominance, and sovereignty, but by scientific evaluation of environmental and socioeconomic risks that defined the meaning of these issues.

Again, science appeared as the ultimate judge – more rigorous environmental risk assessment and socio-economic evaluations (or the lack thereof) were considered to vest farmer publics with epistemic legitimacy. However, the construction of farmer publics was not always about asserting the right to ownership over productive resources, but rested on a deficit model of such a public: Biotechnologist Padmanaban explicated that science should speak to farmers more directly in order to convince them of the benefits of GM crops: "Scientists should be much more present and communicate through farmer leaders" (interview Padmanaban, 2012). At the same time, the supporters of the commercialisation of Bt-brinjal debunked arguments about seed sovereignty not as an issue pertaining to farmers, but as a concern imported from elitist NGOs (interview Rao, 2013). Yet, as the issue of seed sovereignty indicates, and as farmer leaders explained in interviews, the meanings attached to Bt-brinjal still went beyond science-based considerations about Bt-brinjal's biosafety. Activists (interview Saldanha, 2012 & interview Sahai, 2012) explained for instance that the Bt-brinjal consultations were not just about human health, environmental safety, and seed sovereignty. Instead, a broadening of the debate occurred that included such issues as the institutional organisation of India's regulatory apparatus for GMOs. This issue gave rise to what I call citizen publics, to which I will turn next.

The actors in the Bt-brinjal consultations not only linked the issue of technological risks to questions of trust in risk assessment science, or to issues of control over the means of agricultural production, but also to the debate about India's regulatory apparatus for GMOs. According to activist Suman Sahai, linking these issues made clear that "there is not only a chance but a necessity […] to go to the public domain to ask for controls and a greater say in decision-making." How the Bt-brinjal biosafety data were first obtained and then questioned ultimately resulting in public consultations showed to her that "it is not only important to articulate our rights but to assert them. We must say that we want that control" (interview Sahai, 2012). As opposed to the deficit model of the public, a sovereign public that asserts citizenship rights and attempts to actively shape the governance of GM crops emerged. The issue of contention was the institutional set-up consisting of multiple government authorities to regulate GM crops. Almost all actors saw the multilateral regulatory network between RCGM, GEAC, and different expert committees as too complex, or simply outdated. Legal scholar MK Ramesh from National Law Scholl of India University (NLSIU) in Bangalore explained: "The problem is that GEAC came into existence long before many things, before GM technology, before the biodiversity convention, before the Cartagena Protocol, and there were no updates thereafter" (interview MK Ramesh, 2012).[186] So, the Bt-brinjal con-

[186] India became signatory to the Cartagena Protocol on Biosafety 23 January 2003. It amends the Convention on Biological Diversity (CBD) which was finalised at the UN Conference on Environment and Development (UNCED) in Rio 1992. The Cartagena Protocol refers to "the need to protect human health and the environment from the possible adverse effects of the products of modern biotechnology" and obliges for "an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms

sultations became a canvas for different blueprints for the renewal of India's regulatory apparatus for GM crops– as activists explained, the Bt-brinjal consultations became an arena to discuss the legal frameworks for regulating GM crops more broadly (e.g. interview Saldanha, 2012).

However, ideas about the problems of the current institutional set-up varied significantly. Biotech advocate CK Rao described the multiplicity of India's regulatory agencies as "excessive" (interview Rao, 2013). Biotechnologist Padmanaban, as well as representatives of biotechnology advocacy organisations lamented regulatory barriers were too high and caused delays in the approval of GM crops with detrimental effects on India's development and competitive edge. An ABLE representative alluded the various Expert Committees, as well as the Parliamentary CoA were biased towards NGO arguments, which required a new and unbiased institutional setup (interview Seetharama, 2013). In their submissions to Ramesh, scientists repeatedly demanded an autonomous Biotechnology Regulatory Authority (e.g. Padmanaban, Gowrishankar CEE 2010, annex IIIa) to replace the current regulatory institutions. By pointing to the US experience with GMOs, scientists from Department of Biotechnology (MoST, GoI) argued that the GM regulation was too strict, too complex, and that RCGM and GEAC should be replaced (Gowrishankar, 2009). Instead, the burden of proof should be shifted in the sense of "innocent until proven guilty", for which a streamlined regulatory authority was necessary. This new institution was thought to enhance the speed with which applications for cultivating new GM crops would be dealt with by having only one regulatory agency (interview Rao, 2012). Moreover, the idea of the democratising potential civil society activists had ascribed to the Bt-brinjal consultations was not shared by people like CK Rao from FBAE. According to him, the Bt-brinjal consultations had provided a stage for emotional and non-scientific arguments by international NGOs. These had imposed their "anti-technology activism", "MNC phobia and anti-Americanism" onto unsuspecting farmers and consumers (CEE, 2010a, annexure IIIa). So, public engagement should be avoided in the future, and instead, expert committees should be staffed with the appropriate expertise.[187]

On the other hand, others regarded India's regulatory apparatus as structurally biased towards the interests of agri-business and transnational corporations in order to attract foreign investment. Activist Suman Sahai alluded Bt-brinjal was an entry for transnational corporations to conquer India's huge agricultural input market (interview Sahai, 2012). In that sense, PM Bhargava accused the existing regulatory authorities for "rubber stamping" risk assessment studies without proper review. Instead of critically evaluating the data, RCGM and the Department of Biotechnology functioned as a "vendor" of GM crop technology and GEAC had too often uncritically taken over RCGM's verdict in the favour of the GM crop applicant (interview Bhargava, 2012). MK Ramesh from NLSIU agreed: "Everything just got approved. It was an approval committee rather than critically evaluating" (interview MK Ramesh, 2012). Activist Ramanjaneyulu from CSA also pointed to conflicts of interest in the

resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity" (Secretariat, 2000).

[187] CK Rao revealed in an interview that he thinks the expert committees (ECI and ECII) had enrolled the wrong scientists, amongst them PM Bhargava, who had brought in too many "unscientific arguments" (interview Rao, 2012).

scientific Expert Committees in. There, scientists involved with GM crop development had participated in the evaluation of Bt-brinjal's risk assessment. For example, some Expert Committees members had conflicts of interest: "Arnand Kumar was a developer of Bt-brinjal, and Deepak Pental was involved in GM mustard" (interview Ramanjaneyulu, 2012). In the consultations, the submission by "independent scientists" accused the regulatory apparatus to have failed to realise that "the promises taken verbatim from ISAAA industry promotion material do not match either scientific fact or reality" (CEE, 2010a, annex IIIb). Though it was renowned Indian scientists PM Bhargava, who most explicitly accused India's scientific elites to be diluted by vested interests, which included its regulatory institutions: "our scientific community with some important exceptions is about what one calls financial, intellectual, and professional corruption" (interview Bhargava, 2012).[188]

Instead of letting these entanglements determine the future course of regulating GM crops, activists argued that instead of ad-hoc replies to public controversy, institutionalised public consultations were needed to counterbalance the power of transnational capital and to democratise decision-making on technological development: "We need that kind of framework to force industry and investors to acknowledge that their right to invest is not an absolute right. It is subordinated to people's will" (interview Saldanha, 2012). These arguments pointed to the need for a new, independent regulatory authority, but not the one-stop shop that industry friendly voices demanded, since TNCs like Monsanto were already "practically determining how policies change" (interview Sahai, 2012). Instead, *Lok Sabha* CoA leader Acharia demanded a transparent and independent regulatory authority "that protects farmers' interests" and "makes the company accountable if the technology fails" (CEE, 2010a, annex II).

Activists and scientists equally imagined an overhauled regulatory institution to be free of conflicts of interest (interview Ramanjaneyulu, 2012), which includes risk assessment to be conducted not by the applicant, but by publicly funded research (interview Swaminathan, 2013).[189] Moreover, these voices argued for public participation to become a more permanent feature of Indian policy-making to keep technocratic decision-making that relies too heavily

[188] In my interview with PM Bhargava (2012), he gave the example of Monsanto having bribed dozens of Indonesian government officials for the approval of Bt-cotton, indicating that the same might be happening in India.

[189] The debate about a new Biotechnology Regulatory Authority of India (BRAI) began in 2008 when the Department of Biotechnology had drafted a proposal for renewing India's regulatory apparatus for GMOs. The so-called BRAI bill was fiercely contested, not only because it aimed for moving regulatory responsibility away from the MoEF towards the Ministry of Science and Technology, which is generally considered to take more industry friendly decisions. Concerns voiced during the Bt-brinjal consultations also criticised the proposed bill as "undemocratic" because of secrecy and lack of public review in its drafting (interview Saldanha, 2012). Since the bill went through subsequent revisions in 2011 and 2013, a detailed analysis of the controversy surrounding that process falls out of the scope of this chapter. The bill was scheduled for parliamentary debate in 2013, but was lapsed (for a summary of the BRAI bill, see PRS, 2013). While its advocates envisioned the new BRAI to become a one-stop-shop for more centralised and swift approval of GM crops (see, e.g. Gowrishankar, 2009), civil society actors have produced a mass of material criticising the envisioned BRAI as a technocratic mechanism that would lead to quicker approval of GM crops at the expense of more rigorous biosafety assessment and democratic control (GreenpeaceIndia, 2011; Kiruthika, 2015; Kuruganti, 2011). Until date, the institutional arrangement for regulating GMOs remains with RCGM/GEAC.

on industry data in check (interviews Sarangi, 2012 & Saldanha, 2012).[190] If public engagement would not become an institutionalised procedure, the democratising potential which the Bt-brinjal consultations had demonstrated would remain a diverting guest performance in the arena of technocratic policy-making (interview Sahai, 2012).[191] Activist Saldanha expressed his concern with a long-term perspective on policy-making. To him, the Bt-brinjal consultations constituted an example for an equitable and well-informed debate and a process towards a deeper democratisation which, if taken as a precedence for future policy-making, could contribute to more transparent decision-making and accountability: "We cannot allow an elite minority to decide for the majority. Be it scientists, businessmen or technocrats […] It should be a norm to have consultations". Saldanha further warned that only the institutionalisation of public participation could address the need for intergenerational justice:

> Equality and equity have a deeper resonance when taking decisions when it matters for not only us, but for generations to come. It is not about me eating GMO, it is generations to come who can suffer by my choice. Because of that, my choice has to be such an informed and responsible choice. So the principle of prior informed consent is not just an assembly of words.
>
> (interview Saldanha, 2012) [192]

I suggest that we can understand the publics that got constructed through these arguments about the institutional arrangements for the regulation of Bt-brinjal as citizen publics who aim to renegotiate the relationship between science, the state, and society by means of addressing the set-up of regulatory institutions. Citizen publics are different from consumer and farmer publics in the sense that they relate more directly to the relationship between publics and the state. Also, public involvement of citizen publics emphasises the shift from mere will-formation to issue-formation . Such citizen publics took two forms, which can be conceptualised as liberal and deliberative (cf. Crick, 2004; Habermas, 1996b). On the one hand, the liberal conception regards citizens as believing in market principles to guide technological development. In this view, regulatory institutions in the hands of experts do not need additional scrutiny by other sources of knowledge than science, since citizens have trust in experts to make the right science-based decisions. This perspective does not require additional input of public knowledge to the policy-making process. Instead, market and state

[190] In their submissions to Ramesh, international scientists criticised India's regulatory institutions to have relied too heavily on industry data and analysis (e.g. Andow, Carman, Heinemann, letter independent scientists & Séralini, CEE 2010, annex IIIb). While these transnational discursive entanglements are certainly important to mention, I decided to focus on empirical material from India in this section. My aim is to avoid reproducing an ethnocentric bias that draws on stereotypical ideas about corruption in developing countries. Rather, the conflicts of interest in science and European regulatory institutions that I described in chapter two can also be described as corruption.

[191] Suman Sahai even argued for institutionalising public engagement more generally when it comes to decisions on science, technology, and the environment: "What the Minister has done with Bt-Brinjal should be institutionalised, that before any Ministry takes a decision that affects the public, there must be a public hearing" (interview Sahai, 2012).

[192] The letter by independent scientists appealed to the importance of Ramesh's decision on Bt-brinjal as a precedence for other countries: "the global community needs India in the matter of exemplary regulation of these [GM] crops" (CEE, 2010, annex IIIb).

institutions shall decide on the best course of action – which implies designing regulatory institutional set ups according to the principle of efficiency (centralised and in the hands of a few experts). On the other hand, a deliberative conception regards citizens as political agents who actively shape the political regulation of technology by providing additional sources of knowledge generated through deliberative action such as the Bt-brinjal consultations. This is thought to reconnect the displaced politics of technocratic decision-making by experts and policy-makers to the voices of the multiple publics affected by technological innovation; and thus to shape policy-making on GM crops. Deliberative citizen publics seek to monitor regulatory state institutions in order to guarantee transparency, accountability, and to keep market actors under scrutiny; and this requires the regulatory system to be open to public input.

The construction of the citizen publics in the Bt-brinjal consultations shows that questions about the technology included more than just biosafety concerns, but pertained to the very heart of the institutional cultures of science and policy-making; and the underlying assumptions about the role of publics in the regulation of technology. As Indian activists explained, the calls for greater public involvement in the regulation of GM crops reverberates with the Gandhian notion that direct democracy is not incompatible with modern society and economy, but that the subjects of governance can have more direct control over the decisions affecting them directly (interview Khadse, 2013). In that sense, the construction of citizen publics can also be seen as the constitution of a collective body of active political agents who assert their constitutional right to impact the democratic governance of technological innovation more directly and outside of electoral mechanisms of representation.

Ramesh's Moratorium Decision: how publics of Bt-brinjal shaped policy

The above analysis of the Bt-brinjal consultations reveals which notions of the public got constructed in the Bt-brinjal consultations through public engagement. My analytical perspective has shown the interpretative flexibility of Bt-brinjal lends itself to a number of issues from which heterogeneous publics emerged as new associations of multiple actors. I have described these as heterogeneous consumer publics, farmer publics, and citizen publics that got constructed along the various meanings actors attached to Bt-brinjal as entailing risks to human health, the environment, and the socio-economic conditions of farmers, the issue of seed sovereignty, as well as questions about remodelling India's regulatory apparatus for the approval of GM crops. Next, I will explain how these publics shaped the Minister's moratorium decision.

Ramesh's announcement of aiming to arrive "at a careful, considered decision in the public and national interest" (Ramesh, 2009; 2010, p. 2) reminds of political science literature which highlights the normative assumption that policy is made or should be made in the interest of the public. Yet, underlying this are competing definitions of the 'common good' (Offe, 2012), and it remains a question which public(s) the Minister referred to in the moratorium announcement. Since the consumer, farmer, and citizen publics I have identified above are analytical categories, we cannot expect the Minister to have explicitly invoked these

labels. I will therefore analyse the moratorium document in terms of which issue-associations the Minister referred to in explaining his decision, as well as reactions by various actors, and reflections of Ramesh himself. I will show that consumer, farmer, and citizen publics return in Ramesh's decision, though to different degrees.

On 9 February, only three days after the last public hearing had taken place in Bangalore, the Minister of Environment and Forests announced to the press his decision following the Bt-brinjal consultations in a 19-page document (Ramesh, 2010). Ramesh started off by emphasising he was concerned "with Bt-brinjal alone and *not* with the larger issue of genetic engineering and biotechnology in agriculture" (Ramesh, 2010, p. 3, emphasis in original). Drawing on the importance of agriculture being a state subject, he continued with an extensive summary of the States' Chief Ministers' submissions, emphasising they all rejected the introduction of Bt-brinjal for considerations of risks to health, the environment, and the socio-economic effects on farmers. Commenting on the pesticide reducing potential of Bt-brinjal, the Minister further pointed to alternatives to Bt-crop technology for reducing pesticide use, such as Non-Pesticide Management (NPM) in Andhra Pradesh, stating that "to reduce pesticide use without compromising on food security at the macro-level and returns to farmers at the micro-level is an urgent public policy in our agriculture" (p.5).[193] Although Ramesh recognised many farmers benefited from planting Bt-cotton, and that some farmers' organisations had spoken in the favour of commercialising Bt-brinjal and some against, Ramesh took India's experience with the concentration of the cotton seed market as a warning sign. He alluded farmer publics to be at risk of transnational corporations controlling the food chain, which clearly pertains to questions of seed sovereignty and control over agricultural markets: "I hope in the moratorium period we give serious thought to the strategic importance of the seed industry and how we retain public and farmer control over it even as we encourage private investment in agricultural biotechnology" (p.17). To him, the argument about Bt-brinjal posing a threat to India's indigenous germplasm, through outcrossing seemed a valid concern: "the loss of biodiversity argument cannot be glossed over" (p.7).[194] Yet, the Minister also inferred that "as a country we must learn to derive full benefit of Monsanto's expertise and capabilities, without jeopardising national sovereignty" (p.6). While he recognised the US experience with GM crops, he noted there was "no great compulsion for us to follow suit" (p.9) and instead pointed to China which has indigenously developed Bt-cotton breeding varieties that farmers can reproduce themselves instead of having to buy expensive hybrid seeds every season anew. The issues of potential benefits to farmers, biodiversity risks, corporate control, and seed sovereignty indeed spoke to and from the farmer publics that I have identified above.

However, the issues of the reliability of biosafety tests invoking consumer publics' concerns with risks to human health, as well as citizen publics' calls for remodelling India's regulatory apparatus got more attention from Ramesh. Noting that brinjal was an "item of daily consumption for most of us" (p.5) and that food labelling would be too difficult in the context

[193] In a footnote, Ramesh stated that potential pesticide reduction was the only benefit speaking for Bt-brinjal. Contrary to "the enormous priority that has been accorded to it by private companies" (Ramesh, 2010, p.3, footnote 2), Ramesh did not agree with other arguments about pressing food security concerns, production shortages, or farmer distress, to apply in the case of brinjal.

[194] Ramesh also noted that "public concerns about Bt-brinjal have been influenced very heavily by perceptions of Monsanto itself" (Ramesh, 2010, p. 6).

of Indian agricultural commodity markets, he agreed to the doubts raised about the reliability of risk assessment studies conducted by Mahyco itself. While he recognised some actors provided unconditional support for commercialisation based on the biosafety tests conducted so far, Ramesh also noted that not only arguments about GEAC's limitations should not be ignored, but also that the Expert Committees' recommendations for additional safety tests had not been followed up. So, questions about Bt-brinjal's potential risks to human health remained unanswered (p.9). Quoting a contribution by the Central Institute of Cotton Research (CICR) about insect resistance to Bt-toxins, Ramesh pointed to the "need for more tests that are well-designed, widely-accepted and independently conducted" (p.8). Particularly the issue of chronic toxicity raised by Bhargava, Swaminathan and civil society groups prompted such tests "to be carried out independently" (p.12). Referring to international guidelines and standards such as *Codex Alimentarius* (about toxicological testing), article 15 of the Rio Declaration (invoking the precautionary principle) and the Cartagena Protocol (for including public participation in decision-making), Ramesh further stated: "it does appear that the current standards by which the GEAC has formulated the decision to approve Bt-brinjal do not match these global regulatory norms to which India is a party" (p.10). Instead, he agreed with scientists' arguments for the need for a new regulatory mechanism: "such an authority has to be professional and science-based" in order to conduct all tests "with integrity and impartiality" (p.9). Ramesh envisioned the time of the moratorium to allow for the operationalisation of such a new authority. However, the publics I have identified so far do not stand alone. It was the role of science that became central to the construction of publics which shaped the Minister's moratorium decision.

Four years after he had imposed the moratorium, Ramesh explained in a newspaper article the main reasons for taking his decision: (i) the opposition of state governments, (ii) the possibility of transnational corporations establishing seed monopolies, (iii) the absence of consensus in the scientific community, and (iv) the need for more tests by an independent regulatory authority (Ramesh, 2014). While it appears Ramesh made a strategic move to refer his decision to the Indian federal states' opposition to Bt-brinjal (interview Babu, 2013), it is still remarkable that Ramesh mentioned those issues that spoke to and from consumer publics (additional safety tests), farmer publics (seed sovereignty), and citizen publics (a new regulatory authority). However, it was science that took central stage in his moratorium announcement. Not only did the Minister extensively quote from scientists' contributions for and against Bt-brinjal, but he also referred to scientific rationality as the only authority to provide ultimate judgement on the risks and necessity of Bt-brinjal. Due to scientific uncertainty and the absence of consensus amongst scientists, more rigorous and independent safety tests were required, something only science could provide.

Ramesh extensively referred to MS Swaminathan as "India's most distinguished and senior-most agricultural scientists who was one of the scientific architects of the Green Revolution" (Ramesh, 2010, pp. 14-15). Quoting a letter he had received from Swaminathan in full length, the Minister argued for the need to conduct chronic toxicity and other biosafety tests. The credibility of such tests could only be established through an independent scientific authority. While Ramesh explained "I am also persuaded that the studies being demanded by responsible civil society groups before release of Bt-brinjal should be conducted as a measure of our sensitivity to public opinion" (p.16), it was ultimately Swaminathan as the voice of

eminent Indian science, which he presented as the most convincing argument for conducting additional safety tests and for protecting India's genetic diversity.[195]

The primacy the Minister ascribed to science is most clearly expressed in his invocation of the precautionary principle as responsive to society: "it is my duty to adapt a cautious, precautionary principle based approach […] till such time independent scientific studies establish to the satisfaction of both, the public and professionals, the safety of the product" (Ramesh, 2010, p. 17).[196] Ramesh still invoked the issues around which farmer public emerged in the consultations by arguing for reflecting on the "strategic importance of the seed industry". However, he inferred the importance of farmers' control over seeds "even as we encourage private investment in agricultural biotechnology" (ibid), which from the perspective of seed sovereignty arguments appears contradictory. Yet, we can understand this paradox by looking through the lens of the Minister himself, who needed to respond to the issues raised by diverse actors from industry, civil society, and science alike. It is in this light that he further stated that "under no circumstances should there be any hurry or rush. The moratorium will continue for as long as it is needed to establish public trust and confidence", indicating his decision to be "both responsible to science and responsive to society" (ibid, p.18).

It appears that despite the issue associations connected to the construction of consumer, farmer and citizen publics invoked by the Minister, a hierarchy of knowledge emerged in which science appeared on top. In a technocratic move, the Minister of Environment and Forests refrained from prioritising societal concerns and instead regarded scientific rationality and the existing regulatory apparatus to provide impetus for further decisions: "I expect the GEAC to take follow-up action on the matter of further studies and tests" (ibid, p.18).

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[195] Ramesh still valued that critical scientists and civil society had pointed to important problems with the existing biosafety tests in terms of study protocols and procedures, and the analysis, interpretation, and reporting of data by Mahyco and GEAC's analysis thereof (2010, p.16).

[196] The precautionary principle (PP) developed in Swedish and German environmental policies in the 1970s. It implies decision-makers to anticipate harm before it occurs, such as for instance when there is considerable uncertainty as to technological risks in scientific risk assessment. There is disagreement about whether it constitutes a binding legal principle or merely an approach to policy-making. Controversy exists between regulatory cultures about the interpretation of the PP, with the United States insisting on a 'soft' interpretation, and the European Union applying a 'hard' version (e.g. in the regulation of GM crops in EU Directive 2001/18/EC), even beyond environmental issues (and involving cumulative long-term adverse effects, value judgements, mandatory post-marketing measures, re-examination of risk analysis, and public participation in authorisation procedures). The PP has been introduced in international environmental treaties and agreements. For instance, principle 15 of the Rio Declaration on Environment and Development stipulates in regard of applying the PP: "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (UnitedNations, 1992). There is considerable disagreement as to the extent and implications of the PP, for instance about the lack of clear and applicable definitions (Myhr & Traavik, 2002). Others point to the paradox between scientific uncertainty and precautionary measures on technological risks (Asselt & Vos, 2008), the limits of uncertain scientific knowledge in applying the PP (Hom, Plaza, Feijoo, & Palmen, 2009), the need to employ precaution through experience (R. Welsh & Ervin, 2006), and the lack of normative standards when applying the PP in risk assessment and risk management (Myhr, 2010). Indian actors frequently refer to the EU's use of the PP, though it remains unclear as to which interpretation of the PP will be used in which policy field in India in the future.

These tests would rest on classical risk considerations about human health and the environment. So, only science could provide the ultimate judgement to convince the public and policy-makers. This makes clear that from the Minister's point of view, the publics of Bt-brinjal could not be conceived of without science. Ramesh concluded his statement by explaining what should happen in the meantime: "I hope the moratorium period will be used to build a broader consensus so that as a country we are able to harness the full potential of GM technology in agriculture in a safe and sustainable manner" (ibid, p.17) – so the decision for a moratorium on Bt-brinjal cannot be seen to constitute a more general verdict on the role of transgenic seeds in Indian agriculture. Moreover, during the time a new regulatory authority should be set up, Ramesh reverted to the existing regulatory apparatus, despite the shortcomings pointed at during the consultations. He asked the GEAC to engage with the issues that had come to the fore in the Bt-brinjal consultations; and he asked for a broader parliamentary debate about the subject.

However, Ramesh's decision was highly contested; the actors that had participated in the Bt-brinjal consultations attached different interpretations of what it meant that Ramesh imposed the moratorium. On the one hand people like CK Rao from the biotechnology advocacy organisation FBAE lamented that the Minister had given in to the anti-technology attitude and "misinformation and disinformation (a la Goebbels)" of the anti-GM movement. If all the issues the Minister had wished for would be addressed, India would be deprived "of the perils of Bt-brinjal" for decades (Rao, 2010, p. 22). Even eminent scientist MS Swaminathan, who is critical of GM crops, argued a moratorium constitutes a standstill: "I don't agree with any moratorium. A moratorium will give you complacency, you won't do anything" (interview Swaminathan, 2013). On the other hand, civil society activists like Kavitha Kuruganti argued "the time of the moratorium is time to start promoting alternatives. The campaign is not 'against', but *for* alternatives" (interview Kuruganti, 2012); and public intellectual Shiv Visvanathan praised the moratorium as a time for deep reflection, not only on Bt-brinjal, but on the relationship between science and society more broadly (Visvanathan, 2010). Yet, it was science that was deemed the ultimate arbiter of truth to feed into policy-making.

As if to confirm Ramesh's technocratic turn, the MoEF asked the six Indian Academies of Science to compile a report to assess the current state of science on the biosafety of Bt-brinjal.[197] The so-called inter-academy report (Sood et al., 2010a) however, did not set aside the critics' doubts about the close ties between science and industry. Rather, the report further exemplified that the focus on risk issues was insufficient to deal with the controversy about Bt-brinjal and that scientific risk assessment had reached its limits in providing an impasse to the debate. Published on 24 September 2010, the inter-academy report recommended to resume the commercialisation of Bt-brinjal starting with limited release of the technology. However, the advocacy group Coalition for a GM-free India immediately identified sections of the report to be copied from a 2009 article in *Biotech News* written by Anand Kumar, an explicit supporter of Bt-brinjal involved with the development of GM crops himself (cf. GMwatch, 2010; Shetty, 2010). Other sections of the report were copied from a

[197] The Indian Academy of Sciences, Indian National Academy of Engineering, Indian National Science Academy, National Academy of Agricultural Sciences, National Academy of Medical Sciences and National Academy of Sciences (India) were asked by Mr Ramesh to produce a report on GM crops and Bt-brinjal.

publication by the International Service for the Acquisition of Agri-Biotech Applications (ISAAA) (Choudhary & Gaur, 2009), a biotechnology advocacy organisation.[198] Kumar was quick to wave aside the accusation of plagiarism as a lapse in proper referencing (Shetty, 2010) and other biotech advocates equally regarded it a minor issue (interview Padmanaban, 2012). Environmental activists however were quick to point out that the inter-academy report had "not a single citation", made sweeping statements and unsubstantiated claims which revealed the close connections between India's regulatory institutions and transnational biotechnology corporations, thus making it "a scandal for Indian science" (Jishnu, 2010). Jairam Ramesh himself regarded the inter-academy report unscientific since it reflected only Anand Kumar's view on the subject (OutlookIndia, 2010). An updated version of the report (Sood et al., 2010b) was equally criticised for scientific imprecision and for disregarding counter-evidence. To its critics, the updated report did not provide sufficient justification for maintaining its initial conclusions for the release of Bt-brinjal (Jishnu, 2011). Rather, the inter-academy report symbolised the arrogance of deceit and scientific hubris: "They wanted to bluff the people. They think that science confers immunity upon them, that they are beyond the rest of the human race" (interview Saldanha, 2012). So, the scientific remedy Ramesh had counted on did not materialise and PM Bhargava's grim perspective on the lack of scientific integrity and corruption seemed confirmed once again. Instead, science as an arbiter of truth became more contested and the moratorium on Bt-brinjal remains in place till date.

Conclusion: the elephant in the room

This chapter uncovers which publics got constructed in the Bt-brinjal consultations and how these affected Ramesh's moratorium decision. By reconstructing the consultation process initiated by India's Minister of Environment and Forests in 2010, I show how different publics were constructed through public engagement: consumer, farmer, and citizen publics. Depending on how the respective relevant social groups connected the interpretative flexibility of Bt-brinjal, its risks, and the various issues around GM crop technology, these publics were constructed quite differently. Citizen publics were constructed as either interested in cheaper agricultural commodity prices; or as highly concerned about the potential health risks of Bt-brinjal. Farmer publics were constructed either as interested in innovative seed technology to boost productivity and to reduce input costs and pesticide applications in the field; or as being at risk of unknown environmental effects and a further concentration of the seed market in the hands of a few powerful corporations. Similarly, citizen publics were constructed as either trusting the institutional mechanisms of the state and market; or as seeking input of publicly generated knowledge into and scrutiny of the regulatory apparatus and policy-making processes. Each side in the contestation for and against Bt-brinjal accordingly constructed its own consumer, farmer, and citizen publics. Also, during the consultations, the scientific citizen publics inside the auditoria and the unruly quasi-publics who used different means of political engagement outside the auditoria acted in accordance. While they

[198] I have used this ISAAA report as primary source myself, e.g. in chapter two. Anand Kumar was director of the National Research Centre for Plant Biotechnology and had been member of ECII (ExpertCommitteeII, 2009, p. 3).

catered to different audiences (to the minister inside and to the media and its audiences outside), they still complemented each other. This shows these categories are more permeable and less strictly separated than Varughese's taxonomy (2012) suggests. Although rather tangible in the Bt-brinjal debate, publics remain an elusive category. How did the construction of publics shape the moratorium decision?

Civil society saw the moratorium decision as an outcome of its enduring campaigning efforts against Bt-brinjal. To activists, the Bt-brinjal consultations showed the importance of campaigning and public engagement, a precedent for institutionalising public knowledge input into technology policy-making in order to diversify the sources of knowledge that inform decisions on techno-scientific development, and ultimately to make this process more democratic: "the Gini is out of the bottle now […] we have to democratize choices of technology. You cannot just walk away and say: we know best" (interview Saldanha, 2012). While the Bt-brinjal consultations remained a unique event in Indian policy-making, they are still a sign of a vivid democratic debate exemplifying the discursive heterodoxy of the Indian controversy about GM crops. Moreover, Ramesh's invocation of the precautionary principle indeed seemed to have put science on par with publics: "it shows there should be a convergence between the public and the scientific opinion" (interview Saldanha, 2012). Nevertheless, although Minister Ramesh invoked such issues as environmental integrity and seed sovereignty in his moratorium decision (e.g.: "rich genetic wealth existing in our country"), he resorted solely to scientific risk assessment for future decision-making on Bt-brinjal. As a consequence, it was not the issue-based publics that got constructed in the consultations, but science that the Minister assigned on the top of a hierarchy of knowledge to decide on the future of Bt-brinjal. Also, the publics of Bt-brinjal could not be conceived of without science: Not only did advocates of strong positions try to present themselves as impartial scientists in the debate, but also the CEE report noted that many issues raised in the consultations needed backing by scientific sources, or more research.

So, throughout this chapter, science has somewhat been the elephant in the room. The issues from which consumer, farmer, and citizen publics got constructed all hinged on the scientific assessment of risks to human health and the environment, the socioeconomic conditions of farmers, what it means to have equitable access to the means of agricultural production in the form of seeds, and the scientific mechanisms that vest regulatory decision-making with epistemic authority. Ramesh's moratorium announcement entailed a call on science as the ultimate arbiter of truth: if science was more rigorous and independent, the underlying assumption was that it could answer the pending questions about Bt-brinjal, foremost its potential effects on human health and the environment. Eminent Indian molecular scientists MS Swaminathan clearly explained the unquestioning belief in scientific knowledge production: "Science is the search for truth. You should do it as honestly as possible. And publish your results honestly whether they are for what you wanted, or are against it" (interview Swaminathan, 2013). Yet, as we have seen, the inter-academy report, which thought to provide further scientific judgement on the biosafety issues raised in the debate, could not provide an impasse but instead confirmed the criticism about the lack of scientific integrity in evaluating Bt-brinjal. It revealed once again the close ties between industry and science in regulatory risk assessment, one of the central criticisms of activists. Also, the idea of a new regulatory authority could not materialise as quickly as some had wished for (Yadugiri, 2010);

and the moratorium on Bt-brinjal has not been lifted at the time of writing this chapter, while a range of other GM crops are in the pipeline for regulatory approval in India, with GM mustard being the closest to marketing stage, despite renewed controversy about the reliability and accessibility of biosafety risk assessment and broader societal opposition to the release of this GM food crop (Reuters, 2017; Todhunter, 2017; Warrier & Pande, 2016).

Ramesh's recourse to science as the most legitimate source of knowledge vis-à-vis the issue-publics that emerged from the Bt-brinjal consultations confirmed a hierarchy of knowledge where science is seen to provide answers above all other concerns. Yet this hierarchy silences other political issues around about Bt-brinjal and transgenic crops, such as the relationship between industry and science, or between ecological diversity, farmers' sovereignty, and proprietary transgenic seeds. This hierarchy of knowledge can be said to relate to the wider culture of policy-making in the Indian context. Brian Wynne argues that the primacy of scientific risk assessment over ethical concerns in Europe's GM debate entails a "projective construction" and "systemic patronisation" of public concerns (Wynne, 2001, p. 447). This allows screening out cultural assumptions about the power of science to mediate all possible concerns related to technological development. The Indian case of Bt-brinjal reveals this divide to pertain even more so to the political issues and their publics we saw arising in the Bt-brinjal consultations. Anthropologist and public intellectual Shiv Visvanathan reflected on the public hearings as an instance which entailed the question of the relationship between science and publics; he asked "whether citizenship was to remain a passive act of consuming science or whether the citizen as scientist was to have a say in technologies modifying life and livelihood" (Visvanathan, 2014).

The Minister failed to use the opportunity to take further the reconfiguration of the relationship between science and society that Visvanathan prompted. Ramesh's call on science to provide the answer to convince not only experts, but also the public exemplifies the inability or unwillingness of policy-making to incorporate the deeper political issues connected to GM crops, such as ideas about the importance of ecosystem stability, the farming community's sovereignty over the means of agricultural production, as well as the citizen publics' aspirations to democratise the institutional mechanisms of regulatory science and policy-making. In some sense, the publics that were constructed in the Bt-brinjal consultations call into question the very culture of policy-making that the regulation of GMOs is embedded in. This leads me to the wider question I aim to answer in this thesis about the implications of the construction of a multiplicity of elusive publics for the democratic governance of science and technology, which I will address in the concluding chapter.

Chapter 5

Conclusion - Elusive Publics

This book explores the construction of GM crop technology by studying the role of publics in the controversies about the risks of transgenic crops in India and Europe. In the preceding chapters, I scrutinise some of the salient arenas (scientific risk assessment, sociotechnical futures, and public engagement) of the GM crops debates to identify how various publics shape the technology's development. The central question I address in my inquiry is: What is the role of publics in the current controversy about the risks of GM crops? This book accordingly explains the development of GM crops by tracing how this technology is shaped by public involvement. Publics serve as a lens through which I study the construction of GM crop technology and its risks. At the same time, I argue that publics are not fixed entities but that publics continuously get shaped in the process of the controversy about the risks of GM crop technology. I therefore asked more specifically: How is GM crop technology shaped by public involvement; and what sort of publics are constructed in the various arenas of the GM crops debate?

Both questions fit the idea of co-construction, which is a heuristic that provides insight into the mutual constitution of techno-scientific and social orders – of GM crops and its risks on the one hand, and of publics in the controversy about this technology on the other. As Jasanoff explains, "the ways in which we know and represent the world (both nature and society) are inseparable from the ways in which we choose to live in it" (Jasanoff, 2004, p. 2). The co-construction idiom is particularly suitable for understanding how certain ideas and meanings gain supremacy and how others are marginalized in controversies about techno-scientific change, for explaining the "*intelligibility and portability* of products of science and technology across time, place, and institutional context" (Jasanoff, 2004, p. 5, emphasis in original), and for understanding techno-science as a cultural practice in which legitimacy and meaning are socially constructed.[199] This research therefore charts the interpretative flexibility of both the risks of GM crops and of publics. In this chapter, I weave my findings together in order to answer the question what we can learn from my study about the possibilities and forms of democratic governance of science and technology in a globalized world.

Constructing Publics and GM Crops

Genetically modified crops are constructed according to the various meanings that actors ascribe to the technology and its risks. The risks of transgenic seeds are commonly framed as pertaining to biosafety issues, i.e. human health and the environment, and the most appropriate way to assess such risks scientifically. I show in chapter two how public involvement in the controversy around Séralini's long-term rat-feeding study was not only about technical questions of scientific method and test design, but the main issue revolved around the boundary between science and politics. The debate about Séralini's study, in particular

[199] Various important studies in the field of Science and Technology Studies can be seen as precursors to what Jasanoff has termed co-production. For controversies about science, Jasanoff refers to the works of Collins (1985) and Shapin and Shaffer (1985). The changing meanings of techno-science when it travels time, space, and cultural and political context, have been explored by Bowker & Star (1999) and by Jasanoff herself (1995) and the co-production of techno-science, technological artefacts, and political culture has been explored early on in works by Karin Knorr Cetina (1999), Paul Rabinow (1996), and Jasanoff (2005a) herself.

the issue of conflicts of interest in scientific risk assessment, drew into doubt the epistemic authority of science in answering the questions about the biosafety of GM crops. I show how the epistemic status of science is complicated by scientists' attachments (active commitments and dependencies) and the politics of scientific risk assessment (value judgements), which came to the fore in the public debate about the long-term rat-feeding experiment. Séralini's toxicological study oscillated between being recognized as proper science and not being recognized as such because various actors in the debate defined the boundary between science and politics differently. The controversy about publication, retraction and republication of Séralini's study shows that the actors' definitions of the boundary between science and politics did not converge, despite prolonged controversy. This reveals the debate about the toxicity of GM crops and their associated pesticides is more than just about science, its methods, and interpretation of results, but that the controversy about the toxicological risk assessment of transgenic crops is deeply implicated with politics. The debate was about more than just the number and strain of rats in Séralini's experiment, i.e. there is more to GM crops than the discourse about scientific risk assessment suggests.

Various actors ascribe wider meanings to transgenic seeds and the issues revolving around the technology. I show in chapter three how competing, conflicting, and contested imaginaries of a sociotechnical future with(out) transgenic crops reveal the interpretative flexibility of GM crops: the wider issues which the actors invoke in the debate about which sort of technological development is desirable demonstrates how GM crop technology is closely connected to ideas about social order. The various meanings GM crops acquire in the imaginaries of our sociotechnical future reveal the technology to have multiple meanings to the actors of the debate. This goes beyond the issue of health risks and other biosafety concerns. On the one hand, the proponents of GM crops infer the technology to be a solution to productivity problems and the environmental impact of agriculture. From this perspective, GM crops entail the potential to increase productivity, reduce input costs and environmental impact, and therefore contribute to improving farmers' livelihoods, and to enhancing economic competitiveness in global agricultural markets. To the opponents of GM crops on the other hand, the technology has an entirely different meaning. They regard it as a threat to the complex ecosystem, and to farmers' autonomy over seed technology as a central means of agricultural production. From this perspective, transgenic crops entail more risks than only to human health. Rather, the technology poses a severe threat to the stability and integrity of the highly interdependent and complex ecosystem which is insufficiently understood and conceptualized by risk assessment science. GM crops accordingly acquire the meaning as a technology of dominating not only nature, but also society. In this view, transgenic crops serve the monopolizing tendencies of transnational corporations which aim to conquer new markets for their proprietary seed technology. This they argue, endangers the autonomy of farmers and the rural organization of labour, for GM crops impose a system of agriculture that favours industrial monoculture and economies of scale. From this perspective, transgenic seeds are part of a larger transformation of agriculture that sustains the system of input-intensive industrial farming and postcolonial relations of dependency. I also show the normative and temporal dimensions of these meaning constructions. Feeding the hungry, preserving the environment, and improving the livelihood of farmers are values the actors ascribe to when imagining sociotechnical futures with(out) the technology – though the problem definitions and suggested solutions vary

widely. Moreover, the actors' visions of the future, as well as their understandings of the sociotechnical present with GM crops are vested in their diverging interpretations of past agricultural development since the Green Revolution. As I demonstrate, the temporal perspectives of the actors in the debate are connected to diverging time-frames of ecological and political development. Accordingly, the meanings attached to GM crop technology have normative and temporal dimensions. However, what about publics?

I argue that there is a multiplicity of publics at play in the GM crops debate. As much as the interpretative flexibility of transgenic crops reveals a diverse range of symbolic meaning constructions around the technology, different relevant social groups construct different publics in accordance with the issues they associate with GM seeds. Publics are not a single, static entity. Instead, they are a plural, continuously shifting category constructed by the various actors in the GM crops controversy around the issues they see implied with the technology. In chapter four I show how the same labels of consumer, farmer, and citizen publics can acquire rather different meanings. Publics are not restricted to the electoral vote as an expression of public interests that policy-makers are supposed to act upon. Instead, publics are a normative category of the demos that is constructed in different arenas differently by different social groups. Publics become visible political units in demonstrations, gatherings, assemblies, and in engagement exercises. Publics are also constructed in speech acts, i.e. through the participation of various actors in technological controversy. The articulation of issues allows for the formation of publics, and in that process transgenic crops as a political object and publics as political subjects get shaped. This is not meant to say that the social construction of publics is a mechanistic and strategic Machiavellian process, but rather that the construction of publics is about political positioning of various forms of collective subjectivity in the process of technological controversy as a form of political contestation.

In the debates about GM crops that I study in this book, publics are constructed as consumers, farmers, and citizens. Although different social groups invoke the same labels, the publics constructed through such meanings are quite different. For instance, the sociotechnical imaginaries of productivity and seed sovereignty both construct contrary images of farmer publics, either as having a stake in productivity gains for food security and competitiveness, or as striving for autonomy from markets and the institutions and agents of neoliberal globalisation. Yet, there are also alternative imaginaries at play about farmer publics assuming independence by engaging with the market at their own conditions to circumvent established market structures, e.g. through exchanging non-proprietary seeds, or by building cooperatives to establish direct producer-to-consumer retail chains. At the same time, these imaginaries also construct different consumer publics, for instance as being interested primarily in healthy food products and cheaper commodity prices, or in more sustainable and environmentally friendly agricultural technologies and practices with which their consumer goods get produced. Similarly, the sociotechnical imaginaries of environmentalism and complex ecology draw very different visions about the interrelationship between technological innovation and the environment which reveals underlying conceptions of the possibilities of technological mastery over nature and the complexity of the ecosystem.

Yet, publics are shifting and evolving, depending on the issue or context at hand. As an industry representative for instance alluded, citizens tend to forget about their capacity as

political agents when they act as consumers. Therefore, the collective political subjectivity of publics is permeable, shifting, and context-dependent.

> There is no such thing as the public, there is consumers and citizens. […] We are all citizens, but the moment we cross that wonderful hot air barrier at the supermarket, we become consumers. And most of us leave behind the things they think about as citizens when they are consumers. That is true. How do you otherwise explain that people do not buy more fair-trade coffee or more healthy food products? It is very simple, we are consumers and we are citizens. All the stuff you see in public opinion polls is citizens' answers. When you start doing consumer polls, you get different answers.
>
> (interview Sarvaas, 2012)

Publics remain difficult to grasp in their multiplicity. There are more publics than the various consumer, citizen, and farmer publics. As chapter two reveals, publics need to have expertise when debating the intricacies of toxicological risk assessment – knowledge about scientific methods, tools, and legitimate interpretations of results are necessary to participate in the controversy about the boundaries of trustworthy and reliable toxicological knowledge. Such scientific citizen publics have interactional expertise (Collins & Evans, 2002), though when commenting on the structure of the regulatory system, and the relationships between regulatory science and industry (or environmental NGOs) wrought by conflicts of interest, the issues became more than scientific methodology.[200] Instead, the structural organization of knowledge production became an issue, which allowed for the construction of citizen publics who either question or support the existing constitution and structures that govern the relationship between the state, the economy, science, and society. Scientific citizen publics remain a red thread throughout this book, not only for the fact that science is so central in technological innovation and development, but also because the complexity of our techno-scientific world requires interactional expertise if political actors want to make meaningful and legitimate contributions to debates about technology. Accordingly, different relevant social groups contribute to the social construction of publics alongside with transgenic crops in the controversy about this technology. Although they invoke the same labels, the publics they refer to have different meanings, not only between different arenas of the debate, but also within each arena the same label assigned to publics can mean very different things. Publics, in their multiplicity, therefore remain elusive.

Moreover, as my analysis shows, publics have a double function. The different meaning constructions of GM crops and the issues evolving around the technology speak *from and to* different publics. This means publics can be both, participants within the arenas of the GM crops debate, and audiences of the contestations going on therein. Publics not only are constructed in the debate as social collectives affected by GM crop technology and its risks, but publics are also addressed as an audience receptive to these issues. For instance, when issues revolve around such normative questions as healthy food, feeding the hungry, preserving the

[200] Ribeiro and Lima however criticise Collins' and Evans' normative theory of expertise, for overestimating interactional expertise while the skills, experience, and judgement of experts is habitually normalised in debates about technology; i.e. "there are no pre-stablished criteria to legitimise those who will have a right to speak in the first place" (2016, p. 304) .

environment, or stimulating economic growth, these meaning constructions aim at enrolling other parts of the populace not directly affected, but sensitive and emphatic to the issues pertaining to other sections of society. For example, journalist Devinder Sharma described the campaigning efforts around Bt-brinjal as directed at a food-conscious middle-class Indian audience sensitive to questions about healthy food consumption. This emphasizes that publics get represented not only as being affected by the technology and having stakes in the debate, but also as audiences to be alerted to the issues at hand to eventually enrol them in other issues of the controversy.

The Bt-brinjal consultations are a clear sign of the representational and performative character of publics. Despite the variety of labels with which participants of the consultations got categorized, those who participated not only represented themselves, but the entire category in which they were placed – citizens, consumers, farmers, and industry. This explains why some actors from industry and civil society strived for being categorized as scientists, a supposedly more neutral, objective, de-politicised actor category, as opposed to those publics forming around explicitly political issues. However, as chapter two shows, the boundary between science and politics is subject to contestation and negotiation. Appealing to supposedly value-neutral science therefore does not provide an easy way out of to the highly political nature of the GM crops debate. Actually, the construction of certain publics works better in some arenas than in others.

My analysis of the Bt-brinjal consultations shows how some publics can impact the debate in some arenas while in others the same publics can be less effective. Whereas participating in the arena of toxicological risk assessment required a certain degree of participatory expertise to judge the reliability of Séralini's toxicological study, the sociotechnical imaginaries constructed in advocacy material, narratives, and speech acts require less scientific expertise but draw more on imaginative repertoires of representation and enactment that make imagining a future with(out) GM crops possible. Mind for instance the strong vision of the future invoked by Vandana Shiva about GM crops leading to a destroyed ecosystem, or the claims by industry representatives about the wondrous potential of transgenic crops to alleviate poverty and fight hunger – such issues and their corresponding publics effectively speak from those affected by these issues, and to those audiences that can empathise with them. However, such constructions cannot effectively shape the debate about the methodological and experimental questions around long-term toxicological rat-feeding experiments and how to interpret their results. In the latter case, scientific citizen publics were much more able to engage in the debate not only about the practice of risk assessment science, but also about the structural relations of scientific knowledge production in terms of the financial and professional attachments in scientific risk assessment. Finally, in the arena of Indian policy-making on Bt-brinjal, I show how Minister Ramesh sought public input into the policy process as an additional source of knowledge for political decision-making on GM crops. However, although mentioning some of the issues that allowed for the construction of citizen, consumer, and farmer publics that were invoked in the consultations, in his moratorium decision the Minister ultimately assigned science the task to provide the knowledge for making a decision on Bt-brinjal. So, although various publics could raise their issues and voice their concerns in the consultations, in the end Jairam Ramesh assigned science the role as

the ultimate arbiter of truth about the risks and benefits of Bt-brinjal. Although the moratorium can indeed be seen as a success of the oppositional publics involved in the debate about Bt-brinjal, it was yet again science that appeared on top of a hierarchy of knowledge for policy-making. So, certain constructions of publics suit some arenas better than others.

Based on my analysis, publics can be understood as a multiplicity, as a normatively laden political category that is shifting and therefore elusive to ad hoc categorization and classification. Publics form around those issues implicated with GM crops and therefore serve as a source of knowledge in the debate about the technology's risks, which *can* inform political decision-making on technology, but not necessarily will have that effect. However, publics cannot be conceived of without science. Even if publics may be constructed in opposition to science, or as accordant with it (interactional expertise), the additional knowledge provided by publics remains subordinate to the epistemic dominance of scientific knowledge production in a hierarchy of knowledge. Particularly when it comes to policy-making, including publics provides additional legitimacy for decision-making, though there is no guarantee that the voicing of issues and concerns will have an impact on the decisions of policy-makers. The Bt-brinjal case clearly shows that in a hierarchy of knowledge about technological risks, science prevails. So let me turn to the particular role of science in technological controversies, such as the GM crops debate, next.

The Role of Science

In the debate about the risks and benefits of GM crops, science and scientific risk assessment take a central role. The potential impacts of transgenic crop technology cannot be legitimately assessed without scientific expert knowledge in various fields from toxicology to environmental risk assessment, plant breeding, ecology, entomology, etc. Chapter two demonstrates that engaging with the questions around toxicological risk assessment requires the actors to understand the intricacies of scientific methods, tools, and legitimate interpretation of results. At the same time, the actors in the debate about Séralini's long-term study engaged in boundary work to demarcate their truth claims about the technology's potential toxicity as reliable and trustworthy, while denying the same to their opponents. To do so, these actors not only drew on issues of method and study design, but they also raised questions about the structural relationships between science, industry, and environmental NGOs, in particular regarding financial and professional conflicts of interest. This shows that different actors define the boundary between science and politics differently; for science and politics are closely intertwined in the GM crops debate.

Science therefore becomes central in constructing publics when they engage with issues around transgenic crops, but also the other way around: publics are important for science and its epistemic status. Publics can be constructed in opposition to science, e.g. when a public supposedly lacks expertise about technoscience to engage meaningfully in a technological debate. At the same time, civil society activists argue that decisions on technological development should not hinge on science alone: "if you are adopting technologies, especially transformative technologies, those that affect peoples' lives, then you have to ask the people; those days of patriarchal decision-making are over" (interview Sahai, 2012). Publics can be

defined as both opposing science, and as being constitutive of and supplementing it (e.g. scientific-citizen publics), but rarely can publics be conceived of without science, i.e. when publics immerse in technological controversy, they cannot do so without referring to scientific knowledge to either challenge or agree with hegemonic forms of institutionalised knowledge production. Publics need to engage with science in order to legitimately participate in technological debates. Chapters two and three have shown that simply pointing to political issues or the politicisation of knowledge production is insufficient to shape a controversy - be it about toxicological risk assessment or imagined sociotechnical futures - science always plays a role in the social construction of publics in the GM crops controversy. Ramesh's moratorium decision left the ultimate verdict about Bt-brinjal to science. This shows how the Minister assigned primacy to scientific knowledge over the complex political issues that public participation revolved around in the Bt-brinjal consultations, i.e. despite issue-based publics shaping the Indian debate about GM crops, when it came to policy-making on Bt-brinjal, a hierarchy of knowledge emerged with science at its top.

Nevertheless, my analysis also shows that science does not unproblematically assume the role at the top of a hierarchy of knowledge. Throughout the arenas I have studied - from toxicological risk assessment to the publicly circulating images of possible techno-scientific futures, and participatory policy-making - scientists face allegations of conflicts of interests and corruption. Science as the prime institution of modern knowledge production is questioned for its structural links to particular interests of industry or environmental NGOs, and therefore for its capacity to objectively answer the questions about GM crops. At the same time, science is presented as the arbiter of truth to provide ultimate judgement on the risks, benefits, and desirability of transgenic crops in their socio-cultural environment. This means that the actors in the debate present predictive claims and methods of the science they draw upon to construct the truth claims they make as objective and value-neutral in order to shape political decision-making. At the same time, the actors either screen out or emphasise uncertainty and attachments (commitments and dependencies of scientists) at play in the debate to present themselves and the science they draw on as being trustworthy and reliable, or to deny the same to their opponents.

As Bijker, Bal, and Hendricks show in their book *The Paradox of Scientific Authority* (Bal et al., 2002; Bijker et al., 2009), risk and scientific uncertainty are central characteristics of technological cultures. Although the status of scientific institutions has been eroded particularly when it comes to uncertain and ambiguous risks, scientific advice still has authority to guide political decisions on technology. Yet, they argue, we need to differentiate scientific advice (science-based policy recommendations) from the work by which that advice is produced, which often rests on disagreement and compromise due to uncertainty of knowledge. As my analysis shows, the publics around GM crops question science for its incapacity to provide definite judgement in situations where it cannot predict risks with absolute certainty, as for instance in the case of long-term toxicological risk assessment of NK603 and its associated herbicide Roundup™. Still, science is the best way to find the truth, even if uncertainty prevails with regard to risks, and the GM crops debate is a good example for the epistemic status that science with its specific language about technological risks assumes.

Due to the hegemony of risk discourses as decisive for decision-making on new and emerging technologies, it remains to the scientific community to determine which methods,

theories, and ways of interpretation are best suited to find an answer to the pending questions about such technologies as transgenic crops. At the same time, publics form around the issues that techno-science gives rise to, such as questions of how to feed the hungry, how to preserve the complexity of interdependent ecosystems, how to sustain economic growth, how to protect farmers' livelihoods, or how to arrange regulatory decision-making in an objective, yet fair, and democratic way. Also, publics engage with and comment on the methods, standards, and tools of science, as I show in chapter two. The case of Séralini's contested long-term toxicological feeding study, as well as the issues raised around regulatory institutions and the links between science and industry show that public engagement questions the institutions and organisation of scientific knowledge production they would like to see much more complimented by other (i.e. public) sources of knowledge. However, this does not mean we need entirely new institutions of scientific advice, but instead these need to be made more transparent and accountable. Further, to democratise science and technology decision-making, we need non-scientific input in policy processes through "a radical increase in public participation in order to complement the existing structure of representative democracy" (Bijker et al., 2009, p. 153) – the Bt-brinjal consultations are an example of how this ideal could be achieved. This view is confirmed by the issues citizen publics raise, particularly if technological risks are ambiguous and uncertain (i.e. marked by a high degree of scientific uncertainty and broader disagreement as to the values and societal goals), as opposed to simple or merely complex risk issues (i.e. marked by a low degree of scientific uncertainty and disagreement).[201] Activist Sahai explained for instance that technologies are powerful agents of change, which "need to be subject to scrutiny and control and the penalising action of the public. Without that they will become dangerous" (interview Sahai, 2012).

Publics raise issues that the science of transgenic crops cannot answer, since such concerns have complex political, normative, and temporal dimensions that quantitative risk assessment is unable to incorporate in its evaluation of transgenic crop technology. Publics are a necessary counterbalance to science to prevent a de-politicisation and displacement of politics. When there are important social and political concerns implied with a technology, publics have the power to make debates about technology more socially and politically reflexive. By explicating political issues around technology, publics have the capacity to rearticulate the object of politics and thus to prompt political decision-making on technology to become more inclusive, holistic, and democratic. However, it is not only science that is caught up in a paradox, but public authority can also be contradictory: publics can be constructed to democratize science and technology, but publics can equally be constructed to prevent the politicization of issues and the pluralization of voices in technological controversy. It is the implications for the wider question of democratising political cultures of techno-science to which the broader question of my research applies and to which I shall turn next.

[201] This classification of risk problems stems from Renn (2005): Simple risks means risks can be described clearly and scientific knowledge is certain and almost complete; complex risks means scientific knowledge is certain but there remains scientific disagreement due to the complexity of variables involved; uncertain risks are marked by a high degree of scientific uncertainty, e.g. regarding long-term effects and at the same time there is scientific knowledge that indicates there might be harm; ambiguous risks refers to situations in which there is no agreement as to the values and societal goals implied with a technology (see also Bijker et al., 2009, pp. 158-162).

Democratising Techno-Scientific Culture: the paradox of public authority

The broader motivation to study the case of the GM crops debates in India and Europe is to understand democratic politics in technological culture. I therefore asked: How do GM crops technology and public involvement in this issue shape democratic political culture in a globalized techno-scientific world? The answer to this question extends the audience of this book beyond those immediately concerned with the debate about transgenic crops. How GM crop technology and social and political order interrelate is not only of interest to the actors who participate in the debate about the risks of this technology, or to STS scholars who want to understand and explain the politics of techno-scientific controversies to incorporate such knowledge in theoretical and conceptual refinement. Understanding the debate about transgenic crops as a case of the co-evolution of technology and democracy is also of interest to those who want to get a better grasp of the evolution of political culture, be it political scientists, policy-makers, or citizens. The lessons learned from this debate can also be useful for understanding other controversies about techno-science in which the constitution and involvement of publics as units of social aggregation is thought to be important for democratic politics. So, what does the case of the GM crops debate tell us about how democracy gets shaped in a deeply inter-connected techno-scientific world?

My analysis has shown the central role of publics in the controversy about the risks and benefits of transgenic crops. GM crops as well as publics are subject to interpretative flexibility in the different arenas of the controversy. So, the arenas of the debate provide the context for the construction of both, the multiple meanings ascribed to transgenic crops, and a plurality of publics. Accordingly, the construction of GM crops and publics goes hand in hand. This not only confirms the epistemological argument in STS that the technical is political, but it also empirically describes the politics of technology in risk society (cf. Beck, 1992; Thorpe, 2008). Although the labels attached to various publics are similar across the arenas of the debate, they differ in meaning, depending on contextual contingencies, i.e. the arena of toxicological risk assessment allows making different arguments (and constructing different publics) than the arena of the imaginaries of a sociotechnical future. Conversely, in the policy-making arena, we saw various issue-based publics striving to impact political decision-making. However, in each arena, certain issues were regarded as more legitimate than others. Accordingly, the issues connected to GM crops speak to and from such publics, i.e. publics form around the issues relevant social groups raise in technological controversy and at the same time, publics represent these issues in the various arenas of the debate. This shows two things: 1) the construction of publics in the GM crops debate is continuous, i.e. publics are neither restricted to election-based representation, nor to single arenas of the controversy, but they are continuously being constructed by the actors in the debate *across* different arenas; and 2) publics can be understood as multiple, shifting, overlapping networks of interaction. This means that publics remain elusive, despite the analyst's attempt to empirically and conceptually fix them.

This elusiveness of issue-based publics corresponds with the goals of technological development being diverse and contested rather than clear and given. Technology is not neutral, but has normative and temporal aspects that do not necessarily receive equal consideration in

policy-making, as for instance questions about biosafety through scientific risk assessment. When public involvement (in particular uninvited forms of participation) challenges established representations of issues and the normative commitments of experts, it is a clear sign that there is a lack of recognition of issues and meanings ascribed to a technology, which in turn requires settlement through political contestation, debate, and positioning (cf. Wynne, 2007). A clear example is the temporal dimension of those sociotechnical imaginaries I have described in chapter three. The temporality of imaginaries in reference for instance to neo-colonial structures, ecological time spans, and capitalist markets illustrates the necessity for deeper debate. Finally, in democratic societies, one can expect such contestation to be a fruitful impetus for political decision-making. As Philip Kitcher (2001) argues, the directions of techno-scientific development are best determined through informed public deliberation since critical inquiry in public debate can enhance the societal value of techno-science. Independent of its outcome, we can interpret the Bt-brinjal consultations in this light, for parts of the public got a voice that were previously entirely excluded from GM crops policy-making. It remains a question however, if and how the Bt-brinjal consultations can serve as a blueprint for similar debates about technological development, in particular in political contexts different from the one in India. The vibrant discourse by a plethora of societal groups in the Bt-brinjal consultations revealed the argumentative heterodoxy which in turn serves as a good example of lively democratic debate that other democracies can learn from.

Public involvement in the controversy about transgenic crops has important effects: it questions the assumptions underlying scientific knowledge production about the epistemic privileges of experts; it rearticulates the importance assigned to some risks and not others; it makes explicit both normative underpinnings and structural constraints at play; and it challenges existing institutional arrangements as inadequate to solve conflicts about technological development (cf. Yearley, 1999). Why is this important for democracy, one might ask. The notion of 'the public' is at the heart of democratic politics which tries to solve conflicts between different societal interests through negotiation and compromise. Usually, in democracy the relationship between state and society is mediated through election-based representation. Yet, as my analysis shows, publics are more than that. Instead, publics are continuously constructed in the various arenas of the controversy, which is not restricted to pre-election periods. Yet, the publics in such debates about techno-science still remain representations, i.e. some actors function as representative of a larger group of people affected by an issue and in whose name they claim to speak. Publics rarely become a tangible entity, unless physically present in protest and direct action or when getting labelled as such, for instance in organised engagement exercises such as the Bt-brinjal consultations. Rather, publics are constructed in the discourses and practices particular to the different arenas of the controversy. So, publics remain an abstract entity of collective political agency that is bound together by common discourse. Such discourses, I argue, are specific to the respective arena in which they take place, and so are the constructions of elusive publics dependent on the contextual contingencies of the arena in which they are constructed.

Despite a multiplicity of elusive publics at play in the GM crops debate, various actors refer to a single 'public': scientists do so to demarcate their expertise from lay knowledge; in publicly circulating imaginaries, publics are both those affected by an issue, and those who form a receptive audience to the arguments of such futures (each imaginary claims to speak

for, from, and to 'a public'); and policy-makers refer to 'the public' in order to be responsive to societal debate, to present their decisions to be in the public interest, and to legitimise their political decisions in case of conflict. Minister Jairam Ramesh's moratorium decision bears witness to this tendency to understand publics as a singularity. This goes back to democratic theory as it developed in the nineteenth and twentieth centuries, which took for granted the link between the demos, electoral mechanisms for representation, and the territorial boundedness prescribed by the nation state as the prime form of socio-political organization (Held, 2003). Vis-à-vis the state, there was only one electorate and accordingly one public. However, the idea of elusive publics draws into question not only the conception of the public as a singularity, but also the link between the demos and the territorial boundedness of the nation state. This applies in particular in the context of globalising techno-science, where the same GM crop technology is supposed to work the same in widely different agrarian, cultural, economic, and social contexts. The case of Séralini's contested long-term toxicological feeding experiment shows how the results of his study also had a meaning for the Indian debate, and how for instance civil society actors invoked the study beyond the European context to warn about the potential long-term risks of GM crops and their complementary pesticides. In India's Bt-brinjal consultations, not only Indian actors participated, but scientists, corporate representatives, and civil society groups from other places also participated in the debate. Similarly, the moratorium decision had implications for other parts of the world, from the Philippines to the European Union, if only as an example of a groundbreaking regulatory decision against GM crops for human consumption.

Accordingly, elusive publics supersede the boundaries set by the polity of the nation state. This becomes particularly evident when examining the issues civil society actors address in India and Europe – the object of politics often is very similar, e.g. the role of consumers, the integrity and balance of ecosystems, the political sovereignty of the farming community, or the role of regulatory ideas such as precautionary principle. Moreover, the issues themselves and the corresponding socially constructed publics are enmeshed in transnational linkages, be it through the normative questions how to feed the hungry, stimulate economic growth, to preserve environmental stability, to protect the farming community's autonomy and livelihood; or how to model regulatory institutions to become more transparent and accountable. Different social groups address these same issues, independent of their geographical location. Publics are therefore not only elusive, but they are transnational in character, spanning different cultural, spatial, and temporal domains (cf. Fraser, 1990, 2007).

The various consumer, farmer, and citizen publics had different meanings to different actors in different arenas, despite getting assigned the same labels. The concepts of publics offered by anthropology, political science, and STS literature have their limits in describing and categorizing the elusive publics in the GM crops debate. While Chatterjee suggests civil society and political society to be spheres apart, in the Bt-brinjal consultations civic engagement inside the auditoriums and unruly protest outside the venues went hand in hand: Street-level protest as a form of non-elite political mobilisation by political society complimented the argumentative engagement of those civic actors who spoke to the Minister. The conception of a public sphere in which civil society engages with the state (Habermas, 1989) therefore does not fully hold. Instead, the case of the Bt-brinjal consultations shows how various publics from civil as well as political society acted in concert in order to shape the Minister's

decision. Varughese (2012) offered a conceptual refinement of different forms of publics based on the idea of political and civil society which we can use to better understand the GM crops debate: scientific citizen publics, quasi-publics, and non-publics.

Figure 12: Farmer Jury assembly in Bhubaneswar, Odisha (author, 2012)

Scientific citizen publics engaged in the controversy about Séralini's long-term feeding study on NK603; but such publics are also integral to constructing imaginaries of sociotechnical futures, which actors try to invest with authority and credibility by drawing on scientific literature to make trustworthy predictions about how technological development will shape society's future; scientific-citizen publics also appeared in the Bt-brinjal consultations when various actors attempted to convince the Minister by either presenting themselves as scientists, and by appealing to scientific rationality, or to the uncertainty of scientific knowledge. Quasi-publics, whose mode of engagement with the state and the economy are not regarded as legitimate also appear in different forms and arenas: the destruction of GM crops field trials by European activists; the vandalizing of fast-food restaurants as symbols of neoliberal globalisation by Indian farmers; when protestors attempted to prevent certain groups from gaining access to the Bt-brinjal consultation venues; and when farmer cooperatives in India and Europe try to establish their own retail chains in order to circumvent established market and pricing structures. Non-publics in contrast appeared as reference points when for instance claims were made about the socioeconomic effects of GM crops, farmer suicides, and the interests of small and marginal subsistence farmers in developing countries – yet, non-

publics indeed merely serve as a reference point for other actors, instead of gaining a discursive voice themselves. However, grassroots NGOs such as Living Farms in Bhubaneswar, Odisha work had to empower small and marginal farmers to inform themselves, organise and exchange their ideas about the future of farming to gain a political voice (see also figure 12 above). Varughese's conceptual taxonomy appears useful for categorising the publics at play in the GM crops controversy and for understanding the subjective position of some publics vis-à-vis the economy, the state, and other publics. However, assigning such labels does not tell us about the elusiveness of publics and the implications that multiple and shifting collective political subjectivity has for democratic politics in techno-scientific culture.

What lessons are to learn when explaining the construction of GM crops and elusive publics if we want to understand efforts to democratise scientific and technological development? Although publics are not always strategically constructed, I suggest STS research can contribute to understanding technological controversy much better if it pays greater attention to how different publics exist concurrently, how publics shift from one subjectivity to another, and how in the process of technological controversy publics are subject to a process of stratification. The latter refers to publics being shaped by mechanisms of socioeconomic differentiation and inequality of social status ascribed to certain relevant social groups of the debate. This means different publics take relative positions in different arenas of technological controversy which determines the hierarchies of knowledge at play in the respective arena. Accordingly, it makes sense to investigate the strategies of publicity with which different social groups construct publics to either (re-)produce or challenge such stratifications.

Indian journalist Devinder Sharma for instance explains the changing campaigning strategies against Bt-brinjal from constructing a farmer public concerned with the environmental and socioeconomic risks of Bt-brinjal, towards including middle-class urban elites' concerns for healthy food consumption. To him, the turn towards middle-class issues was a pragmatic choice oriented towards shaping policy-decisions: "I will go on changing my strategy depending on what suits me" (interview Sharma, 2013). The elusiveness of publics therefore also refers to shifting constructions: from unruly quasi-publics to scientific citizen publics and vice versa. Particularly farmer organisations are illustrative of such shifting collective subjectivity: once spraying milk at riot police in Brussels, or ransacking fast-food restaurants in Bangalore, farmer publics (often with the help of activists) can also engage in more democratic modes of discursive engagement to negotiate with political and economic elites through their leaders; but they can equally go back to more unruly modes of protest action, for instance the destruction of GM crop field trials, or use these different modes of political engagement concurrently (interview Brändle & Hollow, 2012).

Moreover, although consumer, citizen, and farmer publics got a voice in the Bt-brinjal consultations for their manifold political arguments, scientific rationality came out on top in a hierarchy of knowledge that shaped Ramesh's decision for the moratorium – his decision reflects which issues he thought were most significant and which actor (namely science) could provide an answer to the open questions about Bt-brinjal's risks. Again, explaining the stratification of publics will yield greater insights into the democratic credentials of such attempts to include public knowledge into political decision-making. Organising public debates and consultations, as democratic as such efforts might appear on first sight, does not guarantee that the debate itself will become more democratic, or that state institutions will give

greater room for public voices and knowledge in their decisions. A perspective that takes into account how publics acquire an authoritative voice that is taken up in policy-making discourse and decision-making will help to understand the democratic character of techno-scientific controversy. Such a perspective can help to explain why some publics can legitimately be referred to in some arenas, and not in others, and under which circumstances it might make sense to assign a greater role for public involvement in debates about techno-science and its risks, for instance through a greater degree of institutionalisation of public participation. Ultimately such knowledge might help to make science and technology decision-making more responsive to society's concerns.

This perspective does not naively assume that letting publics speak or participate in institutionalised discourses is per-se leading to more democratic debates and decisions on science and technology. Since it can equally be the other way around, public authority is caught in a paradox: drawing on and constructing publics in technological controversy can be understood as making a call for the politicisation of issues in order to make decision-making more inclusive, fair, and respectful towards those affected by an issue related to techno-science. However, drawing on and constructing publics in technological controversy can also exclude certain voices from participating in the debate (e.g. through boundary work) and it can also silence, marginalise, or render certain (political) concerns invalid. This latter tendency is particularly evident when deficit models of the public are mobilised by the actors of a debate since they resent public concerns not as rational and science-based, but as emotional, politically motivated, and based on a general lack of knowledge about techno-science. This is not to say certain publics by default are in a better or worse position to bring into a debate the meanings they ascribe to technology, but that the stratification of (representations of) publics is central for understanding why some concerns are perceived as better or worse, or more or less valid than others by decision-makers.

Some actors, particularly in India, have argued for the institutionalisation of public participation when there is extensive public opposition to technological development. Scholars have similarly made a point for broader societal debate in case of complex and uncertain technological risks to increase the legitimacy of decision-making (Benhabib, 1996; Jasanoff, 2003, 2007; Wynne, 2003), though STS scholars have pointed to the complications such calls for more deliberation imply for democratic practices and institutions (Brown, 2007, 2009, 2015; Hagendijk & Irwin, 2006; Moore, 2010). At the same time, a paradox between public deliberation and a lack of consistent criteria for how to make it work in liberal democracy exists (Lövbrand et al., 2011). Let me finally turn to the broader question of the democratisation of technological culture.

Democratising science and technology is neither straightforward business nor will the insight that publics are multiple, shifting, and elusive make it much easier either. As my analysis has shown, publics get continuously constructed in the various arenas of the debate about GM crops. Only in some instances, such publics have access to institutionalised procedures, and in the case of the Bt-brinjal consultations, it was a unique decision by Jairam Ramesh to include publics in policy-making. Some actors opposed this move out of principle because they could not see anything coming from such engagement but irrational and emotional anti-GM propaganda. Others in contrast saw institutionalised participation as a chance to bring forward issues so far unattended, and accordingly to bring those publics into the

policy-making arena, which had until then been excluded from the debate. To them, Ramesh's call for public engagement was a showcase of how to democratise technological development. Accordingly, civil society generally is positive of gaining an institutionalised place in decision-making processes vis-à-vis the privileged access science and industry have to policy-makers. However, simply institutionalising publics will not do.

While participation allows access for some publics, at the same time, its institutionalisation bears the danger of reproducing the stratification of knowledge with the effect of yet excluding others. Future attempts to democratise science and technology under circumstances when a multiplicity of shifting and elusive publics is at play need to be highly sensitive to the possibility of creating new forms of stratification and exclusion. Just calling on publics to provide input to established institutional procedures, or creating institutional mechanisms for including certain publics will not instantly democratise science and technology. Rather, if we want to radically change the ways in which political decision-making becomes more responsive to public knowledge, we need new institutional ways of negotiating the compromises necessary between expert and public knowledge – and to find ways in which different sorts of knowledge get their legitimate place in the political process leading up to decisions on techno-scientific development. How such mechanisms need to look like will most likely depend on context and case. In that sense, the Bt-brinjal consultations were a timely and necessary institutional route to go, but we cannot predict whether the same mechanisms will work equally well in other cases and places.

When thinking about the stratification of publics, it makes sense to look more closely at the attachments (cf. Gomart & Hennion, 1999; Marres, 2007), i.e. active commitments and dependencies of individual actors and relevant social groups, and to make these transparent and explicit. This applies in particular if societies aim for democratising debates about technological development more generally. Since some actors with financial and professional ties to industry and other vested interests construct various publics, we need to carefully look at the networks they embed in between science, industry, and civil society activism, for these actors have different capacities and strategies of publicity. I have shown for instance in chapter two how certain actors present themselves as either members of the public, or as supposedly value-neutral scientists in order to make their arguments appear more legitimate, while their attachments lie elsewhere than the publics they seem to speak to and from. Certainly, due to the power of capital, industry actors are in a different position than activists when it comes to producing forms of publicity in the debate about transgenic crops. For publics are not static and fixed, but fluid and elusive, and dependent on the contextual contingencies of the arenas in which the controversy plays out, policy-makers need to be more sensitive to such structures that link commercial, financial, and professional ties between actor groups in the constructions of publics. That is in case policy-making wants to give an equal voice to all those involved in technological controversy and affected by technological innovation, i.e. if policy-makers strive for democratising decision-making on technological development.

An institutionalisation of public involvement in policy-making as desired by many actors in India allows giving those a voice who are habitually excluded from elite forms of political contestation. At the same time, there is no universally applicable blueprint of how to make such institutionalisation fair and inclusive and how to avoid creating now forms of exclusion and marginalisation. It is at this point, where I see a greater role for STS researchers to get

involved in debates about techno-scientific development more directly through reflexive analysis and evaluation of technological controversies and cultures. STS researchers have the capacity to become public intellectuals who combine "their long-term academic agendas with clear political and societal engagement" (Bijker, 2003, p. 7). This means STS research cannot only meaningfully contribute to understanding technological controversy conceptually and theoretically, but it can also help policy-makers in designing case-specific institutional structures for inclusive public engagement, or even devote part of its work to the political empowerment of publics marginalised and excluded from techno-scientific controversy.

Finally science, being so central to debates about techno-scientific development, will also need radical reform. Many actors in science and activism saw the incapacity of science to provide judgement on the question of the (un-)desirability of transgenic crop technology not so much in the uncertainty of scientific knowledge, but rather in the conflicts of interest stemming from the structural ties between institutional knowledge producing practices and the way these get financed. In particular Indian actors located a shift in the role of scientific institutions in the liberalisation of the Indian economy during the 1990s, which led to the privatisation of science. Since then, publicly funded scientific institutions incrementally got replaced by corporate-funded knowledge production, and their activities fall out of public purview, for instance through the Right to Information Act, which only applies to public institutions (interview Saldanha, 2012). Activist Suman Sahai explained in this regard: "everything began to go wrong with the privatisation of science, the conflicts of interest, the public perception of science became cloudy, and questions arose as to who was benefiting from the science – not the people" (interview Sahai, 2012). Considering that the same actors which apply for market approval of transgenic crop technology are also responsible for assessing its risks, it becomes imperative to argue for a greater role of public institutions in scientific risk assessment in Europe and India alike. Founding member of EFSA Herman Koëter and eminent figures of Indian science such as PM Bhargava and MS Swaminathan all argued for scientific risk assessment of transgenic crops (and other technologies) to be taken out of the hands of corporate actors. Accordingly, a task for regulators will be to invest in publicly funded institutions for scientific risk assessment and to impose and enforce rules that oblige knowledge production to be more transparent and accountable, in particular in regard to conflicts of interest, instead of naively assuming existing rules sufficiently exclude the potential for corruption.[202] Finally, there remains no easy way out to the paradox of either, scientific or public authority, due to the political, normative, and temporal aspects of technological controversy, in which elusive publics continuously get re-constructed.

[202] I have shown in chapter two, representatives from DG SANCO regard EFSA to have a well-working policy with regard to surveying potential conflicts of interest of its scientific members. Nevertheless, civil society actors such as Corporate Observatory Europe (CEO) and Friends of the Earth repeatedly have pointed to loopholes in EFSA's system for managing its scientific personnel's potential conflicts of interest. Also in the Indian case of Bt-brinjal, scientists with direct professional and financial ties to the GM producing industry were involved in ECI and ECII, which both positively assessed the adequacy of Mahyco's risk assessment and GEAC's evaluation thereof. According to civil society activists, this seems to repeat itself in the current case of assessing transgenic mustard.

Appendix: List of Interviews

Name	Function/ Organisation	Date, Place
Babu, Dr. P.	Director, Institute for Cultural Research and Action	11.01.2013, Bangalore
Bekkem, Herman van	Campaigner Gentech en Duurzame Landbouw, Stichting Greenpeace Nederland	13.12.2012, Amsterdam
Bhargava, Prof. Dr. Pushpa Mittra	Former Director Centre for Cellular and Molecular Biology, Hyderabad	28.03.2012, Hyderabad
Brändle, Philipp &	Former Press Officer, Witzenhäuser Agrar Studierende, Landwirte und Gärtner für eine gentechnikfreie Landwirtschaft	22.06.2013, Berlin
Holloh, Regine	Coordinator and Campaigner, Meine Landwirtschaft	
DG SANCO	Policy Officers Biotechnology, European Commission, Health and Consumers Directorate (DG SANCO)	10.01.2014, Brussels
EFSA	European Food Safety Authority, GMO Panel	25.03.2014, Parma & Maastricht (via telephone)
Waigmann, Elisabeth	Head, GMO Unit, EFSA	
Devos, Yann	Scientific Officer, GMO Unit, EFSA	
Ramsay, James	Editorial and Media Relations Unit, EFSA	
Gall, Eric	Parliamentary Assistant to Member of European Parliament Corinne Lepage	16.07.2013, Brussels
Ganeshaiah, Prof. K.N.	Trustee Ashoka Trust for Research in the Ecology and the Environment (ATREE), Honorary Senior Fellow Jawaharlal Nehru Centre for Advanced Scientific Research (Bangalore)	28.02.2013, Bangalore
Ganguly, C.K. (Babloo)	Chief Functionary, Timbaktu Collective	15.02.2013, Amritha Bhoomi, Chamaraja Nagar
GEAC member (former) preferred to remain anonymous	Researcher in agricultural sciences, forestry, environmental sciences, ecology, and conversation	28.02.2013, Bangalore
Gheysen, Prof. Dr. Godelieve	Director Institute of Plant Biotechnology Outreach, Department Head Molecular Biology, Faculty of Bioscience Engineering, Universiteit Gent	11.12.2012, Gent
Gupta, Ashish	Secretary, Organic Farming Association of India	25.01.2013, Delhi
Isaac, Dr. Benson	Researcher, Azim Premji University	16.01.2013, Hyderabad
Janßen, Georg	Secretary General (Bundesgeschäftsführer), Arbeitsgemeinschaft Bäuerliche Landwirtschaft	06.06.2013, Hamm (Westfalen)
Kannan, Dr. Elumalai	Associate Professor Agricultural Development and Rural Transformation, Institute for Social and Economic Change (Bangalore)	11.01.2013, Bangalore
Kannayan, S.	Convener South Indian Coordination Committee of Farmers' Movements (SICCFM)	14.02.2013, Amritha Bhoomi, Chamaraja Nagar
Khadse, Ashlesha	Global Communications Officer, La Via Campesina	14.02.2013, Amritha Bhoomi, Chamaraja Nagar
Koëter, Herman B.W.M.	Managing Director, Orange House Partnership	28.09.2012, Brussels

Name	Function/ Organisation	Date, Place
Krishnan, Rajesh	Campaign Manager Agricultural Campaign, Greenpeace India	24.02.2012, Bangalore
Kuruganti, Kavitha	Convener, Alliance for Sustainable and Holistic Agriculture	16.02.2012, Bangalore
Kuruganti, Kavitha	Convener, Alliance for Sustainable and Holistic Agriculture	08.01.2013, Bangalore
Mathur, Dr. Pooja Bhatnagar	Senior Scientist molecular biology, International Crop Research Institute for the Semi-Arid Tropics (ICRISAT)	21.01.2013, Patancheru, Hyderabad
Mishra, Dr. Savy	Deputy Programme Manager food safety and toxins, Centre for Science and Environment	09.03.2012, Delhi
Mishra, Prof. Srijit & Sarthak, Dr. Gaurav	Researchers development economics, Indira Gandhi Institute for Development Research	13.03.2012, Mumbai
Müller, Dr. Jan Marco	Assistant to the Chief Scientific Advisor to the European Commission, Bureau of European Policy Advisers	10.10.2014, Brussels
Nagaraj, Dr. N.	Principal Scientist economics, International Crop Research Institute for the Semi-Arid Tropics (ICRISAT)	21.01.2013, Patancheru, Hyderabad
Padmanaban, Prof. Govindarajan	Professor of Biochemistry, Indian Institute of Science (Bangalore)	19.02.2012, Bangalore
Prasad, Dr. Shambu Chebrolu	Assistant Professor Rural Management, Xavier Institute of Management, Bhubaneswar	20.-21.03.2012, Bhubaneswar
Ramanjaneyulu, Dr. G.V.	Executive Director, Centre for Sustainable Agriculture	27.03.2012, Hyderabad
Ramanjaneyulu, Dr. G.V.	Executive Director, Centre for Sustainable Agriculture	19.01.2013, Hyderabad
Ramesh, Dr. M.K.	Senior Assistant Professor of Law, National Law School of India University (Bangalore); Member of India's National Biodiversity Authority	23.02.2012, Bangalore
Rao, Dr. Chavali Kameswara	Executive Secretary, Foundation for Biotechnology Awareness and Education (FBAE); Consultant Biotechnology and Medicinal Plants	10.01.2013, Bangalore
Ravikanth, Dr. G.	Research Fellow (Associate Professor) Biosystematics Programme Ashoka Trust for Research in Ecology and the Environment (ATREE)	07.02.2013, Bangalore
Sahai, Dr. Suman	Director, Gene Campaign	28.02.2012, Delhi
Sakkhari, Kiran	Programme Anchor – Millets, Watershed Support Services and Activity Network (WASSAN)	28.03.2012, Secunderabad
Saldanha, Leo	Coordinator, Environmental Support Group	20.02.2012, Bangalore
Sanchez, David	Researcher and Campaigner, Corporate Europe Observatory	14.06.2012, Brussels

Name	Function/ Organisation	Date, Place
Sarangi, Debjeet	Founder and Management Trustee Living Farms, Bhubaneswar	17.03.2012, Bhubaneswar
Sarvaas, Carel du Marchie	Director Agricultural Biotechnology, EuropaBio the European Association for Bioindustries	10.12.2012, Brussels
Satheesh, P.V.	Director, Deccan Development Society; National Convenor Southern Action on Genetic Engineering; National Convenor Millet Network of India; South Asia Coordinator Alliance for Democratising Agricultural Research in South Asia	18.01.2013, Pastapur, Medak District, Andhra Pradesh
Satish, Joseph	Research Associate, Knowledge in Civil Society	24.03.2012, Secunderabad
Schimpf, Mute	Food Campaigner Food, Agriculture and Biodiversity Programme, Friends of the Earth Europe	28.09.2012, Brussels
Seetharama, Nadoor	Executive Director, Association of Biote-led Enterprises (ABLE)	28.01.2013, Delhi
Séralini, Prof. Dr. Gilles-Eric	Professor of Molecular Biology, Laboratory of Biochemistry and Molecular Biology, University of Caen; President Committee for Research & Independent Information on Genetic Engineering (CRIIGEN)	15.05.2013, Caen & Maastricht (via Skype)
Sharma, Devinder	Journalist, agriculture, food and trade policy analyst	14.02.2013, Amritha Bhoomi, Chamaraja Nagar
Sharma, Dr. Kiran	Principal Scientist cell biology, International Crop Research Institute for the Semi-Arid Tropics (ICRISAT)	21.01.2013, Patancheru, Hyderabad
Shiva, Dr. Mira	Director, Initiative for Health, Equity & Society	02.03.2012, Delhi
Singh, Yudhvir	General Secretary, Bharatiya Kisan Union (BKU)	03.02.2013, Delhi
Sopori, Dr. Sudhir	Vice Chancellor, Jawarhalal Nehru University	06.03.2012, Delhi
Swaminathan, Monkombu Sambasivan (M.S.)	Chairman Swaminathan Research Foundation	11.02.2013, Chennai
Vergnettes, Jeannie	Legislative Officer, Principal Administrator, Health and Consumers Directorate, European Commission, (DG SANCO)	21.03.2014, Brussels
Vissa, Kiran	Member of Board of Directors, Association for India's Development	16.01.2013, Hyderabad

Nederlandse Samenvatting

Elusive Publics onderzoekt de constructie van genetisch gemodificeerde (gg) gewassen door de rol van het publiek in de huidige controverses rond de risico's en voordelen van deze technologie in India en Europa te onderzoeken. In de discussie rond transgene gewassen beroepen vele actoren zich op het concept van het publiek om hun beweringen over de (on-)wenselijkheid van de technologie te ondersteunen. Tegelijkertijd vindt er een bredere publieke discussie plaats over de culturele, economische, sociale en politieke implicaties ervan. Deze controverse is al aan de gang sinds gg-zaden in de jaren '90 voor het eerst op de markt werden gebracht in de geïndustrialiseerde landen en is meer recent weer in een stroomversnelling gekomen toen multinationals de technologie voor transgene gewassen overbrachten naar ontwikkelingslanden. Daarom kijkt deze studie naar de controversen rond gg-gewassen vanuit het perspectief van de publieksgroepen om inzicht te krijgen in de sociale constructie van deze technologie. Deze studie betoogt dat het publieksgroepen geen vaststaande entiteiten zijn, maar net zoals de vele andere kwesties rond transgene zaden voortdurend worden gevormd in de loop van de discussie. Daarom wordt in dit onderzoek de centrale vraag behandeld hoe gg-gewassen gevormd worden door de betrokkenheid van het publiek en welke soorten publieksgroepen worden geconstrueerd in de verschillende arena's van de discussie.

Om inzicht te krijgen in de wederzijdse vorming van technisch-wetenschappelijke en sociale ordes van gg-gewassen en de daaraan verbonden risico's enerzijds, en van publieksgroepen in de controverse rondom deze technologie anderzijds, kijkt deze studie vanuit het perspectief van de constructivistische *Science, Technology, and Society Studies (STS)*. In het bijzonder wordt de theorie van *Social Construction of Technology* gebruikt om inzicht te verwerven in de manier waarop gg-gewassen onderworpen zijn aan een cultureel ingekaderd proces van constructie en interpretatie. De studie verklaart op welke manier de technologie verschillende betekenissen kan hebben voor verschillende groepen mensen in hun eigen culturele en historische contexten. Er wordt gesteld dat niet alleen transgene zaadtechnologie sociaal geconstrueerd wordt, maar dat publieksgroepen eveneens onderworpen zijn aan verschillende interpretaties en constructies. De auteur hanteert kwalitatieve sociaalwetenschappelijke methodes voor een *multi-sited ethnography* van de discussies rond gg-gewassen in Europa en India, waar de controverses voortduren. De etnografie volgt de circulatie van de bij het debat betrokken artefacten, discoursen, ideeën, betekenissen, mensen en instellingen in verschillende ruimte- en tijdschalen en sociale schalen. De verschillende kwesties rond transgene gewassen en de constructie van publieksgroepen die aan het debat deelnemen via verschillende publiciteitsstrategieën, zijn in deze studie vastgesteld op basis van interviews met belangrijke actoren in de discussies, de observatie van deelnemers en de analyse van documenten. In deze technisch-wetenschappelijke controverse, zo betoogt de auteur, wordt een veelheid aan publieksgroepen geconstrueerd. Dat studie toont aan dat er nog steeds moeilijk grip te krijgen is op publieksgroepen in de discussie rond gg-gewassen, omdat zij aan voortdurende verandering onderhevig zijn en daarom ongrijpbaar blijven, ondanks een aantal nuttige conceptuele benaderingen van publieksgroepen in de antropologische, politicologische en STS-literatuur.

In drie empirische hoofdstukken worden verschillende arena's van het debat behandeld: hoofdstuk twee onderzoekt hoe wetenschappelijke expertise wordt geconstrueerd bij de evaluatie van gezondheidsrisico's van gg-gewassen; hoofdstuk drie gaat over de kwesties die

actoren in verband brengen met de risico's en voordelen van transgene gewassen door toekomstscenario's voor te stellen met of zonder transgene zaadtechnologie; in hoofdstuk vier wordt onderzocht welke rol publieke inspraak speelde in de beleidsvorming rond het eerste gg-voedselgewas in India, Bt-brinjal. Het begrip 'arena' dient in deze studie als een heuristische metafoor om de symbolische locaties van deze technisch-wetenschappelijke controverses te identificeren. De bedoeling hiervan is te laten zien hoe verschillende actoren collectief optreden in de discussie om de epistemologische en normatieve kwesties rond gg-gewassen expliciet te maken en hoe ze de collectieve besluitvorming over de risico's van de technologie proberen vorm te geven.

In het hoofdstuk *More than Just Rats* wordt de arena van wetenschappelijke risicobeoordeling onderzocht door te kijken naar een betwist voedingsonderzoek op lange termijn waarbij mogelijke tekenen van toxiciteit van herbicide-resistente gg-maïs en de bijbehorende herbicide werden vastgesteld bij ratten. Na langdurige controverse tussen wetenschappers, journalisten, burgers en vertegenwoordigers van maatschappelijke organisaties en het bedrijfsleven, werd de studie ingetrokken door het peer-reviewed internationale tijdschrift waarin het oorspronkelijk was geplaatst. Een paar maanden later werd het artikel echter gepubliceerd door een open-access-tijdschrift. Het hoofdstuk volgt de discussie over de publicatie, intrekking en herpublicatie van de studie om te begrijpen hoe het toxicologische voedingsonderzoek onderwerp van publieke inspraak werd en hoe verschillende actoren de status van het onderzoek als legitieme en betrouwbare wetenschappelijke kennis hebben beoordeeld. Deze casus laat zien hoe wetenschappelijke en publieke controverse op elkaar kunnen ingrijpen. In eerste instantie werd de publicatie betwist vanwege de onconventionele opzet van het langetermijnonderzoek en gerelateerde vragen over de methode en interpretatie van de gegevens. De discussie bleef echter niet beperkt tot wetenschappelijk publicaties. De betrokkenheid van het publiek ging ook een belangrijke rol spelen. Er ontstond controverse over de afbakening tussen feiten en waarden en tussen wetenschap en politiek. Beide kanten van het debat beschuldigden hun tegenstanders ervan een verborgen politieke agenda na te streven, wat ongewenst werd geacht en de zoektocht naar de waarheid over de potentiële toxiciteit van het betreffende gg-gewas hinderde. Dit hoofdstuk laat zien welke strategieën deze actoren gebruikten om de grenzen te construeren van wat volgens hen legitieme en betrouwbare toxicologische kennis was. De tweedeling tussen een zogenaamde waardevrije wetenschap enerzijds en een gepolitiseerde kennisproductie anderzijds ging een belangrijke rol spelen. Dit hoofdstuk stelt dat de controversiële toxicologische studie niet als wetenschappelijk erkend kon worden, omdat de publieke inspraak aan het licht bracht dat de actoren te veel van elkaar afweken in hun definitie van de grens tussen wetenschap en politiek. Bovendien laat de analyse zien dat de wetenschappelijke publicatie-instituties niet een arena van controverse bleven, maar zelf onderwerp van de discussie werden. Hoe langer de controverse voortduurde, des te meer actoren twijfels uitten over het peer-review-systeem en de nauwkeurigheid van wetenschappelijke publicaties. Langdurige publieke betrokkenheid leidde derhalve tot een breder scala aan vragen over de methode, onderzoeksopzet en interpretatie van de gegevens, en over de politisering van de wetenschappelijke risicobeoordeling, met name via financiële, materiële en professionele verplichtingen en afhankelijkheid van wetenschappers en wetenschappelijke tijdschriften.

Het hoofdstuk *Imagining Futures with(out) GM Crops* beschrijft de verschillende toekomstvoorstellingen die de betrokken sociale groepen construeren met betrekking tot technologie voor gg-gewassen. Ervan uitgaand dat risicobeoordeling een te beperkt uitgangspunt is om inzicht te krijgen in de controverse rond gg-gewassen, onderzoekt dit hoofdstuk verschillende sociaal-technische toekomstvisies van transgene gewassen die in het publieke discours zijn geconstrueerd. Deze casus toont aan welk scala aan argumenten en betekenissen verstrikt is geraakt in de discussie: de diverse probleemdefinities rond gg-gewassen en de voorstellingen van de verbonden risico's en voordelen, de constructie van publieksgroepen die relevant zijn voor de respectievelijke sociaal-technische denkbeelden, alsmede de uitdrukking van beleidsopties en voorkeuren – kortom: de interpretatieve flexibiliteit van gg-gewassen en de publieksgroepen. Door te onderzoeken hoe toekomstscenario's met of zonder gg-gewassen worden verbeeld, krijgen we zicht op de normatieve aard van het debat: de verbeelde toekomstscenario's gaan evengoed over de rol van technologie als over wat goed en wenselijk is voor de politieke gemeenschap, d.w.z. de verbeelde ontwikkeling van technische *en* sociale ordes.

Vier sociaal-technische denkbeelden laten zien dat de controverse over transgene zaadtechnologie zeer normatief is: Voorstanders van gg-gewassen mobiliseren de *imaginary of productivity*, waarbij de noodzaak om de wereld van voedsel te voorzien en het economisch concurrentievermogen te verbeteren door middel van technologische innovatie worden benadrukt ten koste van eventuele zorgen over de risico's van de technologie. Hun *imaginary of environmentalism* is een tegemoetkoming aan de eisen van het publiek om milieuvriendelijke technologieën. Hierbij worden gg-gewassen voorgesteld als een duurzame technologie die het gebruik van pesticiden kan verminderen. Critici van technologie voor gg-gewassen verzetten zich echter tegen dergelijke argumenten door beroep te doen op het *imaginary of complex ecology*. Zij benadrukken de complexe onderlinge afhankelijkheidsrelaties in ecosystemen, die door monoculturen van transgene gewassen in gevaar worden gebracht. Op deze manier wordt aan gg-zaden de betekenis verbonden dat ze de biodiversiteit dermate in gevaar brengen dat het ecosysteem kan instorten. Tot slot neemt in het *imaginary of seed sovereignty* de dominantie van transnationale ondernemingen in de zaden- en agrochemische markten als uitgangspunt om te betogen dat gg-gewassen de autonomie en vrijheid van de landbouwers brengen. Dit denkbeeld benadrukt het belang van de diversiteit en beschikbaarheid van zaden en het gevaar dat gg-gewassen daarvoor vormen. Dit hoofdstuk beschrijft ook de tijdsdimensies van deze betekenissen. Deze zijn geworteld in en geconsolideerd door interpretaties van de actoren met betrekking tot de ontwikkeling van de landbouw sinds de *Green Revolution*: ofwel als een eenvoudige technologische impuls aan de productie van gewassen, ofwel als een ecologisch en sociaal problematische transformatie van de landbouw richting input-intensieve landbouwmethoden.

Net zoals de normatieve en temporele onderbouwing van de denkbeelden in de discussie over gg-gewassen strijdig zijn, betwist worden en met elkaar concurreren, zo geldt dit ook voor de verschillende publieksgroepen die in samenhang met dergelijke toekomstvisies geconstrueerd worden. De denkbeelden in de discussie over gg-gewassen in India en Europa tonen aan dat etiketten voor bijvoorbeeld de publieksgroepen van burgers, consumenten en landbouwers, niet slechts één betekenis hebben. In alle sociaal-technisch denkbeelden blijft het publiek een constructie van de actor die namens dat publiek spreekt: Boeren worden

geconstrueerd als groep die belang heeft bij gg-gewassen om de productiviteit te verhogen en inputkosten te besparen, maar ook als groep die risico loopt op verlies van autonomie en soevereiniteit als het gaat om gewaskeuze. Burgers worden geconstrueerd als groep die bezorgd is over de verschillende risico's van de technologie, maar ook als consumenten die voorrang geven aan goedkope consumentenproducten boven politieke overwegingen rond technologische ontwikkeling. Tot slot werden het milieu en het ecosysteem geconstrueerd als ruimten voor de projecties van deze publieksgroepen, d.w.z. als een kneedbare context waarin interventie causaal, lineair en instrumenteel kan zijn, of als een complex web van sociale en ecologische onderlinge afhankelijkheid en kwetsbaarheid dat landbouwtechnologieën op een andere wijze problematiseert. Het hoofdstuk toont derhalve aan dat de denkbeelden in de controverse rond gg-gewassen zowel publieksgroepen aanspreken (als doelgroepen die openstaan voor de normatieve onderbouwing van denkbeelden) als vanuit publieksgroepen spreken (d.w.z. vanuit de kwesties waaromheen sociale groepen zich vormen om collectieve politieke subjectiviteit tot stand te brengen).

Het hoofdstuk *The Bt-brinjal Consultations* analyseert een geval van publieke inspraak in de Indiase regulering van het eerste transgene voedselgewas in het land, Bt-brinjal (aubergine) en stelt de vraag welke publieksgroepen werden geconstrueerd door publieke betrokkenheid en hoe deze het besluit tot een moratorium op de technologie hebben beïnvloed. In de openbare raadplegingen over Bt-brinjal, in 2010 in India gehouden door de Minister of Environment and Forest, Jairam Ramesh, werden diverse publieksgroepen van consumenten, boeren en burgers op zeer verschillende wijze geconstrueerd door een aantal deelnemers: Publieksgroepen van burgers werden geconstrueerd als geïnteresseerd in goedkopere landbouwgrondstoffenprijzen of als zeer bezorgd over de mogelijke gezondheidsrisico's van Bt-brinjal. Publieksgroepen van boeren werden geconstrueerd als geïnteresseerd in innovatieve zaadtechnologie om de productiviteit te verhogen en de inkoopkosten en het gebruik van pesticiden te verminderen, of als groepen die risico liepen ten aanzien van onbekende milieueffecten en een verdere concentratie van de zadenmarkt in de handen van enkele transnationale ondernemingen. Evenzo werden publieksgroepen van burgers geconstrueerd als groepen die vertrouwen stelden in de institutionele mechanismen van de staat en de markt, of als groepen die streefden naar de inbreng van publiek gegenereerde kennis in het regelgevend apparaat en de besluitvormingsprocessen. Beide kanten in de strijd voor en tegen Bt-brinjal construeerden hun eigen publieksgroepen van consumenten, boeren en burgers. Met verschillende vormen van publiciteit tijdens de raadplegingen, van conventioneel maatschappelijk engagement tot onhandelbaar protest, slaagde men erin om niet alleen om de minister te informeren, maar ook om nieuwsberichtgeving te genereren om breder publiek te bereiken.

Het besluit van minister Ramesh tot een moratorium op Bt-brinjal deed een beroep op het voorzorgsbeginsel en leek de wetenschap en de publieksgroepen op één lijn te brengen. Hoewel de minister in zijn besluit kwesties als milieu-integriteit en zadensoevereiniteit noemde, beriep hij zich uitsluitend op wetenschappelijke risicobeoordeling voor de toekomstige besluitvorming over Bt-brinjal. De beleidsvorming ten aanzien van Bt-brinjal was dus gebaseerd op een hiërarchie van kennis, ondanks het raadplegingsproces. De kwesties van waaruit de publieksgroepen van consumenten, boeren en burgers werden geconstrueerd, draaiden allemaal om de wetenschappelijke risicobeoordeling op het gebied van menselijke gezondheid, het milieu, sociaal-economische gevolgen voor de boeren, eerlijke toegang tot

landbouwproductiemiddelen en de mechanismen waarmee epistemisch gezag wordt verleend aan de besluitvorming over regelgeving. Ramesh' aankondiging van een moratorium deed een beroep op de wetenschap als ultieme arbiter van de waarheid: de onderliggende veronderstelling was dat, indien de wetenschap nauwkeuriger en onafhankelijker was, zij de resterende vragen over Bt-brinjal zou kunnen beantwoorden, met name rond de potentiële gevolgen voor de menselijke gezondheid en het milieu. Deze hiërarchie van kennis staat in relatie tot de bredere beleidsvormingscultuur in de Indiase context, die vergelijkbaar is met de regelgevingscultuur in de Europese Unie, waarin risicobeoordeling voorrang heeft boven ethische en politieke zorgen over technologische ontwikkelingen. Dit gaat ten koste van een dialoog over diepere politieke zorgen rond technologie voor gg-gewassen, zoals ideeën over het belang van de stabiliteit van het ecosysteem, de soevereiniteit van de landbouwgemeenschap en de aspiraties van burgers om de institutionele mechanismen van de wetenschap en beleidsvorming voor regelgeving te democratiseren.

Dit onderzoek toont aan dat een publiek geen enkelvoudige, vaststaande entiteit is. Een publiek is een meervoudige, voortdurend verschuivende categorie die door de verschillende actoren in het debat rond gg-gewassen wordt geconstrueerd rond de kwesties waarop de technologie volgens hen van invloed is. De omschrijving van kwesties maakt de vormgeving van publieksgroepen mogelijk, en tijdens dat proces worden transgene gewassen gevormd als politiek object en publieksgroepen als politiek subject. Dit betekent niet dat de sociale constructie van publieksgroepen een mechanistisch en strategisch machiavellistisch proces is, maar wel dat de constructie van publieksgroepen draait om de politieke positionering van diverse vormen van collectieve subjectiviteit in de politieke twisten rond technologische ontwikkeling. Publieksgroepen hebben een dubbele functie: De verschillende betekenisconstructies van gg-gewassen en de kwesties die zich rond de technologie ontwikkelen, spreken verschillende publieksgroepen aan en worden vanuit verschillende publieksgroepen ter tafel gebracht. Dit betekent dat publieksgroepen zowel deelnemers kunnen zijn binnen de arena's van het debat rond gg-gewassen, als doelgroepen van de twisten die daarin gaande zijn.

Naast het onderzoeken van de rol van publieksgroepen in de huidige debatten over technologie voor gg-gewassen, streeft dit onderzoek tevens naar inzicht in de democratische politiek in de hedendaagse technologische cultuur. Tot slot wordt daarom de vraag gesteld: Hoe wordt in een geglobaliseerde, technisch-wetenschappelijke wereld de democratische politieke cultuur gevormd door gg-technologie en betrokkenheid van de burgers in deze kwestie?

In het technisch-wetenschappelijke debat rond gg-gewassen speelt wetenschap altijd een rol in de sociale constructie van publieksgroepen. Een legitieme beoordeling van de mogelijke effecten van de technologie voor transgene gewassen is niet mogelijk zonder deskundige wetenschappelijke kennis. De wetenschap krijgt dan ook een centrale rol bij de constructie van publieksgroepen wanneer zij zich bezighouden met kwesties rond transgene gewassen, m.a.w. publieksgroepen hebben de wetenschap nodig om op legitieme wijze deel te kunnen nemen aan technologische debatten. Publieksgroepen zijn echter ook belangrijk voor de wetenschap en haar epistemische status. Publieksgroepen kunnen worden gedefinieerd in een tegengestelde, vormende en aanvullende rol ten opzichte van techno-wetenschap, maar kunnen zelden worden opgevat zonder wetenschap, m.a.w. wanneer publieksgroepen deelnemen aan een technologische controverse, kunnen zij dit niet doen zonder zich te beroepen op wetenschappelijke kennis als hegemonische vorm van kennisproductie. Vele actoren betogen

dan ook dat besluiten over de technologische ontwikkeling niet uitsluitend op wetenschap gestoeld moeten zijn en dat dergelijke besluitvorming ook gebruik moet maken van niet-wetenschappelijke kennis. Publieksgroepen kunnen een noodzakelijk tegenwicht vormen aan de wetenschap om te voorkomen dat technologie gedepolitiseerd wordt als er belangrijke sociale en politieke kwesties op het spel staan. Dit geeft publieksgroepen dus de macht om debatten over technologie sociaal en politiek reflexiever te maken. Daarom moet men om inzicht te krijgen in het democratisch bestuur van omstreden techno-wetenschap kijken naar de strategieën waarmee publieksgroepen zich een gezaghebbende stem verwerven die wordt opgenomen de beleidsvorming. Een dergelijk perspectief kan mede verklaren waarom er in sommige arena's een legitiem beroep kan worden gedaan op bepaalde publieksgroepen, maar in andere niet, en onder welke omstandigheden het zinvol is om een grotere rol toe te wijzen aan publieke betrokkenheid in debatten over techno-wetenschap en haar risico's, bijvoorbeeld via een grotere mate van institutionalisering van publieke inspraak. Zo kunnen wetenschap en technologie beter rekening houden met de zorgen van de samenleving.

Dit perspectief gaat echter niet uit van de naïeve veronderstelling dat de deelname van publieksgroepen aan geïnstitutionaliseerde discoursen onvermijdelijk leidt tot democratischer debatten en besluiten inzake wetenschap en technologie. Aangezien het evengoed andersom kan zijn, heeft het openbaar gezag met een paradox te maken: het construeren van publieksgroepen en het zich beroepen op publieksgroepen in een technologische controverse, kan begrepen worden als oproep om kwesties te politiseren om te komen tot een inclusiever, eerlijker en respectvoller besluitvorming. Door publieksgroepen te construeren en hier een beroep op te doen in technologische controversen, kunnen echter ook bepaalde stemmen worden uitgesloten van deelname aan het debat en kunnen bepaalde politieke zorgen verzwegen, gemarginaliseerd of ongeldig gemaakt worden. Deze laatste neiging is met name duidelijk wanneer *deficit models* van het publiek worden ingezet, want deze leveren het verwijt dat de zorgen van het publiek niet rationeel en op wetenschap gebaseerd zijn, maar emotioneel en politiek gemotiveerd en gebaseerd zijn op een algemeen gebrek aan kennis over techno-wetenschap. Dit wil niet zeggen dat bepaalde publieksgroepen altijd beter of slechter in staat zijn om de betekenissen die ze aan technologie toeschrijven in een debat ter tafel te brengen, maar dat de stratificatie van publieksgroepen essentieel is om te begrijpen waarom beleidsmakers sommige zorgen als beter of slechter, of meer of minder geldig beschouwen dan andere.

In de arena's die in deze studie worden onderzocht, werden bepaalde kwesties als legitiemer beschouwd dan andere. De kwesties rond gg-gewassen spreken derhalve verschillende publieksgroepen aan en worden vanuit verschillende publieksgroepen ter tafel gebracht, m.a.w. publieksgroepen komen tot stand rond kwesties die door belanghebbende sociale groepen aan de orde worden gesteld in technologische controverses en tegelijkertijd vertegenwoordigen publieksgroepen deze kwesties in de verschillende arena's van het debat. Derhalve is de constructie van publieksgroepen in het debat rond gg-gewassen een voortdurend proces, wat betekent dat publieksgroepen niet beperkt zijn tot op verkiezing gebaseerde vertegenwoordiging, noch tot enkele arena's van de controverse, maar voortdurend worden geconstrueerd door de actoren in verschillende arena's in het debat. Publieksgroepen zijn meervoudige, aan verschuivingen onderhevige, overlappende interactienetwerken. Dit betekent dat publieksgroepen ongrijpbaar blijven ondanks de poging van de onderzoeker om ze empirisch en conceptueel te vangen.

English Summary

Elusive Publics explores the construction of genetically modified (GM) crops by scrutinizing the role of publics in the current controversies about the risks and benefits of this technology in India and Europe. In the debate about transgenic crops many actors invoke the notion of the public to support their claims about the (un-) desirability of the technology. At the same time, there is a broader public debate about its cultural, economic, social, and political implications. This controversy has not reached closure since the first commercialisation of GM seeds in industrialised countries in the 1990s, and the debate has gained new momentum when multinational corporations transferred transgenic crop technology to developing countries more recently. Therefore, this study looks at the controversies about GM crops through the lens of publics to understand the social construction of this technology. It argues that publics are not fixed entities but that publics continuously get shaped in the process of the debate along with the many issues around transgenic seeds. Therefore, this research addresses the central question of how GM crops get shaped by public involvement, and what sort of publics are constructed in the various arenas of the debate.

To understand the mutual constitution of techno-scientific and social orders of GM crops and their risks on the one hand, and of publics in the controversy about this technology on the other, this study takes the perspective of constructivist Science, Technology, and Society Studies (STS). More specifically, it employs the theory of the Social Construction of Technology to understand how GM crops are subject to a culturally framed process of construction and interpretation. It explains how technology can have different meanings for different groups of people in their respective cultural and historical contexts. This study argues that not only transgenic seed technology is socially constructed, but that publics are also subject to various interpretations and constructions. The author employs qualitative social science methods for a multi-sited ethnography around the GM crops debates in Europe and India where such controversies are ongoing. It follows the circulation of artefacts, discourses, ideas, meanings, people, and institutions involved in the debate that spans different spatial, temporal, and social scales. The study draws on interviews with key actors of the debates, participant observation, and document analysis to identify the various issues around transgenic crops and the construction of the publics that engage in the debate through various strategies of publicity. In this techno-scientific controversy, the author argues, a multiplicity of publics get constructed. Despite a range of useful conceptual approaches to publics from various literatures in anthropology, political science, and STS, this study demonstrates how the publics in the GM crops debate remain difficult to grasp, since they remain constantly in flux and therefore elusive.

Three empirical chapters address different arenas of the debate: chapter two looks at how scientific expertise is constructed in GM crops health risk assessment; chapter three studies the issues actors connect to the risks and benefits of transgenic crops by envisioning futures with(out) transgenic seed technology; and chapter four examines the role of public participation in policy-making on India's first GM food crop, Bt-brinjal. The study uses the notion of 'arenas' as a heuristic metaphor to identify the symbolic locations of these techno-scientific controversies. This is to understand how various actors engage in collective discursive action to symbolically articulate the epistemological and normative issues around GM crops and how they aim to shape collective decision-making on the technology's risks.

The chapter More than Just Rats looks at the arena of scientific risk assessment by studying a contested long-term feeding experiment which identified possible signs of toxicity of a herbicide resistant GM maize and its associated herbicide in rats. After prolonged controversy amongst scientists, journalists, civil society and industry representatives, and citizens, the study got retracted from the peer-reviewed international journal where it was initially published. A few months later, however, the paper was republished by an open access journal. The chapter follows the debate about the study's publication, its retraction, and republication in order to understand how the toxicological feeding study became an object of public involvement and how various actors judged its status as legitimate and trustworthy scientific knowledge. This case demonstrates how scientific and public controversy can interrelate. At first sight, the publication was contested because of its unconventional long-term study design and related questions about method and data interpretation. Yet, the debate did not remain within the institution of scientific publishing, but public involvement became important too. Controversy arose about the demarcation between facts and values and between science and politics. Both sides of the debate accused their opponents of pursuing hidden political agendas, undesirable and impinging on the quest for finding the truth about the potential toxicity of the GM crop in question. The chapter demonstrates with which strategies these actors constructed the boundaries of what they considered legitimate and reliable toxicological knowledge. It was the division between an allegedly value-free science on the one hand and politicized knowledge production on the other that became important. The chapter demonstrates that the controversial toxicological study did not succeed to be recognized as scientific because public involvement revealed the actors' definitions of the boundary between science and politics to diverge too much from each other. Moreover, the analysis shows how the institutions of scientific publishing shifted from being an arena of controversy to being the target of the debate. The longer the controversy took, the more actors expressed doubts about the mechanism of peer review and the rigour of scientific publishing. Prolonged public involvement therefore widened the questions about method, study design, and data interpretation, to questions about the politicisation of scientific risk assessment, particularly through financial, material, and professional commitments and dependencies of scientists and publishing journals.

The chapter Imagining Futures with(out) GM Crops depicts the various ideas about the future that relevant social groups construct around GM crop technology. Starting from the idea that risk assessment is too narrow a scope for understanding the controversy about GM crops, the chapter scrutinises various visions of socio-technical futures of transgenic crops constructed in public discourse. This case demonstrates the range of arguments and meanings entangled in the debate: the various problem definitions around GM crops including the representations of their risks and benefits, the construction of publics relevant to the respective socio-technical imaginaries, as well as the expression of policy options and preferences - in short: the interpretative flexibility of GM crops and their publics. Scrutinising how futures with(out) GM crops are imagined provides a perspective on the normative nature of the debate – the futures imagined are equally about the role of technology as well as about what is good and desirable for the political community, i.e. the envisioned evolution of technical and social orders.

Four socio-technical imaginaries demonstrate how the controversy about transgenic seed technology is highly normative: Proponents of GM crops mobilise the imaginary of productivity which elevates both the imperative of feeding the hungry and of enhancing economic competitiveness due to technological innovation above possible concerns about the technology's risks. Their imaginary of environmentalism responds to public demands for environmentally friendly technologies and presents GM crops as a sustainable technology because of its pesticide reducing potential. Those critical of GM crop technology however, oppose such arguments based on the imaginary of complex ecology. They emphasise the complex interdependencies in ecosystems, endangered by monoculture cropping with transgenic crops. GM seeds thus come to mean an endangerment to biodiversity to the point where the ecosystem may collapse. Finally, the imaginary of seed sovereignty takes the dominance of transnational corporations in the seed and agrochemical markets as its starting point to argue that GM crops endanger farmers' autonomy and freedom. This imaginary emphasises the value of diversity and availability of seeds being at risk due to GM crops. The chapter on imaginaries also shows the temporal dimensions of these meanings. These are rooted in and consolidated by the actors' interpretations of past agricultural development since the Green Revolution: either as a straightforward technological boost to crop production or as an environmentally and socially problematic transformation of agriculture towards input-intensive farming practices.

As much as the normative and temporal underpinnings of the imaginaries in the GM crops debate are conflicting, contested, and competing, so are the various publics that get constructed alongside such visions of the future. The imaginaries of the Indian and European GM crops debate reveal such labels as citizen, consumer, and farmer publics not to have one single meaning. In each imaginary, publics remain constructions of those actors who speak on their behalf: Farmers get constructed as having an interest in GM crops for productivity increases and input cost saving, but also as being at risk of losing autonomy and sovereignty over cultivation choices. Citizens get constructed as concerned about the various risks of the technology, but also as consumers who prioritise cheap consumer products over political considerations of technological development. Finally, the environment and the ecosystem get constructed as spaces of projections of such publics, i.e. as a malleable context in which intervention can be causal, linear and instrumental, or as a complex web of social and ecological interdependencies and vulnerabilities that problematizes agricultural technologies differently. The chapter therefore demonstrates that the imaginaries of the GM crops controversy speak to publics (as audiences receptive to the normative underpinnings of imaginaries) and from publics (i.e. from the issues around which social groups form to constitute collective political subjectivity) alike.

The chapter The Bt-brinjal Consultations analyses a case of public participation in India's regulation of its first transgenic food crop, Bt-brinjal (aubergine) and asks which publics got constructed through public engagement and how these affected the decision for a moratorium on the technology. In the public consultations on Bt-brinjal held by the Minister of Environment and Forest, Jairam Ramesh in India in 2010, various consumer, farmer, and citizen publics got constructed by a variety of participants, though quite differently: Citizen publics were constructed as either interested in cheaper agricultural commodity prices; or as

highly concerned about the potential health risks of Bt-brinjal. Farmer publics were constructed either as interested in innovative seed technology to boost productivity and reduce input costs and pesticide applications in the field; or as being at risk of unknown environmental effects and a further concentration of the seed market in the hands of a few transnational corporations. Similarly, citizen publics were constructed as either trusting the institutional mechanisms of the state and market; or as seeking input of publicly generated knowledge into the regulatory apparatus and policy-making processes. Each side in the contestation for and against Bt-brinjal accordingly constructed its own consumer, farmer, and citizen publics. Also, different forms of publicity, from conventional civic engagement to unruly protest worked in accordance during the consultations, not only to inform the Minister, but also to generate news coverage intended to reach broader audiences.

Minister Ramesh's decision for a moratorium on Bt-brinjal invoked the precautionary principle and seemed to put science on par with publics. However, although the Minister raised such issues as environmental integrity and seed sovereignty in his decision, he resorted solely to scientific risk assessment for future decision-making on Bt-brinjal. Accordingly, policy-making on Bt-brinjal drew on a hierarchy of knowledge, despite of the consultation process. The issues from which consumer, farmer, and citizen publics got constructed all hinged on the scientific assessment of risks: to human health and the environment, of socioeconomic consequences for farmers, of equitable access to the means of agricultural production, and of the mechanisms that vest regulatory decision-making with epistemic authority. Ramesh's moratorium announcement entailed a call on science as the ultimate arbiter of truth: if science was more rigorous and independent, the underlying assumption was that it could answer the pending questions about Bt-brinjal, foremost its potential effects on human health and the environment. This hierarchy of knowledge relates to the wider culture of policy-making in the Indian context, which is similar to regulatory culture in the European Union where risk assessment has primacy over ethical and political concerns related to technological development. This goes at the cost of engaging with deeper political concerns related to GM crop technology such as ideas about the importance of ecosystem stability, the farming community's sovereignty, as well as the citizen public's aspirations to democratise the institutional mechanisms of regulatory science and policy-making.

This research reveals publics not to be a single, static entity. Instead, they are a plural, constantly shifting category constructed by the various actors in the GM crops debate around the issues they see implied with the technology. The articulation of issues allows for the formation of publics, and in that process, transgenic crops as a political object and publics as political subjects get shaped. This is not meant to say that the social construction of publics is a mechanistic and strategic Machiavellian process, but rather that the construction of publics is about the political positioning of various forms of collective subjectivity in the political contestation about technological development. Publics have a double function: the different meaning constructions of GM crops and the issues evolving around the technology speak from and to different publics. This means publics can be both, participants within the arenas of the GM crops debate, and audiences of the contestations happening therein.

Besides analysing the role of publics in the current debates about GM crop technology, the intention of this research is also to understand democratic politics in contemporary technological culture. To conclude, it therefore asks: How do GM crop technology and public

involvement in this issue shape democratic political culture in a globalized techno-scientific world?

In the techno-scientific controversy of the GM crops debate, science always plays a role in the social construction of publics. The potential impacts of transgenic crop technology cannot be legitimately assessed without scientific expert knowledge. Science therefore becomes central in constructing publics when they engage with issues around transgenic crops, i.e. publics need to engage with science in order to legitimately participate in technological debates. Nonetheless, publics are also important for science and its epistemic status. They can be defined in opposition to techno-science, and as being constitutive of and supplementing it, but rarely can publics be conceived of without science, i.e. when publics immerse in technological controversy, they cannot do so without referring to scientific knowledge as the hegemonic form of knowledge production. Many actors therefore argue that decisions on technological development should not hinge on science alone and that such decision-making should include non-scientific knowledge. Publics can constitute a necessary counterbalance to science to prevent a de-politicisation of technology when there are important social and political issues at stake. Consequently, publics have the power to make debates about technology more socially and politically reflexive. Accordingly, when trying to understand democratic governance of contested techno-science, one needs to take into account the strategies with which publics acquire an authoritative voice that is taken up in policy-making. Such a perspective can help to explain why some publics can legitimately be referred to in some arenas, and not in others, and under which circumstances it makes sense to assign a greater role for public involvement in debates about techno-science and its risks, for instance through a greater degree of institutionalisation of public participation. This can help to make science and technology more responsive to society's concerns.

Yet, this perspective does not naively assume that letting publics speak or participate in institutionalised discourses is per-se leading to more democratic debates and decisions on science and technology. Since it can equally be the other way around, public authority is caught in a paradox: drawing on and constructing publics in technological controversy can be understood as making a call for the politicisation of issues to make decision-making more inclusive, fair, and respectful. However, drawing on and constructing publics in technological controversy can also exclude certain voices from participating in the debate and it can also silence, marginalise, or render certain political concerns invalid. This latter tendency is particularly evident when deficit models of the public are mobilised as these resent public concerns not as rational and science based, but as emotional, politically motivated, and based on a general lack of knowledge about techno-science. This is not to say certain publics by default are in a better or worse position to bring into a debate the meanings they ascribe to technology, but that the stratification of publics is central for understanding why some concerns are perceived as better or worse, or more or less valid than others by decision-makers.

In each of the arenas that this study scrutinises, certain issues were regarded as more legitimate than others. Accordingly, the issues connected to GM crops speak to and from such publics, i.e. publics form around the issues relevant social groups raise in technological controversy and at the same time, publics represent these issues in the various arenas of the debate. Therefore, the construction of publics in the GM crops debate is continuous, meaning publics are neither restricted to election-based representation, nor to single arenas of the

controversy. Instead, publics are continuously being constructed by the actors in the debate across different arenas. Publics are multiple, shifting, and overlapping networks of interaction. This means that publics remain elusive, despite the analyst's attempt to empirically and conceptually fix them.

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Valorisation Addendum

This dissertation shows the publics of the GM crops debate to be an elusive multiplicity constructed by different actors in various arenas of the controversy. I have shown how publics emerge in the debate along with the many issues of transgenic crop technology. I have also indicated how this matters for the democratic governance of technological innovation, in particular if various actors strive to democratise decision-making on techno-scientific development in contemporary technological culture. How can my research be significant for society?

Scientific knowledge speaks not for itself. It has to be made relevant and applicable by scientists translating their knowledge to society. Universities, policy-makers and funding agencies use valorisation to stimulate researchers to make their knowledge production relevant and applicable to society at large. In Dutch academia, valorisation refers to the discourse around the relevance and impact of scholarly knowledge production to foster closer links between scientific research and society, and in particular between scientific research and the business sector. This poses specific challenges for the humanities (Belfiore, 2015; Benneworth, 2014; Zomer & Benneworth, 2011). Since university research is partially state funded, there is a societal expectation that public funding needs to yield returns to society (Hessles, Van Lente, & Smits, 2009). Today, almost all funding agencies require scholars in their research funding applications to explicate how they will make their knowledge production relevant and applicable to societal issues and problems. This translates into valorisation having become the university's "third mission", next to teaching and research (Shore & Mclauchlan, 2012; Zomer & Benneworth, 2011). It is argued that valorisation has become part of a renewal of the ethical norms of science through procedures and directives that shall ensure that scholars remain responsive to society's demand for applicable and relevant research (cf. Vinck, 2010). Yet, this demand, how it is communicated by governments and funding agencies, and how it is responded to by universities and researchers is not unproblematic.

In her study of how humanities scholars in the Netherlands respond to the demand for valorisation, Dani Older (2015) shows how valorisation is broadly defined by the Dutch government and the central funding organization NWO. These actors communicate valorisation to imply different logics: civic (referring to cooperation and sharing of knowledge), market (economic growth), industrial (knowledge utilisation), and inspired (flexibility and creativity). Older argues however, as universities communicate the demand for valorisation as an instrumental response to tighter competition for research funding acquisition from public bodies (thus the market logic), scholars are prompted to respond strategically to this demand: "humanities scholars feel forced to respond to valorisation on market terms because of its role in determining their success" (Older, 2015, pp. 67-68), e.g. in the assessment of their research proposals and funding applications. Although the prevailing definition of valorisation is framed within the market logic because of its role in distributing resources in the research community, Older reminds us that "the demand for valorisation is not established or negotiated according to a market definition alone" (p.67). Therefore, she prompts us to think of the many forms of valorisation to recognize how valorisation is, should, and could be otherwise. The following is an attempt to frame my research on the elusive publics of the GM crops debate in such terms.

In this valorisation addendum, I reflect on the relevance and applicability of my research and my vocation as an academic. How did I make my research relevant and to whom and for what will the findings on the mutual shaping of GM crop technology and its elusive publics be applicable? In the following paragraphs, I provide a brief overview of what I consider my past valorisation activities. Next, I provide a critical note on the importance of recognizing the social responsibility of science, and of Science and Technology Studies (STS) scholars in particular. Based on this discussion, I will conclude by charting other audiences to whom the knowledge I produced might be relevant and applicable and in so doing reflect on potential future (valorisation) activities related to my Ph.D. research.

How valorisation is otherwise: teaching vs. research?

I consider making research relevant by communicating and translating the insights I gained to various audiences. As a PhD candidate, I gave a numerous presentations and talks at different institutions and in various places. For instance, during my second field trip to India in 2013, I discussed my research and theoretical approach at the Institute for Social and Economic Change, Bangalore, exchanging views with Indian social science scholars. There I not only shared my insights but also questioned my own ethnocentric assumptions about the Indian debate on GM crops. Doing so, my Indian colleagues and I engaged in a process of conversation and exchange of knowledge. During my fieldwork, fellow academics also invited me to give presentations about my research to their students. For example, I gave a lecture on agrarian discourses from an STS perspective to MA students of political science at St. Joseph's College in Bangalore. At home in the Netherlands, I also had various talks about my findings to contribute to students' educational curricula. I gave workshops at the United Nations University – Maastricht Economic and Social Research Institute (UNU-MERIT) to MSc students of Public Policy and Human Development about the politics of risk assessment science (2014, 2015, 2017), a lecture on the same topic to engineering students at Technical University Eindhoven (2015), seminars about risk governance to MA students of European Studies at the Faculty of Arts and Social Sciences, Maastricht University (2012, 2014), and a lecture at the University of Groningen to PhD students in the project SOCBIOAfr (=addressing societal challenges of biotechnology in Africa – towards balanced innovation) in 2016.[203]

All these activities, together with my teaching duties in the BA and MA programmes at Maastricht University, allowed me to share the insights of my research with wider, largely non- STS student audiences. I regard university teaching that is based on scientific research valorisation because most students will not become academics, but leave the university to work in and for corporate organisations, government agencies, and other societal institutions. Teaching students about the insights from my research is a valuable form of making the knowledge I generated valid to society. Students carry the academic skills and knowledge

[203] All these activities, with the exception of the workshop at UNU-MERIT in 2017 I provided free of charge. My motivation was to share knowledge, create a space for the exchange of ideas, and to stimulate students' ideas about science, technology, and agriculture. Between the years 2011 and 2015, teaching activities within the Faculty of Arts and Social Sciences at Maastricht University were part of my teaching duties which in turn was an agreed upon duty of my appointment as a PhD candidate for which I received a remuneration in the form of a monthly salary (that is between the summer of 2011 and the summer of 2015).

they have acquired during their studies to society at large when they leave the university and commence careers outside academia after graduating. Within the changing context of contemporary academia with decreasing public funding for scholarly research and teaching however, the latter seems to get assigned less importance. Some argue that, as a result of the current structural changes of higher education funding, university teaching has become a second-class academic activity (under temporary and precarious employment conditions) reserved for those less successful in acquiring external funding and publishing enough of their research findings. (e.g. Gill, 2009; Halffman & Radder, 2013).[204] It is from this critique that a number of movements, some more oriented towards analysing the structural transition of academic research in general (see, e.g. the Dutch Science in Transition initiative: SiT, 2013), as well as the future of research and teaching at Dutch universities more specifically (see Platform Hervorming Nederlandse Universiteiten: H.NU, 2018) have emerged. My own experience of engaging with the latter movement allows me to reflect on the role of scholars as public intellectuals.

How valorisation should be otherwise: a role for public intellectuals?

Scientists enjoy some academic freedom, but they also have a responsibility to society. Some of my colleagues take this idea quite literally by regularly disseminating their expertise in public talks and lectures, newspaper articles, TV and radio interviews, particularly when pressing societal issues and discussions can benefit from scholarly insights. Others prefer not to engage directly with societal debates and issues for the fear of compromising their position as disinterested observers and analysts who want to produce objective knowledge. While both positions certainly have their merits, it is not my intention to discuss these positions here in any depth. Rather, this divide in the academic community I experienced first-hand when helping to organise an alternative opening of the academic year with others from the Platform H.NU in Maastricht in autumn 2014 (see Degens, 2014). While it was our intention to stimulate discussion of how to make the university a better place for high quality teaching and research, as a consequence of our engagement with the concerns about the changing landscape of academia, some of us experienced hostility, but also encouragement and constructive feedback.[205]

Disregarding the divide, the status of higher education and research has direct implications and relevance for society, in particular in the context of knowledge production systems that are socially distributed (Gibbons et al., 1994).[206] We should therefore not cease to have this discussion and seek to make both teaching and research endeavours from which society as a whole can benefit. At the same time, leaving the Ivory Tower is like skating on thin ice. The valorisation value of such movements as Science in Transition, H.NU, and more recently

[204] Mind that the Dutch Higher Education and Research Act (1992) stipulates research and teaching to be the combined core task of universities (https://wetten.overheid.nl/BWBR0005682/2018-06-01).

[205] Amongst such hostilities was, at least for one of us, the threat of getting fired.

[206] Gibbons et al. (1994) describe the social distribution of knowledge production under the banner of the transition from Mode1 to Mode2 knowledge production, the latter being characterized as generated in a context of application, transdisciplinary in operation, conducted by heterogeneous actors (not only the university), reflexive and subject to a wider set of economic, political, and social quality evaluation criteria (for a literature review and research agenda of Mode2, see Hessels & van Lente, 2008).

WOinActie (see WOinActie, 2018) is that they scrutinise the role of academia in society and the organisation and dissemination of knowledge production. Such debate is necessary and we should not shy away from provoking fierce discussion, making problems explicit, and maybe even taking a stance that goes against the tides of the contemporary neo-liberal restructuring of higher education and research. This will also add to the societal relevance of academia which could, and maybe should, also be considered valorisation in the broader sense.

However, I do not plead for all academics to become activists. There are other positions, which Science and Technology Studies scholars are in particular suitable to take. STS scholars can take three possible routes with various degrees of politically inspired concerns: the *Academic Highway* (scientific publishing, taking academic leadership roles); the *Policy Street* (advising public and private sectors); and the *Democratisation Boulevard* (combining long-term academic agendas with political and social engagement) (Bijker, 2003). Bijker's own life-long journey on each of these routes serves as a role model for researchers to not only study contemporary technological culture, but also to help constructing the socio-technical world of our societies, and to eventually move between these positions with integrity, modesty, and a humble concern for issues of democracy, development, and social justice (cf. Bijker, 2017). I will conclude with what valorisation potential I envision for my own work on the GM crops debate beyond the timeframe of my Ph.D. research.

How valorisation could have been otherwise: missed opportunities, or future agenda?

Academics face numerous financial, structural, time, and personal constraints that pose a limit to how much they can do. This, however, does not frustrate imagining ways in which the societal impact and relevance of their research could have been otherwise. Such ideas need not get buried under a pile of exams to grade, papers to publish, or a successfully completed dissertation manuscript. Instead, such ideas could be the inspiration for a long-term scholarly agenda that combines the skills and knowledge acquired with societal engagement to make academic work more relevant to society in the future. Let me briefly chart other audiences which could benefit from the knowledge I have produced. This is course goes beyond the academic community, which will benefit more directly from my research as it gets published in academic journals and books (e.g. Mitzschke, 2017; Mitzschke, forthcoming).

The participants of the GM crops debate could learn to take a different perspective on their ways of constructing publics and their strategies of publicity. A range of activities stemming from my research could find their way to activists, industry representatives, and scientists directly involved in the debate and regulation of GM crops. These could take the form of consultation activities, participation in stakeholder workshops, the drafting of information material on various aspects of biotechnology and its risks, and through communicating the findings of my research in public media such as newspapers, online journalism, and open access publishing which are accessible to wider audiences than the scientific community alone. In the case of risk assessment science, science journalism, civil society, and business could all increase their credibility and trustworthiness in the use of scientific findings if they were more sensitive to the problems of scientific uncertainty, and the paradoxes of

scientific and public authority alike. The question of the reliability and trustworthiness of science is pertinent in a climate of "alternative facts" (Swaine, 2017) and "post truth politics" (Roberts, 2010), where it will be useful for policy-makers and regulatory authorities to establish clear rules of transparency and accountability for their use of science in regulatory decision-making. Also, there is an increasing need for an analysis of the politicisation of science and technology in order to understand different sources of knowledge: Policy-makers can mobilise the analytic expertise and insights of STS researchers when organising and conducting public participation exercises in various forms to pay attention to institutionalised mechanisms possibly perpetuating, re-establishing, or even challenging established patterns of social stratification. STS research can help policy-makers in questioning their taken-for-granted assumptions about publics, and in designing and analysing public participation to help making engagement exercises more fair, inclusive, and democratic.

These are just a few examples of making the knowledge I have produced and the skills I have acquired over the past years relevant and applicable to society. If we want a broader definition of valorisation (beyond the market logic) to take effect, we need to devise roles for STS scholars that allow them to oscillate between their academic environment and societal arenas more easily. Yet, this will depend to a great extent on the availability of resources for such kind of activities and the willingness of all actors involved to listen to each other. After all, the greatest challenge remains to reconcile the demands of democracy as a slow form of political decision-making, with the fast pace of technological innovation.

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