The why's and how's of public sector scientists' policy engagement

The lessons from agricultural biotechnology

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DOI
10.4233/uuid:ff150699-5f50-4196-8d25-9e959f06ce51

Publication date
2016

Document Version
Final published version

Citation (APA)
van der Werf-Kulichova, Z. (2016). *The why's and how's of public sector scientists' policy engagement: The lessons from agricultural biotechnology*. [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.4233/uuid:ff150699-5f50-4196-8d25-9e959f06ce51

Important note
To cite this publication, please use the final published version (if applicable).
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THE WHY'S AND HOW'S OF SCIENTISTS' POLICY ENGAGEMENT

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THE WHY'S AND HOW'S OF PUBLIC SECTOR SCIENTISTS' POLICY ENGAGEMENT

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Cover designed by Zuzana van der Werf Kulichova with support of Silvia Augustin (www.gastro-creative-art.com)
About the cover: The split picture of agricultural land depicted on the book cover represents the divided views about how modern agriculture should look like (conventional agriculture, organic agriculture, agriculture that uses the techniques of modern biotechnology).

Editor: Zuzana van der Werf Kulichova

Printing: Ridderprint BV, The Netherlands
ISBN: 978-94-6299-449-2

THE WHY'S AND HOW'S OF PUBLIC SECTOR SCIENTISTS' POLICY ENGAGEMENT

The lessons from agricultural biotechnology

Proefschrift

Ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft;
op gezag van Rector Magnificus Prof. Ir. K.C.A.M. Luyben,
voorzitter van het College voor Promoties,
in het openbaar te verdedigen op
dinsdag 25 oktober 2015 om 15:00 uur

door

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Master of Science in Environmental Sciences
Universiteit Wageningen
Geboren te Piešťany, Slowakije

Dit proefschrift is goedgekeurd door de promotor
Prof. Dr. P. Osseweijer

Samestelling promotiecommissie:
Rector Magnificus, voorzitter
Prof. Dr. P. Osseweijer, Delft University of Technology, Promotor

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This thesis is the result of a research project of the CSG Centre for Society and the Life Science and the BE Basic foundation, carried out at the Delft University of Technology, Faculty of Applied Sciences, Department of Biotechnology, Section Biotechnology and Society.

Everything is theoretically impossible, until it is done (Robert A. Heinlein).

Contents

Chapter 1

Introduction



"By 2030, the global population is expected to increase by 28%, from 6,5 billion in 2005 to 8,3 billion, and average global per capita income by 57%, from USD 5,900 in 2005 to USD 8,600. A larger and a more affluent population will increase world demand for health services that improve quality and length of life and demand for essential natural resources: food, animal feed, fibre for clothing and housing, clean water, and energy. At the same time many of the world's ecosystems that support human societies are already overexploited and unsustainable. Climate change could exacerbate these environmental problems by adversely affecting water supplies and agricultural productivity" (Oborne 2010).

1 Introduction

1.1 Biobased economy and the role of agricultural biotechnology

This thesis focuses on policy-making regarding agricultural biotechnology and the resulting regulatory climate for research and market release of genetically modified crops. Learning from the case of agricultural biotechnology this thesis argues that a successful transition to the biobased economy requires that scientists, as socially responsible experts, become more aware of and more engaged in policy discussions regarding implementation of novel life science technologies. Using the theoretical and empirical findings, this thesis provides a starting point and should stimulate thinking about the strategies that are necessary to facilitate scientists' policy engagement.

Our society is becoming aware that in order to ensure the livelihood of the future generations we must change the way we think about production and consumption of food, feed, fibre, pharmaceuticals, chemicals, materials and energy. Biobased economy, which has been defined as the economy where the basic building blocks for materials, chemicals and energy are derived from renewable plant based resources, can contribute to a more sustainable development (Oborne 2010, McCormick and Kautto 2013, Langeveld, Dixon, and Jaworski 2010, Souza et al. 2015, Kline et al. 2016). Instead of relying on non-renewable fossil fuels, such as coal, oil and natural gas, the biobased economy relies on renewable biomass as an input into production processes. Biomass can be obtained, amongst others, from edible as well as non-edible parts of agricultural crops and from organic wastes converted in biorefineries into a wide range of usable products. However, this huge potential can only be achieved through sustainable production of large quantities of biomass that neither compromise the land that is needed for food and feed production nor the conservation areas that are important sources of the worlds' biodiversity. Conventional agricultural practices that are currently widely applied carry along many negative externalities, and therefore, ensuring sustainable production of biomass, as feedstock replacing fossil fuels necessitates an improvement of agricultural management. This demands new innovations in agriculture that can increase supply, quality and composition of crops while minimizing negative environmental impacts (Chapotin and Wolt 2007).

Genetic engineering has been identified as a key enabling technology for increasing agricultural production yield for the bioeconomy in a more sustainable way (Chapotin and

Wolt 2007, UN 1992, Godfray et al. 2010). Genetic engineering uses a variety of methods to isolate single genes from one or more microorganisms, plants or animals and insert them into the genetic material of the cells of another. These methods are collectively termed in vitro nucleic acid techniques, and have been developed since 1970s. Through genetic engineering (also called genetic modification), genes are transferred and modified in ways that do not exist in nature, i.e. between different species and between different animals and plants and microorganisms (Mackenzie and Ascencio 2003). Genetically modified (GM) crops resistant to insects, diseases and herbicides have been commercially grown since 1996 (James 2014). This development has contributed considerably to the reduction of pesticide use and the simplification of weed management practices (Jikun Huang et al. 2008, Shaner 2000, Ammann 2005). Benefits of pesticides reduction include economic benefits to farmers, such as savings in production costs as well as improved management practices and health benefits to human and environment, such as decreased incidents of farmers' poisoning or less contamination of ground water, surface water and food. While the first-generation GM crops brought along many on farms benefits, the second-generation GM crops are expected to provide additional value to the end users. For example, soybean engineered with high oleic content can prove valuable for industrial purposes. Furthermore, crops engineered to be stress tolerant, for example crops able to grow in extremely dry conditions, may provide opportunities to use marginal lands for crop production. As such, GM crops have a great potential to contribute to more sustainable production of agricultural commodities as well as sustainable biomass production.

While genetic engineering has been recognized as an important technology for achieving sustainable development, the market approval of GM crops has been difficult. Currently, four GM crops (soybean, maize, cotton, canola) with two major traits (insect resistance, herbicide tolerance) dominate the markets in five countries while dozens of GM crops have been developed worldwide to fit the specific climate conditions and the local farmers' needs (Atanassov et al. 2004b, James 2014). One of the reasons that contribute to the disparity between anticipated and available GM products is the complexity, time inefficiency and high costs of regulatory procedures (Chapotin and Wolt 2007, Strauss et al. 2010, Strauss et al. 2009a, Hartung and Schiemann 2014, Masip et al. 2013, Nang'ayo, Simiyu-Wafukho, and Oikeh 2014). These regulatory procedures are used to assess the safety of GM crops to humans, animals and the environment. Despite the widespread scientific consensus that GM crops that passed the regulatory procedures are as safe as their conventional counterparts

there has been a strong opposition to agricultural biotechnology questioning the unknown impacts of GM crops and calling for more stringent regulatory procedures.

This introductory chapter outlines the general context for the presented studies. First, the overal aim of this thesis is presented. Second, the rationale behind the need for biosafety regulations is described. Here a brief overview of the history of international regulatory actions regarding biosafety is provided. Third, the potential impacts of regulatory frameworks on the deployment of benefits from agricultural biotechnology are presented. Various problems associated with the regulatory climate and their wider implications are deliberated. The introductory chapter concludes with the overview of the main and specific research questions and the description of the theoretical frameworks that have guided this thesis.

1.2 Aim of this study

The direct engagement of scientists in policy-making has been suggested in the literature to strengthen the impact of science on policy decisions (Steel et al. 2004, Pielke 2007a, Nelson and Vucetich 2009, Brownson et al. 2006, Meyer et al. 2010, Foote, Krogman, and Spence 2009b, Sorian and Baugh 2002, Lavis et al. 2003, Choi et al. 2005b, Weiss 1979, Scott et al. 2007). It is argued that active participation of scientists in policy-making is necessary for creating adequate policy climate for research utilization. Some of the arguments in favour of scientists' policy engagement include ensuring that the recent scientific findings are properly understood by all policy stakeholders and consequently well integrated into policy decisions regarding science and technology (Nelson and Vucetich 2009).

While engagement of scientists in policy-making has been recognized as important, the empirical research on this topic is rather scarce today. Present literature provides only limited empirical data about how do scientists perceive their own role in policy-making (Rainie et al. 2015) and which factors influence the motivation of scientists towards policy engagement (Mathews, Kalfoglou, and Hudson 2005b). Therefore, the overall aim of the studies presented in this thesis is to explore: How do agricultural biotechnology scientists perceive their role in policy-making and which conditions do influence their motivation regarding policy engagement.

1.3 Agricultural biotechnology and the need for biosafety regulations

Although the methods of agricultural biotechnology have a great potential to offer many benefits to society, they may also involve some risks which need to be carefully assessed. These risks include, for example, possible effects on non-target organisms, invasiveness or the possibility of a gene flow from GM crops to other species (OECD 1986). The need to assess the safety of genetically modified organisms was first recognized in 1975 when a conference in Asilomar was called upon by the scientific community to consider the safety implications of the Recombinant DNA technology (Berg et al. 1975). More than 100 concerned scientists came together to discuss the safety guidance for the Recombinant DNA technology, as they believed that they were necessary for enabling responsible and safe continuation of research in this field. From this moment onwards, governments around the world establish scientific committees that are responsible for national biosafety guidelines and/or strategies. Eleven years later, the Organization of Economic Cooperation and Development (OECD) introduced the first international document addressing biosafety issues - the Blue Book with the title "rDNA Safety Recommendations"(Bergmans 2006). Four years later, the first EU Directives and Regulations followed with the objective to regulate the applications of modern biotechnology in the European Union. In 1992, the Convention on Biological Diversity was adopted and followed by the introduction of the Cartagena Protocol on Biosafety that became an important international document regulating the transboundary movement of genetically modified organisms (GMOs) (Cantley 2008). Ever since, regulatory frameworks have been an important instrument that influences the role that biotechnology research should and can play in sustainable agriculture (Kulichova and Van der Meer 2010, De Greef 2004b, Strauss et al. 2009a, Nang'ayo, Simiyu-Wafukho, and Oikeh 2014).

The purpose of biosafety regulatory frameworks is to assess whether environmental, agricultural and industrial applications of GMOs pose an "incremental" risk to humans, animals and the environment. The risks to human and animal health are generally associated with production of novel proteins that can lead to toxic, allergenic or infectious hazard. Environmental risks relate to an evolution of novel traits in already existing populations or the introduction of naturally occurring organisms to an ecosystem to which they are not native (Bergmans 2006, OECD 1986). The safety of GMOs is evaluated at all levels from initial research and development to the final stage of market commercialisation. As noted in the text of the Agenda 21:

> Only when adequate and transparent safety and border-control procedures are in place will the community at large be able to derive maximum benefit from, and be in a much better position to accept the potential benefits and risks of, biotechnology (UN 1992).

Safety procedures for GMOs are generally embedded in national legislation and harmonized by international treaties. Biosafety systems in various countries reflect the country's national, environmental, political, financial and scientific capacities (Falck-Zepeda et al. 2012). The international principles for the biosafety risk assessment, developed by the Codex Alimentarius Commission, suggest that the risk assessment should:

> [..] take into account all available scientific data and information derived from different testing procedures, provided that the procedures are scientifically sound and the parameters being measured are comparable (FAO 2003).

1.4 Biosafety regulatory frameworks and their influence on the deployment of benefits from agricultural biotechnology

In order to facilitate reliable, timely and cost efficient biosafety risk assessment the biosafety regulatory frameworks should meet some criteria (Jaffe 2004). (Falck-Zepeda et al. 2007) studied the efficiency of biosafety regulatory frameworks in two developing countries and concluded the following:

> [..], the need arises to establish regulatory frameworks that are commensurate to the potential risks of the technology, that are flexible enough to adapt to gains in knowledge and experience, that are transparent and fair, and that take into considerations all aspects of a broad and inclusive decision making process. Biosafety thus becomes a process that considers all costs, benefits and risks of prospective technologies, within the scope of overall sustainable agriculture and economic development. The biosafety process itself needs to have 'a golden standard' of best practices in terms of safety data requirements, evaluation methodologies and analysis, but with a clear safety standards to be met, complete understanding of how to judge how much data is sufficient and/or necessary to make a decision [..].

In other words, the reliable and efficient biosafety regulatory frameworks should ensure the safety of GM crops to humans and the environment while being based on solid standards for risk assessment that are cost and time efficient. While (Falck-Zepeda et al. 2007) drew this conclusions based on the regulatory inefficiencies observed in two developing countries other authors also suggest that some biosafety risk assessment procedures that have been introduced around the world do not necessarily meet some of the above described criteria (Jaffe 2004, McHughen 2007).

1.4.1 Problems associated with the length of the regulatory approval procedure

The time required for granting the regulatory approvals for GM crops differs among countries. For example, (Hartung and Schiemann 2014) write that the average approval process for new GM crops in the European Union takes between four to six years. While the average time needed to review a regulatory dossier by the US regulatory authorities was reported to be approximately 15 months (Jaffe 2006). The differences in the length of regulatory approval procedures are causing a so-called "asynchronous regulatory approvals". This means that the approval of new GM crops does not occur simultaneously across countries (de Faria and Wieck 2015, Margarita 2012, Davison 2010). This has an impact on the EU market development in this field, while implications associated with the asynchronous regulatory approvals also negatively influence the international trade flows (de Faria and Wieck 2015). Furthermore, asynchronous approvals are claimed to influence the decisions of some developing countries about whether or not to adopt certain GM crops. It is argued that the developing countries that are exporters of agricultural commodities fear that the decision to adopt the GM crops that are not (yet) approved in their export markets (such as the EU) could deny them the access to these markets (Anderson 2010). Yet, the decision to postpone adoption of GM crops that could increase farmers yields can have a negative impact on economic and social welfare in these countries. For example, (Gruère and Sengupta 2009, Jikun Huang et al. 2008, Kikulwe, Wesseler, and Falck-Zepeda 2008) reported that farmers in developing countries could achieve substantial on farm benefits from adoption of GM crops varieties.

1.4.2 Problems associated with the compliance cost of biosafety regulations

The high compliance cost with biosafety regulations can also influence the deployment of benefits from agricultural biotechnology. (Kalaitzandonakes, Alston, and Bradford 2007) estimated the private sector compliance costs with biosafety regulations for herbicide

tolerant and insect resistant maize in ten key producing and importing countries[1] to be in the range of 6 –14 million USD for herbicide tolerant maize and 7–15 million USD for insect resistant maize. Similarly, (Hartung and Schiemann 2014) reported the compliance costs with regulations in the European Union to be between 7 and 15 million Euro per regulatory dossier. The magnitude of the compliance costs with biosafety regulations not only increase the overall costs of the final product, it also creates an important entry barrier for small firms and the public sector research institutes (Fedoroff and Beachy 2012, Cohen 2005, Atanassov et al. 2004b). (Bayer, Norton, and Falck-Zepeda 2010) assessed the impact of biosafety regulatory framework in the Philippines and drew the following conclusions:

> A high cost of compliance with biosafety regulations may deter a small firm or public sector institution from pursuing GM technologies, or may cause them to abandon or delay commercialization of potentially valuable products. Compared to large multinational corporations, these firms or the public sector may have less financial flexibility to absorb regulatory delays, during which funds spend on compliance with biosafety regulations are sunk costs until the regulatory authority renders its decision (Bayer, Norton, and Falck-Zepeda 2010, 60).

Hence, the high cost of compliance with biosafety regulations can negatively influence the role that public sector research plays in addressing the needs of local farmers and communities. The example from China illustrates that public sector research has potential to deliver considerable benefits to farmers in developing countries (Raney 2006). The public ownership of GM cotton in China enabled farmers to use locally adapted cotton varieties and to buy seeds at a considerable lower price than in other countries, providing Chinese farmers with substantially higher returns. Similar experience was reported in Hawaii where publicly developed GM papaya resistant to papaya ringspot virus was commercialized in 1998 (Gonsalves, Lee, and Gonsalves 2007).

[1] Argentina, Australia, Canada, China, the European Union (EU), Japan, Korea, the Philippines, Taiwan and the United States

1.5 Problems associated with the role of science in agricultural biotechnology policy-making

Some of the problems with biosafety regulatory frameworks, discussed in the previous sections, are associated with an inadequate representation of science in public and policy debates (Miller, Morandini, and Ammann 2008). Although many scientific committees are established worldwide (following the Asilomar conference) many public debates and stakeholder consultation fora are dominated by scientific arguments that are presented by various interests groups rather than by scientific community.

Despite the fact that the scientific community agrees that crops developed by genetic modification are as safe as their conventional counterparts, some interest groups and some individual scientists have maintained the view that GMOs are not safe or otherwise not wanted, and therefore, their use should not be allowed (Drezner 2008, Funk, Rainie, and Page 2015, Commission 2010, Fagerström et al. 2012, Hammond 2010, Gottweis 2008, Krimsky 2015). While the opposition has claimed that its arguments against GMOs are based on available scientific evidence, this particular scientific evidence has been criticized by international scientific communities for inappropriate methodology, and consequently flawed results and conclusions (Goertzel 2010, Miller, Morandini, and Ammann 2008, Ricroch, Bergé, and Kuntz 2010, Apel 2010).

Some scholars expressed the opinion that the policy-making regarding GMOs is driven by political preferences rather than by available scientific knowledge (De Greef 2004b, Bernauer and Meins 2003, Arts and Mack 2003, Gornitzka and Sverdrup 2010). Many scientists claim that regulatory delays regarding research and market approval of GMOs cannot be scientifically justified (Masip et al. 2013, Hartung and Schiemann 2014, Tosun 2014, Cantley 2012, Skogstad 2011, Ammann 2014). For example, some critics argue that the decision making process regarding the approval of new GM crops in the EU fails to reflect on the available scientific knowledge, and therefore, the inefficiency of the EU regulatory system does not have any scientific justification (Drezner 2008, Kuntz, Davison, and Ricroch 2013, Hoffmann-Riem and Wynne 2002, Vàzquez-Salat and Houdebine 2013, Consmüller, Beckmann, and Petrick 2011, Morris and Spillane 2008).

1.6 Research questions

The previous sections reasoned that regulatory frameworks that do not adequately reflect on available scientific insights might prevent deployment of benefits from new technologies. It also showed that the proper understanding and consequently proper integration of scientific knowledge into policy-making contexts, which are characterized by low value consensus among policy stakeholders, might be challenging. Hence, this thesis argues that the adequate integration of science into policy decisions requires that scientists become actively involved in the policy-making processes.

This thesis seeks an empirical contribution to this topic by exploring how scientists who have experience with policy participation perceive their role in policy-making and which conditions influence the motivation of these scientists towards adopting this policy role in practice. The case study of agricultural biotechnology is chosen since this policy field has been characterized by a long lasting controversy and where some scientists are mobilized to actively participate in policy-making debates. By focusing on the case of agricultural biotechnology this thesis seeks to generate insights regarding scientists' policy engagement that may be extrapolated to other science policy fields with similar characteristics. The general research question and the specific research questions that this thesis aims to address are as follows:

General research questions**:**

- Which active roles can scientists adopt in controversial policy-making and which of these roles do agricultural biotechnology scientists prefer to take?
- Which factors are relevant for the motivation of scientists to engage in policy-making?

Specific research questions:

- What are the reasons for and against scientists' policy engagement as articulated in the interdisciplinary literature on science-policy interfaces and as seen by agricultural biotechnology scientists in particular?
- Which factors can predict the motivation of agricultural biotechnology scientists for future policy engagement?

- Do agricultural biotechnology scientists feel institutionally empowered to engage in policy-making and which institutional approaches (if any) are currently in place to encourage scientists' contribution to policy-making?
- Which traits/competences are desirable for a meaningful contribution of scientists to controversial policy-making as perceived by agricultural biotechnology scientists?

1.7 Theoretical framework

In order to answer the general research questions this thesis builds on two theories: The stakeholder model of science in policy proposed by Pielke (2007) and the theory of planned behaviour proposed by Ajzen (1991). The detailed description of these two theoretical frameworks and their relation to the general research questions is elaborated below.

1.7.1 The roles for scientists in controversial policy-making: The stakeholder model of science and policy

To lay the theoretical foundation for exploring the first general research question, this thesis builds on the theoretical framework proposed by Pielke (2007). In his book that focuses on how and why should scientists go beyond the linear model[2] of science and policy, Pielke argues that there are two critical factors to consider when a scientist faces a decision about how to engage with policy and politics (Figure 1). The first criterion concerns the degree of value consensus on a particular issue. Pielke states that sharply contested issues raise the political stakes and introduce dynamics quite different from issues that are less controversial. To supports his arguments, Pielke refers to a series of policy-making problems, including the early controversial discussions about the climate change that took place in the American policy-making context. Translated into this thesis context, agricultural biotechnology policy-making represents policy context that is characterized by low degree of value consensus where different groups of policy stakeholders disagree which values should be taken into account when deciding about applications of biotechnology in agriculture (Gottweis 2008).

The second criterion for deciding which role should scientists take in policy-making is the degree of uncertainty present in a particular decision context. The greater the uncertainty

[2] The linear model of science and policy assume that scientists should be totally separated from the policy-making process. It claims that the only role of a scientist is to produce scientific knowledge through value free research and the results from this work will naturally feed policy-making decisions.

(both political and/or scientific) the more important it is for science to focus on policy options rather then scientific results. In this context, Pielke suggests that policy problems that are characterized with a high level of political and/or scientific uncertainty provide scientists who want to participate in policy-making with two options for engagement. They can either adopt the role of Issue advocates or they can become the Honest brokers of policy alternatives. Figure 1 presents the flow chart illustrating the logic of roles for scientists in policy and politics proposed by Pielke.

While there is an obvious need for scientists to be involved in controversial policy-making it is not clear which of the two proposed roles is socially desirable from the scientists' point of view and why, and how scientists can be supported to adopt this role in practice. This thesis will therefore attempt to extent Pielke's theory by examining these issues. The text below provides a brief description of each of the roles as provided in Pielke (2007).

Issue advocate. Scientists who adopt the role of issue advocates prefer to focus on the implications of their research for a particular political agenda. These scientists prefer to advocate for a certain policy option rather than providing the full spectrum of policy alternatives that are consistent with scientific evidence. The issue advocates can align themselves with an interest group with the objective to advance their interests through policy and politics. Issue advocates do accept the notion that science must be engaged with decision makers, and therefore seek to influence the decision making process (Pielke 2007, p15).

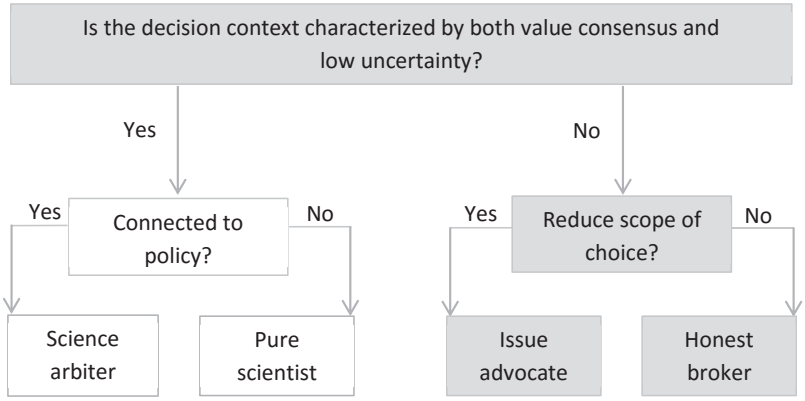

Figure 1 Flow chart illustrating the logic of roles for scientists in policy and politics (Based on Pielke 2007)

Honest broker of policy alternatives. Scientists who ascribe to the role of honest brokers of policy alternatives engage in policy-making by clarifying the policy options that are consistent with their scientific findings, and sometimes, seeking to expand the scope of choice available to policy makers. The honest broker of policy alternatives often operates through a membership in expert advisory committee or scientific organization since it can be difficult for an individual scientist to represent all areas of expertise needed to make policy recommendations.

In order to examine the perceptions of agricultural biotechnology scientists regarding these two roles in policy-making, this thesis employs a mixed method approach that comprises of in-depth interviews and an online survey.

1.7.2 Understanding scientists' motivation to engage in policy-making on agricultural biotechnology: The theory of planned behavior

In order to explore which conditions influence the motivation of agricultural biotechnology scientists towards active policy engagement, this thesis will build on the theory of planned behavior (Ajzen 1991). The theory has been widely applied in empirical studies and has proven to be useful in predicting human motivation to engage in certain types of behaviors (Conner and Armitage 1998, Armitage and Conner 2001), including scientists' motivation to engage in science outreach activities (Poliakoff and Webb 2007, Dudo 2012). The theory of planned behavior (TPB) offers a comprehensive framework for identification of conditions that may be relevant for understanding why some scientists are more motivated to engage in policy-making then other scientists. The TPB proposes that in order to understand peoples' motivation to engage in certain behaviors three independent determinants need to be measured: 1) attitude towards the behavior, 2) subjective norms and 3) perceived behavioral control. The TPB postulates that attitude, subjective norms and perceived behavioral control are functions of beliefs that an individual has about the behavior.

Attitude towards the behavior refers to the degree to which a person values the behavior in question. TPB assumes that the attitude towards behavior develops reasonably from the beliefs people hold about that behavior (Ajzen, p191). Therefore, the attitude towards behavior can be measured by a set of behavioral beliefs of which assessment can help one understand why some people have favorable attitude towards behavior while others do not (Ajzen 2002).

Subjective norms. Social context may also influence peoples' motivation to engage in certain behaviors (Ajzen 1991). Subjective norm attempts to measure how much socially supported one feels in performing the behavior in question. TPB proposes that subjective norms are a function of normative beliefs about approval or disapproval of behavior by important referent individuals or groups.

Perceived behavioral control. Another possible factor that can influence scientists' intention to engage in policy-making is the perceived ability to do so. Scientists' perceived self-efficacy to perform a certain task might directly influence their decision whether or not to engage in that task (Bandura, 1977). Ajzen (1991) suggests that the more people feel equipped with resources and the fewer obstacles to the behavior in question they anticipate, the greater their perceived behavioral control (Ajzen 1991). It is assumed that perceived behavioral control is a function of control beliefs regarding the easiness or the difficulty of engaging in the behavior. Figure 2 provides a graphical representation of the theory of planned behavior.

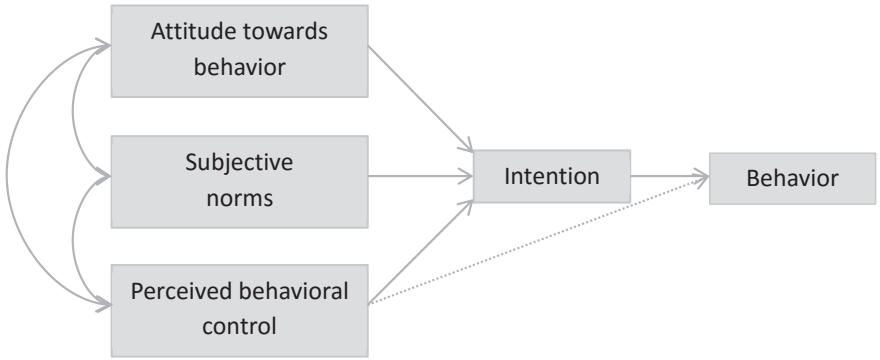

Figure 2 Graphical representation of the theory of planned behaviour (Adapted from Ajzen 1991)

The theory of planned behaviour is used for two purposes. First, we use it as a guide to identify the factors that influence the motivation of scientists to engage in policy-making. Second, this theory is also employed to build a causal model to understand which of the identified factors are significant in predicting scientists' motivation towards policy engagement. The data is collected via an online survey and the causal model is tested using a regression analysis. The population for our survey includes a global sample of scientists working at public sector institutes and universities. To account for potential regional and

employer differences a series of regression models are tested. Two factors are considered: 1) research institutes and universities and 2) different continents.

The distinction between public sector research institutes and universities may be understood as following:

> Public sector research refers to those R&D activities performed in institutions that are either publicly owned or operated or that depend to a large extent on government block funding for their research activities. Such institutions fall into two main categories: universities and public research institutes (PRIs). In addition to research, universities perform the important function of teaching, while PRIs usually solely provide direct R&D support to business firms and public authorities (innovationpolicyplatform.org).

While universities are likely to perform similar functions across different countries, namely research and education, public sector research institutes usually have a stronger focus on technology transfer and support to public policy (OECD 2011). Given their focus on policy support, public sector research institutes are likely to provide different conditions for scientists' policy engagement compared to universities.

1.8 Thesis outline

Chapter 2 presents the results from literature review regarding the general requirements for active engagement of scientists in policy-making. First, it provides an inventory of arguments that are supportive of the active engagement of scientists in policy-making. Second, it offers an overview of the arguments suggested in the literature against the active engagement of scientists in policy-making. Finally, it recommends five theoretical requirements that may need to be taken into consideration for stimulating and facilitating active engagement of scientists in policy-making. (This chapter has been published as: van der Werf Kulichova, Z., Flipse S.M., and Osseweijer P. 2014. Engaging Researchers Actively in Agricultural Biotechnology Policy-making. International Journal of Science in Society).

Chapter 3 reports the findings from a study that focused on the perceptions of agricultural biotechnology scientists about their role in policy-making. Using theoretical, quantitative and qualitative results this chapter first explores the distinction between the linear and the stakeholder model of science and policy. Subsequently, the arguments favouring the latter are elaborated. The empirical findings are then presented regarding scientists' perceptions

about their role in policy-making. This chapter points to the gap between scientists' perceived ideal roles in policy-making and the roles that scientists who are concerned about policy-making regarding agricultural biotechnology actually take (This chapter has been accepted for publication as: van der Werf Kulichova Z., Coumou H.C., Wehrmann C. and Osseweijer P. (in press) The Role of Scientists in Agricultural Biotechnology Policy-making: From Traditional to Alternative Views. International Journal of Biotechnology).

Chapter 4 explores the factors that influence the motivation of scientists to engage in policy-making regarding agricultural biotechnology. Building on the theory of planned behaviour and using the results from the online survey it assesses which factors are significant in predicting scientists' future motivation regarding policy engagement (Prepared for submission to the Environmental Science and Policy Journal).

Chapter 5 continues on the factors that influence the motivation of scientists to engage in policy-making with the specific focus on the institutional support strategies for policy engagement. It presents the results from interviews specifically focusing on how scientists evaluate their time availability for policy engagement, available financial resources for these activities and how scientists perceive the overall institutional support for policy engagement at their place of employment. Special focus is also devoted to exploration of traits/competences that are desirable for meaningful policy engagement (This chapter is currently under review in the New Biotechnology Journal).

Chapter 6 finally considers the findings of the individual chapters in light of the overall objective and the research questions of this thesis. It reflects on the findings and reviews how they relate to the theoretical frameworks that were used to guide this thesis. Finally, the limitations of studies presented in this thesis are discussed and directions for future research are provided.

Chapter 2

Engaging Scientists Actively in Agricultural Biotechnology Policy-making

An adapted version of this chapter was published as:

Van der Werf Kulichova, Z., Flipse S.M., and Osseweijer P. 2014. "Engaging Researchers Actively in Agricultural Biotechnology Policy-making." *International Journal of Science in Society* no. 5 (4)

Abstract

Policy-making regarding modern biotechnology is characterized by direct participation of stakeholders such as industry, environmental organizations and consumer groups. However, public sector researchers traditionally participate only indirectly, for example through memberships in expert advisory committees. This prevents direct interaction with other policy stakeholders who often use scientific knowledge to legitimize their preferences for stricter regulations. Furthermore, it has been argued that indirect participation of researchers in policy-making results in low understanding and even misrepresentation of scientific facts. In this paper, we argue for direct engagement of public sector researchers in policy-making. We analyse available literature on the engagement of researchers in policy-making to answer the following question: What are the requirements for facilitating direct engagement of public sector researchers in policy-making? To do so, we first identify reasons for public sector researchers to become involved in policy-making. Second, we discuss possible obstacles that may prevent them from doing so. Third, based on the identified reasons we recommend five requirements that may be important for facilitation of direct engagement of public sector researchers in policy-making debates. We conclude with critical reflection on the proposed requirements and recommend directions for future research.

2 Engaging Scientists Actively in Agricultural Biotechnology Policy-making

2.1 Introduction

Public sector research in agricultural biotechnology focuses on development of crops with improved characteristics, such as reduced use of pesticides and agrochemicals, increased abiotic stress tolerance (e.g. drought and salinity) and improved product quality (e.g. prolonged shelf-life and enhanced nutritional composition). However, policy and regulatory environment at both national and international level can influence the ability of public sector research institutes to conduct field trials, a necessary step for development and commercialization of new plant varieties (Atanassov et al. 2004a, De Greef 2004a, Cohen 2005, Strauss et al. 2009b). According to the Next Harvest Study conducted by the International Food Policy Research Institute, most of the public sector research in agricultural biotechnology has been carried out at the stage of experimental and confined trials while only limited numbers of products have reached commercial release stage[3][4]. As such, it appears that public sector research institutes are facing difficulties in moving from the laboratory conditions to field trials. Part of the problem is "[..] confusion regarding regulatory standards [..]" (Cohen 2005, 32). As such, unclear regulatory frameworks can hinder developments in public sector research (De Greef 2004a, Kalaitzandonakes, Alston, and Bradford 2006, Matten, Head, and Quemada 2008, Graff, Hochman, and Zilberman 2009, Bayer, Norton, and Falck-Zepeda 2010, Cohen 2005). Furthermore, public funds are not allocated efficiently as public sector research is not able to deliver intended societal benefits on a short term. This indicates that there is a need to turn our attention to the current policy-making regarding agricultural biotechnology and the role of public sector researchers therein.

Policy-making regarding the applications of agricultural biotechnology is characterized by direct participation of stakeholders, including e.g. environmental organizations, consumer groups and agricultural biotechnology industries (Levidow, Carr, and Wield 2005, Cantley 2012, Cohen 2005). Their active involvement in policy-making debates enables them to directly express their concerns with policy proposals. It also provides an opportunity to

[3] The Next Harvest study and the referenced articles that follow provide a more detailed discussion about the regulatory impacts.
[4] Our empirical study focusing on factors which influence the decision of researchers to engage in policy-making regarding agricultural biotechnology also indicates that many researchers believe that regulations negatively influence progress in this field (van der Werf Kulichova et al. under review)

network, further increasing their impact on policy. While diverse stakeholders directly participate in policy-making, researchers traditionally participate indirectly, e.g. through membership in expert advisory committees. As such, researchers are not directly represented and acknowledged as credible stakeholders in policy-making. The lack of their direct involvement can lead to instances where scientific advice is confused with opinions which are obtained during consultation meetings with stakeholders (Allio, Ballantine, and Meads 2006). This may result in wrong interpretation of the scientific results and consequently in non-adequate regulation.

Many scholars who investigated the role of researchers in contentious policy-making (like policy-making on agricultural biotechnology) advocate that researchers should participate actively (Meffe and Viederman 1995, Cortner 2000, Mills and Clark 2001, Lach et al. 2003, Steel et al. 2004, Choi et al. 2005a, Brownson et al. 2006, Gibbons et al. 2008, Foote, Krogman, and Spence 2009a, Meyer et al. 2010). Arguments in favour include 'facilitating better understanding of scientific knowledge by policy makers' whilst arguments against concern the possible impact of engagement on scientists' credibility. This paper discusses the possible barriers and remedies for active engagement of researchers based on a literature review taking relevant results from other fields into account.

Active engagement of scientists in policy-making can take various forms. Steel et al. (2004) suggested that scientists can actively engage in policy-making through 1) interpretation of results of their work, 2) cooperation with policy makers and others to integrate scientific results in policy decisions, 3) advocating for special management policies and 4) making policy decisions. Their investigation showed that policy makers and other stakeholders saw the second mode of engagement as the most appropriate. Pielke (2007) suggested two roles for scientists to actively engage in policy-making; 1) issue advocacy and 2) honest brokering of policy alternatives. He postulated that these roles are especially applicable to policy-making fields, which are characterized by a low degree of value consensus and a high degree of uncertainty. Policy-making in agricultural biotechnology represents similar degrees (Gottweis 2005), therefore these recommendations fit well into our study.

Yet, despite the literature indication that active engagement of researchers in policy-making may improve the integration of science in policy decisions no literature is available to date that provides a synthesis of theoretical considerations regarding the factors that may play an important role in facilitating such an engagement. Therefore, this paper focuses on identifying these factors by answering the following question: What are the requirements for

facilitating active engagement of public sector researchers in policy-making? First, we identify reasons for researchers to actively engage in policy-making. Second, we discuss potential constraints that could prevent researchers from such an engagement and show why these constraints may not always be valid. Based on the identified reasons we recommend and discuss five theoretical requirements that may play an important role in facilitating active engagement of researchers in policy-making. We conclude with critical reflection on the proposed requirements and provide directions for future research.

2.2 Methodology

We conducted a literature analysis to identify reasons for and against active engagement of researchers in policy-making. A Google Scholar search and Scopus search using search terms such as "science-policy interface", "science-policy nexus", "the role of scientists in policy-making", "relationship scientists-policy makers", "advocacy role of scientists in policy-making" etc. resulted in 80 articles from various disciplinary traditions including Sociology, Science, Technology and Society Studies, Environmental Science, Biology, Health Care and Policy Studies. This approach for selection of articles was chosen since it allowed for a broad consideration of interdisciplinary perspectives on the reasons for and against the active engagement of researchers in policy-making. The 80 articles were initially reviewed to obtain the basic knowledge about the field of science-policy interface. From these, 21 articles were identified as relevant for the analysis as these addressed directly (in parts or exclusively) the active engagement of scientists/researchers in policy-making (in contrast to the role of science only)[5]. It is important to note that our literature search yielded only one article dealing particularly with engagement of researchers in agricultural biotechnology policy-making. The remaining articles used for analysis addressed contentious political issues which involved multiple interests, values and uncertainty which are also characteristics of policy-making on agricultural biotechnology (Gottweis 2005). Additionally, we also searched for articles that dealt with motivation of scientists to involve in science outreach activities to validate the reasons that we identified from literature on scientists' involvement in policy-making. We hypothesized that the involvement of scientists in outreach activities may be influenced to some extent by similar factors as involvement in policy-making. We used a mind mapping

[5] The selection of these articles was motivated by the theoretical considerations proposed by Pielke (2007) who suggests that when policy-making problems involve high level of uncertainty and low value consensus (such as that of agricultural biotechnology) scientists should take more engaged role in policy-making in order to ensure that science is well represented during decision making processes.

software (Mindjet Manager) to analyse selected articles. First, all articles were screened in order to identify various reasons for and against engagement of researchers in policy-making. Second, after all reasons (for and against engagement) were identified we mapped their reoccurrence throughout the whole bundle of articles. The next sections present the results from our analysis.

2.3 Results

2.3.1 Theoretical Reasons for Scientists to Actively Engage in Policy-making

First, one of the values that Foote et al. (2009) saw in the active engagement of scientists in policy-making is derived from the participatory character of the contemporary policy debates. They reasoned that scientists should get actively engaged in policy-making since the failure to do so may result in policies which are "largely made by special interest groups, lawyers, religious leaders, legislators, and judges, many of whom may hold narrow perspectives on environmental requirements" (Foote, Krogman, and Spence 2009a, 582). Lovbrand et al. (2010) pointed to similar concerns when they articulated that "poor representation of expert opinions restricts the scope of the debate" (Lovbrand, Pielke, and Beck 2010, 484). As a result, researchers' (recent) insights might be neglected by policy makers when researchers do not actively engage in policy-making by themselves (Weiss 1991b, Brussard and Tull 2007, Scott, Rachlow, and Lackey 2008). As Meyer et al. (2010) put it "The publication of policy-relevant science in peer reviewed journals is rarely sufficient, by itself, to draw enough attention to an emerging environmental threat to initiate action" (Meyer et al. 2010, 299-300). Allio et al. (2006) also pointed to the problem of scientific literacy of policy makers who may not have a scientific background, and therefore, may be unable to make use of research results reported in scientific journals (Allio, Ballantine, and Meads 2006). Holmes and Clark (2008) reported that policy makers find it difficult to establish contact with experts and assess the reliability and quality of information (Holmes and Clark 2008). Therefore, the first reason for researchers to actively engage in policy-making debates is to strengthen the voice of science, and thereby improving the interpretation of scientific results in policy debates.

Second, Weiss (1991) recognized another problem with the use of science in policy-making, the misuse of research results. She articulated that research is (mis)used by policy actors "when and if it advances their case in the [..] decision making" (Weiss 1991b, 40). When researchers do not actively engage in policy debates they miss the opportunity to directly address possible misuses of their scientific results. As such, other stakeholders concerned with

a policy problem may use scientific data to dismiss certain political options and to legitimize their policy preferences (Weiss 1991b). Therefore, the second reason for researchers to actively engage in policy-making is to correct the misinterpretation of scientific knowledge by other policy actors.

Third, Haas (2004) articulated that researchers should participate in policy-making because they possess a high esteemed position in our society. He noted that "Doctors, scientists and engineers remain the most esteemed professions in Europe, and thus command the greatest social legitimacy and deference when providing policy advice [..]" (Haas 2004b, 575). Similar results were reported in the Eurobarometer 2005 and 2010 where general public indicated that researchers working at universities and governmental laboratories are seen as the most capable to explain the impact of scientific and technological development on society (Eurobarometer 2005, 2010). Therefore, the third reason for researchers to actively engage in policy-making stems from a societal demand that indicates that researchers are a trustworthy source of scientific knowledge and hence well positioned to take up an active role. Finally, Lackey states that active engagement of researchers in policy-making "[..] is not only the right thing to do, but we are obligated to do so, especially if our work is funded by public resource" (Lackey 2007). Therefore, the fourth reason for researchers to engage in policy-making is based on societal obligation of researchers to be involved in policy-making. Table 1 provides an overview of these arguments.

Table 1 Summary of reasons for scientists to get actively engaged in policy-making

- To strengthen the role of science in policy-making
- To correct misinterpretations of science
- To provide input of a trustworthy source
- To exercise moral obligation towards society

2.3.2 Theoretical Reasons for Scientists Not to Actively Engage in Policy-making

A frequently articulated concern we found is the impact of active engagement in policy debates on researchers' credibility. Scholars widely acknowledge that when researchers become advocates in policy debates this could harm their hard-earned reputation of researcher as objective and value free source of knowledge. It can also affect their academic status, as perceived by their scientific peers (Lackey 2007, Pielke 2007b, Meyer et al. 2010).

Therefore, the first reason for researchers to refrain from an active engagement in policy-making is the impact on scientific credibility. Yet, the examples from boundary work and policy network literature illustrate that research is by nature not value free and researchers are not politically disinterested and unbiased individuals (Gieryn 1983, Sabatier 1988a, Moore 1996, Montpetit 2011). Moore (1996) advises that rather than seeing researchers only as researchers one should see researchers as "[..] people who have competing, complex and overlapping social commitments [..]" (Moore 1996, 1595). As such, refraining from engagement in policy-making does not ensure scientists' value freedom and objectivity.

The second concern scholars identified is related to the ability of researchers to actively engage in policy-making. The engagement requires that researchers possess certain skills, such as communication and interpersonal skills (Steel et al. 2004) while most researchers are not trained to communicate about their scientific findings with non-scientific audiences (Foote, Krogman, and Spence 2009a). Therefore, a second reason for researchers to refrain from active engagement in policy-making is the perceived lack of skills to do so. However, Moore (1996) illustrates that researchers can develop these skills when they need to communicate about their research with non-scientific audience in order to demonstrate the relevance of their work (Moore 1996), providing a possible solution to this reasons for refrainment.

Third, active engagement in policy-making is a time consuming activity (Brownson et al. 2006, Holmes and Clark 2008). Researchers need to allocate extra time to participate in policy-making and to managing a certain level of awareness about recent policy developments. Andrews et al. (2005) reported that the lack of time was also indicated by researchers as one of the hindering factors of researchers' participation in science outreach activities (Andrews et al. 2005). Therefore, the third reason for researchers not to actively engage in policy-making relates to the time demand. However, this is not a valid reason for all researchers since studies on scientists' involvement in policy networks and scientific outreach activities indicate that deeply rooted intrinsic motives, such as shared beliefs among researchers and personal enjoyment, may play an important role in determining researchers' decision to engage (Sabatier 1988a, Haas 1992a, Martín-Sempere, Garzón-García, and Rey-Rocha 2008). Therefore, it can be argued that when scientists are intrinsically motivated to engage in policy-making they may be willing to invest extra time.

The fourth argument partly follows from the previously articulated time constraints since the time spent on activities different than research is not usually rewarded within academia

(Engels 2005b, Gibbons et al. 2008, Holmes and Clark 2008). This means that the time spent on active engagement with policy-making is not likely to contribute to scientific career development (Brownson et al. 2006). As such, the lack of institutional recognition may be a demotivating factor for researchers to actively engage, as they may need to make a choice between engagement in policy-making and a full focus on activities enhancing their academic careers. If they choose the former their (partial) disconnection from the scientific world may in the long term negatively influence their credibility in the policy process (Meyer et al. 2010). Therefore, the fourth reason for researchers to refrain from active engagement in policy-making is a perceived lack of institutional encouragement of outreach activities. Similar to the time constraint, the lack of institutional encouragement may be less important for researchers who are intrinsically motivated to actively engage in policy-making debates. Interestingly, we have not come across articles that investigated policy engagement that was explicitly institutionally rewarded. Table 2 provides a summary of our findings.

Table 2 Summary of reasons for scientists not to actively engage in policy-making

- Damage to scientific credibility
- Lack of competences
- Lack of time
- Lack of rewards

2.3.3 Theoretical Requirements for Facilitating Active Engagement of Scientists in Policy-making

In this section, we synthetize the findings from section 2.3.1 and section 2.3.2 and recommend five requirements which may play an important role in facilitating active engagement of researchers in policy debates. A description of each requirement is provided below.

Our findings from section 2.3.1 imply that there are several factors which may stimulate researchers to engage in policy-making, e.g. to strengthen and clarify the input of academic science in policy debates or to correct the misinterpretation of scientific findings. Scholarly literature provides examples of other potential reasons, such as a protection of professional authority (Gieryn 1983), demonstration of researchers' social responsibility (Moore 1996), and gaining of a greater impact on policy (Weiss 1991b). These reasons can be conceptualized as motivating factors. We conclude from the literature review that the first requirement

relevant for active engagement of academic researchers in policy-making debates is 'motivation'. Since, our findings give only limited representation of possible determinants of motivation, future research could focus on the question: Which factors determine the motivation of academic researchers to (or not to) actively engage in policy-making debates?

From section 2.3.2 we conclude that time may impose an obstacle to an active engagement of researchers in policy debates and that researchers may not feel institutionally encouraged to engage. This could possibly be remedied by an organizational effort to facilitate active engagement in policy-making and this directly raises the question of representation: Do all researchers have to be active in policy-making? And does the institution have the (moral) responsibility to facilitate engagement of researchers to actively engage in policy-making? To what extent should this be centrally steered? Taking this into account, we define that the second requirement relevant for an active engagement of researchers in policy-making is 'task coordination'. Coordination can be understood as the ability of researchers to align their activities as researchers i.e. doing scientific research, with active engagement in policy-making. Therefore, possible coordination processes need to be identified, including the facilitation and support of these coordinated actions by the institution. Future research could focus on: Which task coordination processes can be employed (e.g. at individual and institutional level) to facilitate simultaneous engagement of researchers in research related activities and in policy-making debates? Also, in order to study coordination processes, the relationship between motives and coordination can be helpful, since motives are important determinants of the willingness to coordinate (Malone and Crowston 1994).

Section 2.3.2 indicates that successful engagement of researchers in policy debates requires that scientists possess certain communication and interpersonal skills. Therefore, the third requirement relevant for active engagement of researchers in policy-making represents 'communication competence'. Communication competence refers "to the extent to which a person achieves desired outcomes through communication [..]" (Morreale, Spitzberg, and Barge 2007, 29). Such competence is needed to constructively communicate with policy makers and other non-scientific stakeholders participating in policy debates. In addition, the communication competence ultimately influences the impression researchers make on policy makers and other stakeholders. As such, future studies about active engagement of researchers in policy-making can benefit from the insights from communication science. Our findings from section 2.3.2 also indicate that researchers may be hindered by a lack of training to communicate with non-scientific audiences. Therefore, we recommend that future

research in this field may focus on the identification of communication competences necessary to facilitate active engagement of researchers in policy-making and on setting up training modules to further enable researchers to become engaged.

Fourth, the findings from section 2.3.2 point out that the lack of recognition, and with that, associated lack of (perceived) appreciation may be discouraging for researchers to get actively engaged in policy debates. Therefore, the fourth requirement relevant for active engagement of researchers in policy-making concerns 'recognition'. Recognition refers to the appreciation of non-research related activities by the institution that researchers work at as well as by academic peers, family and general public. Therefore, to facilitate active engagement of researchers in policy-making it is desirable that the institutes where researchers are employed encourage and reward outreach activities. To explore the current possibilities, future research could focus on the question: To what extent can outreach activities be encouraged and rewarded at public sector research institutes?

Finally, the findings further indicate that researchers may be discouraged to actively engage when they fear their credibility may be negatively impacted. Therefore, a fifth requirement relevant for an active engagement of researchers in policy-making represents 'scientific credibility'. Scientific credibility refers to "[..] the capacity of claims makers to enrol supporters behind their claims, to legitimate their arguments as authoritative knowledge, and to present themselves as the sort of people who can give voice to science" (Epstein 1995, 411). Therefore, one of the necessary requirements for an active engagement of researchers in policy debates is to design strategies, which can make researchers feel confident and comfortable with such engagement. One possible approach could be engagement through larger groups, such as professional societies or advocacy and advisory groups (Mathews, Kalfoglou, and Hudson 2005a). Future research may therefore explore the following question: Which engagement strategies are available for researchers to engage in policy-making that minimize the negative impact on scientific credibility?

2.4 Concluding remarks and recommendations

Policies and regulations regarding the applications of agricultural biotechnology play an important role in facilitating commercial release of agricultural crops with improved characteristics. Yet, the current regulatory environment is considered confusing by public sector research institutes. While policy and regulatory debates are characterized by wide participation of stakeholders, such as environmental non-governmental organizations,

consumer groups and private industries, public sector researchers have not directly participated in these debates.

Our literature review shows that there are strong arguments to involve researchers in policy-making. Active engagement of public sector researchers in policy debates can strengthen the voice and clarification of science in policy debates while at the same time providing researchers with timely opportunities to address potential misuse and misinterpretation of their work. This is especially relevant for agricultural biotechnology where strong influence of activist groups had a large impact on regulatory decisions. Currently, several consortia exists which focus on engagement of scientists in agricultural biotechnology policy-making, yet, no studies have been conducted so far which focus on requirements which are necessary for such an engagement. In this paper, we analysed a broad and multidisciplinary set of available literature on engagement of researchers in policy-making and science outreach activities from which we identified four reasons for and four reasons against the active engagement. These were used to recommend five requirements which may play an important role in stimulating and facilitating the active involvement of researchers in policy-making: Motivation, Task coordination, Communication competence, Recognition and Credibility.

The five requirements presented here should not be seen as independent from each other but rather as mutually interrelated. For example, the more researchers are able to coordinate between scientific career and engagement in policy-making, the more they are likely to be motivated to do so. Similarly, well-developed communicative competence is likely to have a positive impact on understanding and acceptance of scientific findings by non-scientific participants in policy debates, and therefore, it is likely to have an impact on researchers' credibility. Although the validity and the usefulness of the identified requirements is yet to be empirically tested, it provides a possible directions for future investigation about the conditions which determine the propensity of researchers to actively engage at the science-policy interface.

We propose that the requirements we identified are further investigated empirically to confirm their validity. Qualitative study may also uncover requirements that have not been considered in this paper, as they may not have been identified in the literature we studied. We also advise investigating the importance of each of the requirements quantitatively to indicate which of the requirements are the most important determinants for active engagement of public sector researchers in policy-making. The identified requirements may

well be relevant for all public sector researchers and their institutions also beyond the field of agricultural biotechnology. It is likely that they may be important also for other science policy fields that are characterized by uncertainty and dynamic policy-making processes. Our study also raises the question of how science and technology in general should be represented in policy-making and how this should be governed. In any case, the inclusion of research results requires active involvement of researchers and this starts with the motivation of researchers to become actively involved in policy-making debates. Active engagement can enable researchers to directly address the problems with unclear regulations, and thus, it can positively influence the innovation climate for agricultural biotechnology products.

Chapter 3

The role of scientists in agricultural biotechnology policy-making: From traditional to alternative views

An adapted version of this chapter has been accepted for publication as:

Van der Werf Kulichova, Z, Coumou H.C., Arujanan M., Wehrmann C., and Osseweijer P. forthcoming. "The role of scientists in policy-making regarding agricultural biotechnology: From traditional to alternative views " *International Journal of Biotechnology*.

Abstract

Scientists have always played an important role in informing policy decisions. However, many controversial policy problems regarding science and technology, such as agricultural biotechnology, are often characterized by low value consensus and high level of complexity. In these circumstances various policy actors legitimate their policy preferences using science. In this article, we challenge the linear model of science and policy and argue that the stakeholder model of science in policy is more appropriate for governance of controversial policy problems regarding science and technology. We build our argument on available literature and empirical data from interviews and two online surveys. We choose agricultural biotechnology as the case study to illustrate scientists' perception about their role in policy-making. Our study illustrates that agricultural biotechnology scientists sympathize with the stakeholder model of science and policy. However, there is a gap between perceived ideal role for scientists in policy-making and the role, which these scientists actually take.

3 The role of scientists in agricultural biotechnology policy-making: From traditional to alternative views

3.1 Introduction

In modern societies, a large number of policies are related to scientific issues. "As the main instrument through which humans view, understand, and modify nature, the sciences have always held a privileged position in environmental debates" (Chilvers and Evans 2009). The importance of science for policy-making has grown over time since many of the modern policy-making problems are surrounded by environmental concerns, which are likely to have cross-sectorial impacts. For these reasons, scientific methods are utilized to identify and understand complex relationships (Engels 2005a, Woodhouse and Nieusma 1997, Haas 1992b, Holmes and Clark 2008), to identify and assess potential risks (Allio, Ballantine, and Meads 2006), to predict potential impacts (Lach et al. 2003), to compare different scenarios (Pellizzoni 2011) and to frame issues and design options (Liberatore and Funtowicz 2003). Yet, with the increasing importance of science for policy-making concerns have started to emerge that raise critical questions about how science is viewed and used in policy-making. There seem to be a continuous tension between scientific information and societal and political priorities (Schenkel 2010, Pellizzoni 2011). This tension manifests itself in a so-called politicization of science; the processes of construction and deconstruction of scientific knowledge claims that lead to competition among interest groups, industry and politicians, all of whom try to determine how policy relevant science should be interpreted and by whom (Jasanoff 1987, Pellizzoni 2011, Wesselink and Hoppe 2010). Such politically motivated battles over the validity of scientific claims among industry, interest groups and politicians pose big challenges for the integration of scientific knowledge in policy decisions even when this knowledge is supported by scientific consensus of wide scientific society. Some speculate that one of the possible reasons why scientific knowledge gets neglected or even misused in the policy-making process is the lack of participation of scientists in policy-making (Foote, Krogman, and Spence 2009b, Weiss 1991a, Meyer et al. 2010, Allio, Ballantine, and Meads 2006, De Greef 2004b, Strauss et al. 2009a, van der Werf Kulichova, Flipse, and Osseweijer 2014). This paper presents the views of agricultural biotechnology scientists regarding the role of scientists in policy-making. It attempts to shed light on questions regarding the desirability

of scientists' policy participation and the preferable roles for scientists' in policy-making as perceived by scientists themselves.

The participation of scientists in policy-making has been traditionally governed by the so-called 'linear model of science and policy', which suggests that scientists only produce scientific knowledge, and the decision about how this knowledge is utilized in policy-making is completely left to policy makers (Pielke 2007; Chilvers and Evans 2009). This model, however, met with critique as it ignores important relationships between science and policy-making, and science and society (McNie 2007). Consequently, an alternative model of science and policy emerged in mid-90's in the literature and was summarized by Pielke (2007) as a stakeholder model of science and policy (Pielke 2007). The stakeholder model holds "[..] that considerations of how science is used in decision making are an important aspect of understanding the effectiveness of science in decision making" (Pielke 2007, 14). The stakeholder model of science in policy seems to relate to the Ostroom's notion of complex problems which tend to include multiple actors who are concerned about policy outcomes but who do not hold the consensus about how these outcomes should look like (Ostrom 2009). The lack of consensus about the desired policy outcomes poses challenges to the proper integration of science in policy decisions (Smyth, Kerr, and Phillips 2013). As such, the stakeholder model of science in policy advocates that proper integration of scientific knowledge into complex policy problems require that scientists take a more engaged role in policy-making (Pielke 2007a). Pielke reasons that in these policy-making contexts passive delivery of scientific information (as the linear model suggests) cannot provide sufficient basis to determine which course of action should be taken (Pielke 2007, 17-18). However, despite the increasing awareness that the stakeholder model of science and policy may be more suitable for understanding the impact of scientific knowledge on policy decisions in controversial policy debates, only limited empirical research exists focusing on the perceptions of scientists about their own role in policy-making.

This paper aims to explore, on the theoretical as well as empirical level, the views regarding participation of scientists in policy-making. The theoretical part of the paper attempts to answer the following questions: What are the differences between the linear and the stakeholder model of science and policy? How has the stakeholder model evolved in the literature? Which roles can scientists take when they subscribe to the stakeholder model? The empirical part of this paper is based on a case study that focuses on the role of scientists in agricultural biotechnology policy-making. It focuses on the following questions: How do

agricultural biotechnology scientists perceive the role of scientists in policy-making and why? Which roles do these scientists prefer to take themselves in policy-making and why? The empirical data was collected in three phases. In phase one in-depth interviews with agricultural biotechnology scientists were carried out. In phase two and three, two online questionnaire surveys were administered.

3.2 Background: From linear to the stakeholder model of science and policy

"The conventional view on the science–policy interface conceptualizes scientific knowledge as a politically neutral input to rational processes of decision making and assumes a clear, indisputable boundary between science and policy" (Holifield 2009). This, a so-called, linear model of science and policy builds on the "neutrality view on science which implies that scientists only produce scientific knowledge and the decision about how this knowledge is utilized in policy-making is completely left to policy makers (Holifield 2009, Steel et al. 2004, Chilvers and Evans 2009, Pielke 2007a). The neutrality view proposes that "[..] the primary responsibility of the researchers consists in producing reliable, objective knowledge about the world through a process of disinterested, curiosity-driven research"(Schuurbiers 2010, p.20). In essence, the linear model suggests that science and policy-making are two separate worlds, and therefore, scientists should carry out research and policy-making should be left to policy makers. The stakeholder model of science and policy, on the other hand, supports that scientists can be seen as stakeholders in policy debates which concern discussion about research and application of science and technology since the results of these debates directly influence the conduct of their work (i.e. regulatory frameworks, decisions about research funding).

Although the linear model served for many years as the main model for the positioning of scientists in policy-making, over the time scholars started to recognize that the major premises on which it builds cannot be maintained in practice. The seminal work of American sociologists Thomas Gieryn skilfully demonstrated that scientific value freedom; political disinterestedness and objectivity cannot be maintained in practice. To illustrate his argument Gieryn presented three examples in which scientists attempted demarcation by constructing social boundaries between scientific and non-scientific activities. Using these examples, Gieryn illustrated that scientists always attempt to protect their professional authority and

showed that scientists similar to other social actors are not value free and objective individuals (Gieryn 1983).

Scholars in Policy Studies have also recognized the value driven role of scientists in policy debates. Three concepts introduced by policy science scholars illustrate that scientists often step down from the 'ivory tower' and take a stakeholder role in policy-making; The advocacy coalition framework (Sabatier 1988b), epistemic communities (Haas 1992b) and the global knowledge networks (Maxwell and Stone 2004) indicate that scientists are likely to become members of policy networks if the goals of these networks resonate well with their own normative and causal believes. For example, Sabatier (1988) suggests that each policy system has a subsystem, which is represented by actors who are actively concerned about a policy problem or issue. These actors come from different backgrounds including science, since scientists possess special skills and knowledge, which they can leverage to support a cause. Haas (1992) proposed that scientists may enter the policy arena via a network called an epistemic community which represents "(..) a network of professionals with a recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area" (Haas 1992). Members of an epistemic community can be social and natural scientists alike. Stone (2002) proposed that scientists may also become members of so-called global knowledge networks which "[..] incorporate professional associations, academic research groups and scientific communities that organize around a special subject matter or issue". (Stone 2002, p. 2). By using their scientific knowledge and special expertise global knowledge networks can gain authority to inform policy.

Examples offered from boundary work and policy networks indicate that the stakeholder model of science and policy has been attractive to some scientists. According to Pielke (2007), it seems that scientists whose work has become a controversial subject of policy discussions are more likely to subscribe to the stakeholder model of science and policy. Yet, not all scientists are interested in active engagement, and therefore, Pielke proposes four roles for scientists in policy-making: Pure scientist, Science arbiter, Issue advocate and Honest broker of policy alternatives. Pielke attributes the first two roles to the linear model of science and policy and he links the last two roles to the stakeholder model of science and policy. Table 3 presents the proposed four roles for scientists' in policy-making together with their brief characteristics. Building on this conceptual background, the next section presents the design

of a case study, which investigated the perceptions of agricultural biotechnology scientists about their role in policy-making.

Table 3 Possible roles for scientists in policy-making (Based on Pielke, 2007)

Pure scientist	Focuses only on facts and has no interaction with the decision maker
Science arbiter	Answers specific factual questions posed by the decision maker
Issue advocate	Seeks to reduce the scope of choice available to the decision maker
The honest broker	Seeks to expand, or at least clarify, the scope of choice available to the decision maker

3.3 Methodology

3.3.1 Case study rational: How do agricultural biotechnology scientists perceive their role in policy-making?

Agricultural biotechnology has always been surrounded by debate and controversies regarding the appropriate level of regulatory scrutiny. Although the scientific consensus has been that modern biotechnology can be used safely and effectively, there has been a controversial debate among regulators, biotechnology companies, opponents of the technology and non-governmental organizations (NGOs) questioning the safety of genetically modified (GM) crops (Cantley and Kershen 2013). The controversial opinion among different stakeholders played its role during the design of international regulatory frameworks, such as the European Union GMO Directives and Regulations as well as the International agreement on biosafety called the Cartagena Protocol on Biosafety. Some claim that neglecting available scientific evidence resulted in regulatory procedures that are increasingly time consuming, costly and effort intensive (Cantley and Kershen 2013, Ammann 2014, Potrykus 2010, De Greef 2004b, Dubock 2014, Miller and Bradford 2010, Vigani and Olper 2013, McDougall 2011). Strauss et al. (2010) showed that the length of the approval processes for the field testing of GM crops in the United States has increased over the time (Strauss et al. 2010, 738). The same authors suggest that "[..] the current legal and regulatory situation places severe constraints on both the ability to develop GM crops at all, and then on the performance of adequate environmental studies to inform regulatory and other social decisions about their use". The

problems with regulatory compliance are especially felt among public sector researchers who work with restricted research budgets, and therefore, they often do not have enough financial resources to satisfy endless quests for additional data by the regulatory authorities (Strauss et al. 2010, Strauss et al. 2009a). While scientists complain about the unnecessary complexity of biosafety legislations, environmental NGOs are calling for more studies to ensure that any possible negative impacts from cultivating GM crops are prevented (Ansell, Maxwell, and Sicurelli 2006). Given this background, agricultural biotechnology can be seen as a case study for policy-making related to science that is characterized by low value consensus among stakeholders and high level of political uncertainty about possible future impacts. These characteristics make the case of agricultural biotechnology policy-making a valuable case for studying scientists' perceptions about their role in policy-making.

3.3.2 Data collection

The data was collected in three phases. In phase one, semi-structured interviews were carried out with 17 European scientists working in the field of agricultural biotechnology. During this phase, 82 European scientists were approached via e-mail. 57 scientists were subscribers of the mailing list of the Public Research and Regulation Initiative (PRRI). PRRI was established in 2004 with the objective to offer a forum for public sector scientists to be informed about and involved in international discussions about biosafety (www.prri.net). The membership in PRRI is free of charge. Any scientist interested in a PRRI membership can join the organization provided he/she works at a public sector research institute. The interest in PRRI activities seem to indicate that these scientists have some concerns with regulatory procedures and thus are more politically interested scientists. The remaining 25 scientists did not have an affiliation with any organization that facilitates engagement of scientists in policy-making. The inclusion of both kinds of scientists enabled us to observe a broader range of perspectives on scientists' role in policy-making. In total, 30 scientists reacted positively and 17 interviews were scheduled due to time constraints. Twelve scientists in our sample were PRRI subscribers, and therefore had some experience with policy engagement, while the other five scientists had only limited or no experience with policy engagement. Although our sample mostly included life scientists, we also interviewed one science communication specialist and one economist to broaden the possible perspectives on scientists' policy engagement. The sample characteristics of interviewees are presented in Table 4. The interviews took place in July, 2013. In order to investigate scientists' opinion about their role in policy-making we asked scientists the following questions: 1) Do you think that scientists have the responsibility to not

only publish but also to interpret research results for policy makers? Why? 2) Do you think that scientists should personally involve in policy-making or that science and policy-making should be separate processes? Why? 3) Some scientists advocate on specific policy decisions they prefer and thereby use science to reduce the scope of choice available to policy makers. In general, do you think positively or negatively about this? Why? 4) Others argue that scientists should seek to clarify the scope of choice available to a policy maker, so not to advocate a single "best" course of action, but to address the question which policy alternatives are consistent and inconsistent with scientific results? In general, do you think positively or negatively about this? Why? 5) What role do you take in policy-making?

In phase two and three, complementary data was collected via two online surveys with agricultural biotechnology scientists to validate the findings from the interviews. To maintain our sampling strategy, the first online survey targeted scientists who are members of the Public Research and Regulation Initiative, hence politically concerned scientists. The link to an online questionnaire was mailed to 312 scientists who are subscribed to the PRRI mailing list. Scientists who participated in the interviews were excluded from the mailing list. The second survey was administered with agricultural biotechnology scientists who are subscribed to the mailing list of the International Service for the Acquisition of Agri-biotech Applications (ISAAA). 142 ISAAA subscribers were approached. ISAAA is a global knowledge network with its core focus on agricultural biotechnology. It provides science-based information to scientific community and other stakeholders about new developments in the field of agricultural biotechnology and deals with policies and regulation (www.isaaa.org). Because it was likely that some PRRI members may also be ISAAA subscribers, our invitation e-mail for survey participation stated that only scientists who did not participate in the first survey should participate. Inclusion of two groups of scientists allowed us to examine the similarities and differences in their perceptions about their role in policy-making. The sample characteristics of PRRI scientists are presented in Table 5. The sample characteristics of ISAAA subscribers are presented in Table 6. The data was collected between December 2013 and February 2014.

Table 4 Sample characteristics (Phase 1 - Interviews with European agricultural biotechnology scientists)

Gender	Age (years)	Employer	Countries
Male (13)	< 30 (0)	University (10)	Germany (2)
Female (4)	30 - 40 (1)	PRI (7)	Italy (1)
	41 - 50 (1)		The Netherlands (5)
	51 - 60 (9)		Belgium (3)
	> 60 (6)		United Kingdom (1)
			Switzerland (1)
			Spain (1)
			France (2)
			Hungary (1)
17 (100%)	17 (100%)	17(100%)	17 (100%)

Notes: PRI=Public sector research institute

Table 5 Sample characteristics (Phase 2 - Online survey with PRRI members)

Gender	Age (years)	Employer	Continents
Male (77%)	< 30 (3.7%)	PRI (35.6%)	South America (11.1%)
Female (23%)	30 - 40 (11.0%)	University (48.9%)	North America (12.6%)
	41 - 50 (28.9%)	Other * (15.6%)	Europe (40.0%)
	51 - 60 (32.6%)		Africa (14.8%)
	> 60 (23.7%)		Australia (1.5%)
			Asia (20.0%)
139 (100%)	139 (100%)	139 (100%)	139 (100%)

Notes: * International governmental organizations, Self-employed, Retired, PRI=Public sector research institute

Table 6 Sample characteristics (Phase 3 - Online survey with ISAAA subscribers)

Gender	Age (years)	Employer	Continents
Male (75,93%)	< 30 (0%)	University (59%)	South America (0%)
Female (24,07%)	30 - 40 (16%)	PRI (19%)	North America (35,18%)
	41 - 50 (20%)	NGO (8%)	Europe (35,20%)
	51 - 60 (31%)	Other* (22%)	Africa (24,07%)
	> 60 (33%)		Australia (1,85)
			Asia (3,70%)
54 (100%)	54 (100%)	54 (100%)	54 (100%)

Notes: * International governmental organizations, Self-employed, Retired, PRI=Public sector research institute

In order to investigate scientists' perception about their role in policy-making, we asked them to express their agreement or disagreement with the following statements: 1) Scientists are important policy stakeholders, 2) All stakeholders should participate in policy-making to ensure that their interest is reflected in policies and regulations. These statements were assessed on a 5 point Likert scale ranging from Strongly agree to Strongly disagree. The results from interviews indicated that there are some reoccurring themes in our dataset. Therefore, we decided to also ask scientists about these. These themes included perceived impact of regulatory frameworks on research progress in agricultural biotechnology, perceived politicization of science and the feelings of social responsibility. For example, scientists were asked to evaluate the following statements: 1) For an accurate integration of scientific results into regulations, scientists need to interpret scientific results to policy makers; 2) It is scientists' moral duty to ensure that scientific findings are utilized for the well-being of society. These statements were also evaluated on a five point Likert scale. All statements, which were included in the first survey, are presented in Table 7.

Table 7 Results form the online survey with PRRI members

Theme	Statement	SA	A	N	D	SD	(N=)
Perceived roles	Scientists are important policy stakeholders	52.67%	35.33%	8.67%	3.33%	0.00%	150
	All stakeholders should participate in policy-making to ensure that their interest is reflected in policies and regulations	28.67%	56.67%	10.00%	4.67%	0.00%	150
Impact of regulations	Strict regulations prevent innovative research in agricultural biotechnology	44.08%	42.11%	1.97%	10.53%	1.32%	152
Politicization of science	Most policy makers lack the necessary scientific background, and therefore, may misinterpret scientific data	49.34%	36.84%	8.55%	4.61%	0.66%	152
	For an accurate integration of scientific results into regulations, scientists need to interpret scientific results to policy makers	50.00%	46.00%	3.33%	0.67%	0.00%	150
Social responsibility	It is scientists' moral duty to ensure that scientific findings are utilized for well-being of society	50.00%	32.67%	11.33%	6.00%	0.00%	150
	When I engage in regulatory debates, I feel I contribute to societal well-being.	40.13%	44.74%	11.84%	3.29%	0.00%	152

Notes: SA=Strongly agree, A=Agree, N=Neutral, D=Disagree, SD=Strongly disagree, N=Sample size

In phase 3, additional data was collected from agricultural biotechnology scientists who subscribed to the ISAAA mailing list. Due to a nature of this group but also some comments from PRRI scientists on wording of some questions, the second survey included slightly modified versions of the questions, which were asked in the first survey. For example, we asked scientists to indicate their agreement/disagreement with the following statements: 1) I feel that regulatory standards in my country facilitate deployment of benefits from agricultural biotechnology; 2) Engagement in policy-making is my social responsibility. All statements, which were included in the second survey, are presented in Table 8. The data was collected between February 2015 and April 2015.

Table 8 Results from the online survey with ISAAA subscribers

Theme	Statement	SA	A	N	D	SD	(N=)
Perceived roles	I believe that participation of public sector scientists in policy-making regarding agricultural biotechnology is important.	70.00%	25.00%	3.33%	0.00%	1.67%	60
Impact of regulations	I feel that regulatory standards in my country facilitate deployment of benefits from agricultural biotechnology	4.69%	21.88%	7.81%	39.06%	26.56%	64
	I feel that regulatory standards in my country encourage public sector research in agricultural biotechnology (field trials)	12.50%	23.44%	10.94%	34.38%	17.19%	64
	I feel that regulatory standards in my country encourage commercialization of agricultural biotechnology products	7.81%	23.44%	9.38%	23.44%	35.94%	64
Politicization of science	Regulatory standards in my country are mostly based on political preferences	32.81%	29.69%	12.5%	21.88%	3.13%	64
	Regulatory standards in my country are mostly based on public preferences	18.75%	26.56%	18.75%	35.94%	0.00%	64
	Regulatory standards in my country are mostly based on anti GMO NGO preferences	26.56%	25.00%	9.38%	31.25%	7.81%	64
Social responsibility	Engagement in policy-making is my social responsibility.	38.33%	45.00%	8.33%	6.67%	1.67%	60
	Engagement in policy-making is part of my job scope.	25%	43.33%	5%	20%	6.67%	60

Notes: SA=Strongly agree, A=Agree, N=Neutral, D=Disagree, SD=Strongly disagree, N=Sample size

3.3.3 Analytical approach

In order to analyse the data collected from interviews, we used Atlas Ti software, version 7.5.4. This software enabled us to code data according to the themes of our interest and also to sort out themes, which were repetitive throughout the whole dataset. We employed the following main codes in our analysis: Code1: How do scientists perceive their role in policy-making? Code 2: Why do scientists think that they should engage in policy-making? Code 3: Which role do scientists perceive as appropriate for scientists' engagement in policy-making regarding agricultural biotechnology? Code 4: Which policy role do scientists take themselves? These codes corresponded to the questions that we asked scientists to answer during the interviews. Given the exploratory nature of this research we employed the model proposed by Pielke (2007) to identify common beliefs that have influenced scientists in forming their opinion about their role in policy-making. To analyse the results from the two online surveys we used a simple descriptive statistics focusing on frequency distribution of answers.

3.4 Results

3.4.1 General observations

First, the qualitative data we collected from interviews with 17 public sector scientists working in the area of agricultural biotechnology indicate that all scientists in our sample feel strong resonance with the stakeholder model of science and policy. This result is also supported by our quantitative results, which indicate that the majority of scientists believe that scientists are important policy stakeholders. Second, although all interviewees agreed that scientists should actively participate in policy-making some participants expressed opinions that not all scientists need to be active, i.e. because not all scientists have the necessary qualities to do so and not all scientists are necessary interested in policy engagement. Third, as to the question of why should scientists engage in policy-making, we observed that three themes were reoccurring throughout the text; 1) Scientists' discontent with biosafety regulations, 2) Perceived politicization of biosafety regulatory debates and 3) The feeling of social responsibility. Scientists generally felt that the current regulatory environment for agricultural biotechnology is not favourable for public sector research, especially regarding the experimental field trials with genetically modified crops. Similar results were also obtained from the online survey where the majority of scientists disagreed that regulatory frameworks in their countries facilitate deployment of benefits from agricultural biotechnology. Scientists also felt that often policy-making discussions about regulatory standards are influenced by

ideology instead of by scientific evidence. Fourth, regarding the question about which role should scientists take when they engage in policy-making, most scientists in our sample felt that the role which integrates both the issue advocacy and the honest brokering of policy alternative is the most appropriate role for scientists in policy-making. Finally, our findings regarding the actual role that politically concerned scientists take in policy-making indicate that most scientists take the honest brokering role and only two scientists adopt the issue advocacy role. In the next sections, we present some quotes from interviews to illustrate these findings in more details.

3.4.2 How do scientists perceive their role in policy-making?

Most scientists who participated in our study agreed that it is important that scientists do engage in policy-making regarding agricultural biotechnology. 88% of PRRI scientists and 95% of ISAAA subscribers believe that scientists are important policy stakeholders (see Table 7 and 8). These results were also evident during interviews. For example, some interviewees stated:

> [..] I'm pretty convinced that besides publishing scientific results we should also make efforts to communicate these results to the public, but also to the politicians (Interview 10, Belgium, Regularly engages in policy-making).

> Yes, I think it's very important because otherwise, like they say, you're in an ivory tower and that's not good for science (Interview 16, Belgium, Regularly engages in policy-making).

> I think it's… in my area, it's very important because my area is very sensitive. We are talking about crops and food security and biofuels. They are all in the newspapers or on the Internet. Every week. And there are a lot of misunderstandings. With people. With governments. Policymakers. Politicians. And I think it's our responsibility to help to clarify and to come to a consensus (Interview 1, United Kingdom, Regularly engages in policy-making).

Although many scientists agreed that there is a role for them to play in policy-making the results from interviews point out that scientists perceive the question about their engagement in policy-making to be context specific. For example, some scientists stated:

> I think yes, maybe not all of them [scientists], because not everybody, not all scientists are prepared for different things. There are some scientists who

> are better in publishing things and maybe others are better in more … how do you say it, to do master classes or explain themselves better than others. I think we need both kinds of scientists, [..] (Interview 15, Spain, Little experience with policy engagement).

> I think it depends on the individual scientist. Some have stronger interest in policies than others. At least, they have to play the role of informing policy makers. If they then want to become involved in policy-making that is then… I think that has to be the responsibility of each individual scientist. So not everybody also wants to be a policy maker. So everybody has to make his own choices (Interview 1, United Kingdom, Regularly engages in policy-making).

3.4.3 Why do scientists think that they should engage in policy-making?

As described earlier, the arguments for scientists' engagement can be clustered by means of reoccurring themes. We observed that the following themes were repeatedly discussed across all interviews: 1) Discontent with regulatory environment, 2) Inadequate impact of science on policy decisions and 3) The feelings of social responsibility. In the following paragraphs, we present the results in line with these sub-themes.

Discontent with regulatory environment. The first sub-theme relates to dissatisfaction with the current regulatory environment for agricultural biotechnology. The results show that many scientists feel that current regulatory environment is hindering research (mainly field trials with GM crops) and commercialization of green biotechnology. Some interviewees stated:

> [..] if you compare public sector with private sector in Europe it is absolutely clear that public sector is not being able to bring anything to the market and to produce something that goes onto the market in our sector of course, in our research field, because we don't have the financial resources to do that. Because the cost of bringing a product to the market is in the range of many millions of dollars per product. [..] And this means that the legislation has actually killed any contribution of the public sector to the problem (Interview 7, Italy, Regularly engages in policy-making).

> [..] I've now left that area but I worked for 10 years at the [..] where we did GM field trials. But it just becomes too difficult and for me now it's more interesting to work in other areas. It's now a very big mess with the field trials and trying to do GM research in Europe. So I actually got out of it (Interview 1, United Kingdom, Regularly engages in policy-making).

The results from the two online surveys also indicate that most scientists perceive the regulatory environment for agricultural biotechnology as unfavorable for research and commercialization. For example, 86% of scientists who are members of PRRI agreed that strict regulations prevent research progress in agricultural biotechnology (Table 7). Also 66% of scientists who are subscribers to ISAAA agreed that regulatory standards in their countries do not facilitate deployment of benefits from agricultural biotechnology (Table 8).

Perceived politicization of regulatory debates. The second sub-theme concerns the scientists' perceptions about politicization of regulatory debates. Many scientists whom we interviewed expressed their concerns about the misuse of science in policy debates. Some scientists stated:

> [..], when we talk about life sciences, on the GMO issue in particular, these issues are not easy, they are extremely complex. And sometimes, we observe that regulators such as politicians try to simplify issues in a way that doesn't really reflect what allows us to conclude from a scientific point of view (Interview 5, Germany, Regularly engages in policy-making).

> Well, science is being used in the correct way to evaluate GMOs by the European Food Safety Authority, but then at a political level they don't look at the science anymore and they make political decisions that are not based on the scientific conclusions (Interview 16, Belgium, Regularly engages in policy-making).

> So I was involved really in the whole process, but mainly from a scientific point of view. And it was interesting that they were, the policy makers were admitting that their policy was not based on science in all cases and sometimes based on political considerations from the home country (Interview 1, United Kingdom, Regularly engages in policy-making).

Possible misinterpretation/misuse of scientific data in policy-making has been also agreed upon in the two online surveys. 96% of PRRI scientists agreed that in order to accurately

integrate scientific results into policy-making scientists need to interpret their data to policy makers (Table 7). While PRRI scientists had a united opinion about this matter ISAAA subscribers were more divided. Nevertheless, 60% of ISAAA subscribers agreed that regulatory standards in their countries were mostly based on political preferences (Table 8).

Commitment to social responsibility. The third sub-theme, which emerged from our dataset regarding the question why scientists should engage in policy-making, concerns the commitment to social responsibility. Many scientists in our sample expressed that they feel socially responsible to participate in policy-making debates to make sure that scientific evidence is heard and used for achievement of societal goals. Some scientists stated:

> Well, first of all, the research is being funded by public money, so the public has the right to know what this money is being used for (Interview 16, Belgium, Regularly engages in policy-making).

> Shaping restrictive and unjustified rules for a certain technology can be bad for society in various ways. So I think the best help we can offer is to provide information, suggest which solution could work best to improve the society and the development of new plants and cultivation practices (Interview 7, Italy, Regularly engages in policy-making).

> I think I'm hugely passionate about science … I strongly believe that you should do science to benefit the community (Interview 13, United Kingdom, Little experience with policy engagement).

Results supportive of a strong sense of social responsibility among scientists were also obtained from the online surveys. 83% of scientists who are members of PRRI agreed that it is scientists' responsibility to ensure that scientific findings are utilized for well-being of society (Table 7). Also 83% scientists who are subscribers to ISAAA mailing list agreed that engagement in policy-making is their social responsibility (Table 8).

3.4.4 Which role do scientists perceive as appropriate for scientists who participate as stakeholders in policy-making?

Building on the Pielke's typology, we asked scientists whether they think that scientists should take the issue advocacy role or the honest brokering role. Our results indicate that six scientists considered the issue advocacy role as important, four scientists thought that the role of honest broker is more appropriate and seven scientists considered the combination of

these two roles to be the best for participation of scientists in policy-making. Some scientists who preferred the issue advocacy role stated:

> Well, lobbying is like a negative word. Lobby is like propaganda, it sounds a bit negative. But I think it's really needed, because you cannot expect politicians [..] that they have all this knowledge. They should be assisted and they should be coached by scientists who are specialized or experts in certain topics. That would be good. I'm really in favor of that (Interview 10, Belgium, Regularly engages in policy-making).

> I think scientists are only humans, so I don't think you can avoid or disapprove that a scientist advocates a particular course. It's the job of the policy maker to find representatives of all the sides, so that they can weight them up and make decisions on policy (Interview 14, The Netherlands, Regularly engages in policy-making).

One scientist who preferred the role of honest broker explained:

> I think it's important that scientists keep themselves a little bit separated in the sense that they shouldn't make the final decision, but they should be involved in helping making people the final decision, because very often the people making these decisions are non-scientists or have a very poor scientific background. So they have very little idea about what the possibilities are and what the risks are. So they need to be involved, but eventually the policy makers, and these are mostly the politicians, who are deciding (Interview 13, United Kingdom, Little experience with policy engagement).

The majority of scientists in our study concurred integrating roles, both the issue advocacy and the honest brokering of policy alternatives. These scientists stated:

> In general, I think it's good that we try to present all the facts to the public or to policy makers. But I think we should give our own views as well. We shouldn't just say there are four options. You choose. We should say there are four options and I recommend in descending order of choice that three is the best or four is the best (Interview 1, United Kingdom, Regularly engages in policy-making).

> I understand that you think there is a divide [between the two roles] and I would say spontaneously: it's a matter of personal choice. And it's a matter of your own personality. And for me, as a person, I would involve in both. I have done that and I write books and articles and involve myself in political discussions, on all levels (Interview 4, Switzerland, Regularly engages in policy-making).

3.4.5 Which role do scientists take in policy-making?

Since our group included some scientists who regularly engage in policy-making, we were interested to find out which role the majority of scientists take themselves. Our results indicate that out of nine scientists who regularly engage in policy-making six scientists take the roles of honest broker, two scientists engage in policy-making as issue advocates and one scientist takes both roles. These results imply that although many scientists in our study are supportive of the issue advocacy role most of them do not adopt this role themselves. One scientist explained:

> Well, I like to give information, but I'm not the character… I don't have the character to go for lobbying. I like to teach, I like to give information, I like to explain things, so that's a role that I like to do and that in the recent years I've also done (Interview 16, Belgium, Regularly engages in policy-making).

The following statement illustrates an example of how one scientist currently contributes to policy making:

> I try to especially inform them with the good and correct scientific information. If you look to the GMO debate, there are a lot of groups, a lot of people that just spread nonsense and are spreading false arguments, which are really […], which have no foundation at all and politicians and policy makers also read the papers, and they also pick up these arguments. And at the end of the day they don't know what they have to believe. So what I'm trying to do is really to go to the politicians and give them a presentation on GMOs and agriculture and explain them this is what it is about and this is a GMO and these are the arguments that show that it is safe and just provide them with the good information [..]. So this is mainly what I'm trying to do. Just to inform, educate (Interview 10, Belgium, Regularly engages in policy-making).

3.5 Conclusions and discussion

The purpose of this study was to provide theoretical as well as empirical exploration about the role of scientists in policy-making. Our research was motivated by the fast evolving fields of science and technology, such as biotechnology, which would seem to call for more active participation of scientists in policy-making as these fields are often surrounded by high levels of complexity and low consensus on values. Our theoretical exploration indeed shows that proper integration of scientific knowledge into these policy problems requires that scientists become actively engaged in policy-making.

First, we proposed that the value freedom of scientific inquiry, as the linear model proposes, can be questioned in practice, and therefore, the stakeholder model of science and policy might be more appropriate for engagement of scientists in controversial policy-making. Our empirical results also show that most scientists who participated in our study believe that they are important policy stakeholders. Many scientists feel that engagement in policy-making is necessary to ensure the implementation of functioning regulatory frameworks and de-politicization of scientific knowledge in regulatory (and perhaps also public) debates. Taking these results into account, our study confirms the concerns articulated by (Cantley and Kershen 2013; Ammann 2014; Potrykus 2010; De Greef 2004; Dubock 2014; Miller and Bradford 2010; Vigani and Olper 2013) regarding the politicization of regulatory debates and restrictive regulatory environment for agricultural biotechnology research and commercialization. Our results also point out that many scientists consider engagement in policy-making important because they feel a strong sense of social responsibility. This finding supports the views articulated by (Schuurbiers 2010) that the application oriented research makes it difficult to maintain the neutrality view.

Second, our study indicates that many agricultural biotechnology scientists are supportive of a so-called “integrative” role of scientists in policy-making. This role combines the features of issue advocacy and the honest brokering of policy alternatives as proposed by Pielke (2007). This means that our results point out that the ideal role for scientists in policy-making should not only be to present all potential alternatives to decision makers, but also to articulate which of these alternatives are the most plausible from the scientific point of view. Pielke himself recognized that such integrative role is likely to occur in practice. The integrative role also seem to partially overlap with the ‘cooperating’ role proposed by Steel et al. (2004) who defined it as a role in which scientists should work closely with policy makers and other stakeholders in policy debates to integrate scientific results in policy decisions.

Third, we find that although many scientists sympathized with both issue advocacy and the integrative role in policy-making, only two scientists in our study actually do take the issue advocacy role themselves while most scientists tend to engage in policy-making as the honest brokers of policy alternatives. This shows that scientists in our study who regularly engage in policy-making prefer to take the informative role instead of making their views explicit. Some of our results indicate that this could be caused by the clash between what scientists believe is the best for the achievement of desired policy outcomes and how they evaluate their own personality/capacity for doing so. Furthermore, we also find that although many scientists agreed that engagement in policy-making is important some scientists recognized that it is not feasible for all scientists to regularly participate in policy-making (i.e. due to time constraints). This could also partially explain the gap between the perceived ideal and the actual role in policy-making. Scientists' concerns related to the lack of time have been also reported in studies which focused on scientists' engagement in science outreach activities (Mathews, Kalfoglou, and Hudson 2005b, Andrews et al. 2005, Sturzenegger-Varvayanis et al. 2008, van der Werf Kulichova, Flipse, and Osseweijer 2014).

Fourth, our findings raise the question about which institutional strategies are needed at universities and public sector research institutes to facilitate engagement of scientists in policy-making. Furthermore, we need to identify which selection processes should be followed when deciding how many scientists and at which career stages should be politically active per institute, or per working group. Other relevant questions pertain to mapping of faculty evaluation criteria at various universities to broaden our understanding about how engagement in science outreach activities is evaluated, if at all. Gonzales and Nunez recently showed that the number of published articles is still a widely preferred metric when it comes to academic evaluation (Gonzales and Núñez 2014).

Fifth, while institutional strategies will play an important role in facilitating scientists' engagement in policy-making, the understanding of different channels through which scientists enter the policy arena is equally important. Our literature review illustrates that membership in the Global Knowledge Networks; Epistemic Communities and Advocacy Coalitions may provide possible channels for scientists' policy engagement at national as well as global policy-making. The existence of PRRI and ISAAA illustrates that global scientific networks indeed thrive to inform international policy debates.

Finally, controversial policy-making in which scientific knowledge has an important impact on policy decisions seems to call for establishment of criteria that enable evaluation of the

legitimacy of different scientific claims that are presented to policy makers by the industry, NGOs and scientific societies. This still poses a big challenge to the biotechnology sector as 'scientific' claims against biotechnology made by a single research group or an individual scientist usually reach policy makers and public before they can be validated by scientific community at large.

Study limitations

In this section, we discuss some study limitations that we acknowledge with regards to our results and broader implications. First, our interview sample was oriented towards senior scientists, which prevents us from generalizing our findings to younger scientists. It may well be that younger scientists may have different views about their role in policy-making than senior scientists, and therefore future research could focus on examining the views of junior scientists on their role in policy-making. Second, our interview sample consisted of European scientists, and therefore, scientists who live outside of Europe may not share their views. This can be because European policy-making regarding agricultural biotechnology has been generally seen as very restrictive. For this reason, follow up research could focus on interviewing more scientists from outside of Europe to gain a more complete picture. Third, the sample characteristics limitations also apply to our two online surveys where the majority of scientists who participated were also senior scientists. Fourth, the second online survey had higher representation of American scientists than the first survey did. In order to examine regional differences in opinion, we conducted a Kruskal-Wallis test. The results confirmed that PRRI scientists who came from different continents had different strength of agreement with some of the statements but overall they all shared the same opinion regarding the different questions we asked. The results from ISAAA indicated that scientists around the world have different perceptions regarding some questions of interests. For example, European scientists were the only group to agree that policy-making on biotechnology is mostly based on public preferences. In addition, African scientists were the only ones to indicate a clear disagreement with the statement that regulations in their countries support laboratory research on biotechnology. Yet, these results are only indicative and need further research due to the limited sample sizes available for the ISAAA study (3 African scientists and 23 European scientists). Finally, the majority of scientists who participated in this study were public sector scientists working at universities or public sector research institutes. Since policy-making debates are relevant to scientists who work for NGOs, Intergovernmental organizations and

private sector including scientists from these organizations and institutes would enable to gain broader insights about their opinion regarding this important topic. Despite these limitations our findings provide a promising foundation for follow up research on this topic. We believe that despite of our focus on agricultural biotechnology, our study results can be relevant to other controversial policy fields, such as nanotechnology, biofuels and synthetic biology.

Chapter 4

Which factors influence the motivation of agricultural biotechnology scientists to engage in policy-making?

This chapter is prepared for submission to Environmental Science and Policy as:

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Abstract

Advances in agricultural biotechnology and their possible impact on human and environmental safety have led to various policy and regulatory measures. These measures have been widely criticized for slowing down progress in this sector. Concerned scientists assert that regulatory frameworks that were intended to regulate research and market release of genetically modified crops provide inadequate reflection of available scientific knowledge, and therefore call for participation of scientists in regulatory debates. However, limited studies are available that focus on the motivation of scientists to take up such roles. This paper employs the theory of planned behaviour to identify scientists' beliefs regarding engagement in policy-making. The results from literature and a small elicitation study are used to identify relevant beliefs regarding scientists' policy engagement and are quantitatively assessed via an online survey. Using regression analysis we show that not only the positive attitude towards policy engagement but also the perceived access to funding, perceived institutional support and perceived approval of engagement by scientists' superiors are significant in predicting scientists' future motivation to be involved in policy. We therefore conclude that encouragement of scientists' engagement in policy-making requires actions at the institutional level that focus, among others, on raising the awareness among scientists about their role in society in general, and their role in informing policy-making in particular.

4 Which factors influence the motivation of agricultural biotechnology scientists to engage in policy-making?

4.1 Introduction

Growing controversies regarding the advancements in science and technology, such as genetic engineering, have generated intense debate among scholars about the appropriate role of scientists in policy-making (Maasen and Weingart 2005). Central to this has been a growing concern that the participatory character of current policy-making debates, with various stakeholders participating to express their concerns with policy proposals, tend to overshadow the role of scientific knowledge in policy-making (Gottweis 2008, Foote, Krogman, and Spence 2009b). Concerned scholars articulate that scientists should step down from the 'ivory tower' and get more actively engaged in policy-making in order to ensure proper integration of scientific knowledge in policy decisions (Weiss 1991a, Brussard and Tull 2007, Scott, Rachlow, and Lackey 2008, Meyer et al. 2010, Brownson et al. 2006, De Greef 2004b, van der Werf Kulichova, Flipse, and Osseweijer 2014, Steel et al. 2004). While there is ample evidence of an increased awareness that scientists should take a more active role in policy-making limited research is available about the motivation of scientists to actually take up this role. For exceptions see (Mathews, Kalfoglou, and Hudson 2005b), (Coumou et al. 2014) and (Steel et al. 2004).

The present study focuses on the role of scientists in policy-making regarding agricultural biotechnology. We choose the case of agricultural biotechnology since this policy field has been surrounded with a lot of controversy regarding scientific claims. Using the results from an online questionnaire that was distributed to scientists who have some experience with policy engagement this study attempts to identify several factors that may be critical for understanding the motivation of scientists towards policy engagement. Scientists can influence policy-making in various ways. Steel et al. 2004, articulate that scientists can participate in policy-making via direct interactions with policy makers and other policy stakeholders or via contribution of written comments on draft policy proposals (Steel, List, Lach, & Shindler, 2004). As such, stakeholders' consultation forums and the online discussions regarding biosafety regulations may provide appropriate platforms for scientists' policy engagement. In order to determine which of the identified factors are relevant for predicting scientists' future motivation towards policy engagement, we focus on population of scientists

who are to different extents involved in policy-making. For this reason, we chose to study the case of the Public Research and Regulation Initiative (PRRI) as this organization's mission is to facilitate engagement of public sector scientists in policy debates. The organization has 312 members worldwide. Scientists who join PRRI are likely to be concerned about policy developments regarding agricultural biotechnology and therefore interested in influencing policy and regulatory climate. Given the experience of PRRI scientists' with policy engagement, PRRI provides an interesting case study to investigate the following questions: 1) What are the critical factors for understanding scientists' motivation towards policy engagement? 2) Which of these factors are significant in predicting the future motivation of scientists to engage in policy-making? Since members of PRRI come from different geographical locations focusing on this organization also provides an opportunity to examine whether the importance of identified factors differ among scientists worldwide. In addition, scientists who are members of PRRI are public sector scientists working at public sector research institutes and universities. Since these two institutions fulfill different roles in society they may also provide different institutional environments for policy engagement. Therefore, this study also attempts to generate insights into whether factors that can predict the motivation of scientists towards policy engagement differ between these two groups.

The online questionnaire used in this study was guided by the theory of planned behavior (TPB) and available literature on scientists' engagement in science outreach activities. Regression analysis was consequently used to evaluate which of the measured factors are significant in predicting the future motivation of scientists to engage in policy-making. The paper is organized as follows. Section two of this paper presents the background information regarding agricultural biotechnology policy-making. Section three provides a detailed description of the methodology. Section four presents the main study findings. Finally, section five summarizes the main study findings (including a proposal for a conceptual framework that may guide the future studies on scientists' motivation towards policy engagement) and concludes with practical implications and recommendations for future research.

4.2 Background: The impact of regulations on agricultural biotechnology research and commercialization

The applications of agricultural biotechnology are regulated nationally, supranationally and globally. The main regulatory objectives include 1) ensuring human and environmental safety, 2) facilitating deployment of benefits from agricultural biotechnology in a standardized and

timely manner and 3) ensuring consumer and farmers' free choice (www.bch.cbd.int; www.ec.europa.eu). However, the regulatory standards that were agreed upon internationally have been criticized for not meeting some of their objectives. This critique mainly focused on the impact of regulations on facilitating deployment of social and economic benefits from agricultural biotechnology research (Ammann, 2014; Anderson, 2010; Cantley, 2007; Dubock, 2014; Miller & Bradford, 2010; Strauss et al., 2010; Vigani & Olper, 2013). For example, a study by the International Food Policy Research Institute that documented the progress in public sector research in agricultural biotechnology worldwide found that strict regulatory standards were negatively influencing the ability of public sector research institutes to advance their research from laboratory conditions to field trials, a step which is necessary for market approval of new genetically modified (GM) crops (Atanassov et al., 2004). Furthermore, the studies focusing on the economic impact of regulations pointed out that regulatory procedures that lacked clear end points resulted in lengthy and costly approval procedures (Bayer, Norton, & Falck-Zepeda, 2010; Cohen, 2005; Dubock, 2014; Graff, Hochman, & Zilberman, 2009; Kalaitzandonakes, Alston, & Bradford, 2007; Matten, Head, & Quemada, 2008; Potrykus, 2010; Strauss et al., 2010). As a result only few publicly developed genetically modified crops are available on the market today while 46 successfully transformed GM crops events (developed by public sector research institutes worldwide) were already available in 2004 (Atanassov et al., 2004), reflecting the difficulties with regulatory compliance.

Some scientists in the field of agricultural biotechnology feel that the ambiguity of regulatory approval procedures may be related to a low representation of public sector scientists in international regulatory debates and with that associated low impact of scientific knowledge on regulatory standards (De Greef, 2004; Strauss, Tan, Boerjan, & Sedjo, 2009). Studies that focused on the early negotiations under the Cartagena Protocol on Biosafety (CPB) and the European Directives and Regulations, pointed out that non-governmental organizations (NGOs) had a major influence on the regulatory outcomes (Arts & Mack, 2003; Bernauer & Meins, 2003). For example, Arts and Mack (2003) observed that during the early negotiations under the CPB, NGOs served as legal, scientific and political advisers especially to developing countries of which governmental representatives had only a limited knowledge and scientific capacity on biosafety issues (Arts & Mack, 2003). As a result, the CPB became more reflective of the environmental NGOs views and interests rather than of available scientific knowledge. Similarly, Bernauer and Meins (2003) documented the influence of the NGOs who were against GM crops on the EU GMO regulations. They showed that these 'anti

GMOs' NGOs influenced discussions either directly through approaching the members of the European Parliament and the European Commission but also indirectly through organization of public campaigns (Bernauer & Meins, 2003). The lack of integration of science into policy-making decisions has been especially evident in the EU where approval and the use of GM crops by the EU member states has been arduous despite the lack of scientific evidence that GM crops are more dangerous to humans and the environment than their conventional counterparts (Hartung & Schiemann, 2014).

4.3 Methodology

4.3.1 Understanding scientists' motivation to engage in regulatory debates regarding agricultural biotechnology: The theory of planned behaviour

In order to understand which factors may be relevant for influencing scientists' future motivation towards engagement in policy-making, this study builds on the theory of planned behaviour (TPB). This theory was proposed by (Ajzen 1985) and was proven to be valuable for understanding human's motivation towards engagement in various kinds of behaviours (Armitage and Conner 2001). Central to the theory is the assumption that people's intention to engage in a certain behaviour can be predicted by measuring three independent variables: Attitude towards the behaviour, Subjective norms and the Perceived behavioural control. It is also expected that the actual engagement in behaviour develops reasonably from intentions. The TPB postulates that attitude towards the behavior, subjective norms and perceived behavioral control are functions of beliefs that an individual has about the behavior in question. As such it is assumed that:

Attitude towards the behavior can be measured by a set of behavioral beliefs one holds about the behavior (Ajzen, p191). These beliefs may be related to the general evaluation of the importance of engagement in a behavior, such as beliefs about the usefulness of engagement. In addition, moral norms have been identified and proven to be a useful measurement of attitude especially for behaviors with moral dimensions.

Subjective norm can be measured by a set of normative beliefs one holds regarding social approval of his/her engagement in a behavior by important referent groups, such as friends, family and/or colleagues (Ajzen 1991). It is suggested that the more people feel that their social environment is supportive of their engagement the more likely they are to engage.

Perceived behavioral control can be measured by a set of control beliefs regarding the difficulty or easiness of engaging in a behavior. It is assumed that the more people feel equipped with resources and the fewer obstacles they have to face, the more likely they are to engage. Figure 3 presents the graphical representation of the theory of planned behaviour.

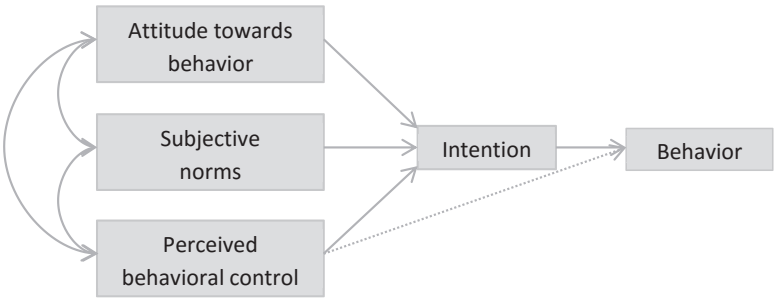

Figure 3 Graphical representation of the theory of planned behaviour (Adapted from Ajzen, 1991)

4.3.2 Identifying scientists' behavioural beliefs, normative beliefs and control beliefs regarding policy engagement

In order to identify relevant behavioral beliefs, normative beliefs and control beliefs that may influence scientists' attitude, subjective norms and perceived behavioral control, we conducted a literature review and a small elicitation study through interviews. As described earlier, empirical studies focusing on the motivation of scientists to engage in policy-making are scarce today. For that reason, our literature review focused on empirical studies that investigated factors that influence scientists' motivation to engage in science outreach activities, such as science communication with publics.

Given that the available literature did not provide information on the specificity of engagement in policy we checked the relevance of identified factors/beliefs from literature within our population of scientists. Following the method proposed by Francis et al. (2004) we conducted a small elicitation study with 10 scientists who are members of the Public Research and Regulation Initiative. The elicitation study comprised of open-ended questions that helped us to uncover beliefs that influence the attitude of PRRI scientists towards policy engagement, their subjective norms and perceived behavioral control. First, in order to uncover the behavioral beliefs related to the attitude towards policy engagement we asked scientists to respond to the following open question: What do you believe are the reasons for

scientists to engage/not to engage in policy-making? Second, to identify normative beliefs related to the subjective norms we asked scientists to openly respond to this question: Are there any individuals or groups who support/not support your active engagement in policy-making? Finally, to identify beliefs regarding perceived behavioural control scientists responded to the following open-ended question: What factors or circumstances would make it easy/difficult for you to engage in policy-making regarding agricultural biotechnology? Using the results from the literature review and the elicitation study, we developed a questionnaire to assess PRRI scientists' beliefs that motivate them or discourage them to engage in policy-making.

4.3.3 Data collection

The online questionnaire was distributed to all members of PRRI together with a brief description of the research rationale. PRRI was established in 2004 with the objective to offer a forum for public sector scientists to be informed about and involved in international discussions about biosafety (www.prri.net). The members of PRRI are public sector scientists working in the field of agricultural biotechnology. Currently, PRRI has 312 members. The members of PRRI come from 79 countries and from 277 public sector research institutes or universities worldwide. The organization is governed by a steering committee and it is supported by a secretariat. The membership in PRRI is free of charge. Any scientist interested in information about policy developments or in participation in policy debates can join the organization provided he/she works at a public sector research institute or a university.

Our decision to focus on this population of scientists was motivated by the following considerations. Many scientists who are members of PRRI have some experience with policy engagement, and therefore, were well-situated to *directly* answer questions about what obstacles they face when they want to engage in policy-making, how their social environment thinks about their engagement and why they think it is important to engage in policy-making. Furthermore, our study focused on public sector scientists since public sector scientists were identified as a trusted group by the public to communicate about biotechnology (Gaskell et al. 2010, Tome, Navarro, and Aldemita 2014) and hence can be expected to be considered trustworthy by other stakeholders in policy-making. In addition, public sector scientists have different conditions for engagement in policy-making than private sector scientists do since private sector scientists may have to adhere to company interests. Therefore, for the purpose of this study aimed at factors that influence the motivation of scientists to participate in policy-making, we restricted our sample to public sector scientists only. Focusing on this group

enabled us to identify issues that need to be taken into consideration during the design of strategies for public sector scientists' policy engagement. Finally, PRRI is an international organization with members from 79 countries. The case of PRRI enabled us to examine and compare perceptions of scientists who come from different geographical locations.

152 Questionnaires were completed representing a 49% response rate. 11 Scientists did not complete the whole questionnaire and were excluded from some parts of our analysis. Table 9 provides some general characteristics about the sample that was used in the multivariate analysis.

Table 9 Sample characteristics of PRRI members who participated in our survey (November 2013 and December 2013, N=139)

Gender	Age (years)	Employer	Continents
Male (77%)	< 30 (3.7%)	PRI (35.6%)	South America (11.1%)
Female (23%)	30 - 40 (11.0%)	University (48.9%)	North America (12.6%)
	41 - 50 (28.9%)	Other * (15.6%)	Europe (40.0%)
	51 - 60 (32.6%)		Africa (14.8%)
	> 60 (23.7%)		Australia (1.5%)
			Asia (20.0%)
139 (100%)	139 (100%)	139 (100%)	139 (100%)

Notes: * International governmental organizations, Self-employed, Retired

4.3.4 Analytical approach

The data analysis was carried out in three steps. Fist, we analyzed the available literature concerning the factors that influence motivation of scientists to engage in science outreach activities. This analysis was conducted using the Mindjet Mind manager Pro software. This software enabled us to map and code the reoccurring themes across all 11 papers in a coherent and transparent manner and by doing so it provided us with a clear picture of factors/beliefs that had positive vs. negative influence on scientists' motivation to engage in science outreach activities.

Second, building on the TPB we arranged the identified beliefs from the literature into variables that represented scientists' attitude towards policy engagement, scientists' subjective norms and perceived behavioral control.

Third, after collecting the data via the online questionnaire we examined the descriptive statistics. Since our sample included scientists from different geographical locations that have different governance structures and different cultural values we carried out Kruskal-Wallis

tests to examine any significant differences in answers among groups of scientists coming from Europe, North America, South America, Asia and Africa. We were also interested to examine the differences in answers between scientists who work at public sector research institutes and those who work in academia. We considered universities as public sector institutes of which the main mission is to perform basic and applied research and education. The public sector research institutes were defined as institutes that are (co)funded by public resources with a larger focus on technology transfer and support for public policy (OECD 2011). We speculated that these two public sector employers might provide different conditions for scientists' policy engagement, and therefore the factors that influence scientists' motivation towards policy engagement may differ between these two groups.

Finally, in order to assess the influence of the identified factors on scientists' future motivation regarding policy engagement we carried out regression analysis. We built the model based on the theoretical assumptions provided by the TPB. To account for geographical and employer differences described above we carried out three series of regression analyses. Australia was excluded from the geographical analysis since it only had two respondents. The first regression analysis included all scientists who participated in our study. The second model took into consideration geographical differences and the third model accounted for differences regarding the place of employment. The next section presents all results.

4.4 Results

4.4.1 Identification of beliefs influencing scientists' attitude towards policy engagement

A number of studies showed that scientists' beliefs about their role in society influence their attitude towards engagement in science outreach activities. Empirical findings further imply that scientists who believe that it is their role to communicate with the public are more likely to engage in science communication activities than scientists who do not feel that it is a part of their job to communicate (Jensen et al. 2008, Mathews, Kalfoglou, and Hudson 2005b, Besley, Oh, and Nisbet 2012, Dudo 2012). Therefore '*beliefs about the role of scientists in policy-making'* may be relevant for influencing scientists' attitude towards policy engagement. The results from the elicitation study indeed supported this. One scientist wrote:

> It is important for scientists to get involved in policy-making, as they are important stakeholders who understand often-complex technical issues (Respondent 8).

The literature review further implied that scientists' attitude towards engagement in science outreach activities might be influenced by scientists' '*beliefs about science misconceptions'* by publics. Some studies reported that scientists who considered the scientific literacy of the general public to be low had more positive attitude towards engagement in science communication activities (Andrews et al. 2005, Sturzenegger-Varvayanis et al. 2008). The results from our elicitation study also showed that some scientists' would engage in policy-making because they perceived the scientific literacy of policy makers to be low. One respondent reacted to the question "what are the reasons for scientists to engage in policy-making" as follows:

> Scientists understand technical issues that maybe important in policy-making and are not well understood by policy makers who may lack scientific training (Respondent 7).

A third factor reported in the literature regarding scientists' attitude towards engagement relates to '*the sense of moral duty'* to engage. Mathews et al. (2005) found that scientists who participated in their study felt *"[..] a sense of professional responsibility to share their knowledge for the betterment of society"* (Mathews, Kalfoglou, and Hudson 2005b). Another respondent in the elicitation study reacted to the question what are the reasons for scientists to engage in policy-making as follows:

> The moral duty to share the benefits of agricultural biotechnology with the people who most need it: farmers and poor people in developing countries (Respondent 10).

As discussed ealier, some regulations may have negative impact on the progress in agricultural biotechnology research and its implementation (Atanassov et al. 2004b, De Greef 2004b, Hartung and Schiemann 2014, Tosun 2014, Bäck, Debus, and Tosun 2015, Twardowski and Małyska 2012). Therefore, scientists' *'beliefs about the possible impact of regulations on progress in the biotechnology sector'* may also influence scientists' attitude towards policy engagement. One respondent from our elicitation study confirmed this as follow:

> Policy-making is nowadays a major obstacle preventing deployment of agricultural biotechnology. If laws would be sensible I would stay far away from policy makers (Respondent 10).

Finally, intrinsic motivation may also play a role in influencing scientists' attitude towards engagement (Ajzen, 2002; Ryan & Deci, 2000). Available empirical results indeed confirm that intrinsic motives, such as the feeling of personal satisfaction do influence scientists' decision to engage in science outreach activities (Dudo 2012, Lam 2011, Jensen et al. 2008, Martín-Sempere, Garzón-García, and Rey-Rocha 2008, Poliakoff and Webb 2007, Sturzenegger-Varvayanis et al. 2008). The factors we identified from the literature study and that were confirmed in our elicitation study were assessed through statements in the online survey that was successfully completed by 139 scientists.

4.4.2 Results from the survey on beliefs influencing scientists' attitude towards policy engagement

To assess the identified attitude related beliefs regarding policy engagement we asked scientists to indicate agreement or disagreement with 11 statements that were responded on a five point Likert scale ranging from strongly agree (5) to strongly disagree (1). We grouped the respondents per continent and examined the differences between continents by conducting a Kruskal-Wallis test. Our results indicate that while the respondents seem to agree on the negative impact of regulations on the research progress in agricultural biotechnology, they are divided on questions regarding the role of scientists in policy-making, scientists' moral duties in society, perceived scientific literacy of policy makers and some of the intrinsic value aspects from policy engagement. Table 10 provides a detailed overview of results taking the continental differences into account. For example, our results indicate that Europeans and North Americans agree the least that the engagement in policy-making is pleasant and personally rewarding. Next, we were interested whether there are significant differences in answers between scientists who work in academia and those who work at public sector research institutes. The results from Kruskal-Wallis did not confirm that there are any significant differences.

Table 10 Attitude related beliefs of PRRI members regarding their engagement in policy-making (November 2013 and December 2013, N=given in brackets per continent)

	Europe (54)		North America (17)		South America (15)		Asia (27)		Africa (20)	
	M	SD	M	SD	M	SD	M	SD	M	SD
1. Scientists are important policy stakeholders	4.06	.98	4.65	.49	4.60	.63	4.52	.64	4.60	.60
2. All stakeholders should participate in policy-making	3.87	.75	4.30	.59	4.20	.94	4.15	.82	4.40	.60
3. It is scientist's moral duty to contribute to societal well-being	4.17	.86	4.00	1.06	4.53	.64	4.70	.54	4.20	.95
4. Engagement enables me to contribute to societal well-being	4.03	.85	4.30	.59	4.27	.80	4.41	.50	4.50	.76
5. Strict regulations prevent research	4.13	.99	4.30	1.16	4.13	1.06	4.19	1.04	4.10	1.02
6. Most policy makers lack scientific background	4.35	.76	4.24	1.16	4.53	.64	4.19	.88	4.55	.83
7. Misinterpretation of scientific data results in strict regulations	4.32	.89	4.77	1.03	4.67	.49	4.59	.57	4.55	.51
8. Engagement is influential	3.67	.65	3.83	.88	3.53	.92	3.82	.48	3.90	.64
9. Engagement is pleasant	2.74	.98	2.94	1.25	3.47	1.46	3.33	1.04	3.40	.94
10. Engagement is worthwhile	3.93	.77	4.35	.49	4.33	.72	3.93	.83	4.15	.50
11. Engagement is personally rewarding	3.39	.83	3.70	1.11	4.27	.88	3.93	.73	3.80	.90

Notes: Response scale: Strongly agree (5) – Strongly disagree (1), M=Mean value, SD=Standard deviation

4.4.3 Identification and results regarding beliefs influencing scientists' subjective norms

In line with the theoretical proposition by the TPB, our results from the literature review indicate that subjective norms may be also an important determinant of scientists' motivation to engage in regulatory debates. Francis et al. (2004) recommend that subjective norms can be measured by general statements that ask people to assess the '*beliefs about approval of engagement by most important referent groups'*. Martin-Sempere et al. (2008) report that *'beliefs about approval of engagement by colleagues'* are relevant for understanding scientists' subjective norms regarding engagement in science outreach activities (Martín-Sempere, Garzón-García, and Rey-Rocha 2008). Other beliefs regarding subjective norms reported in the literature include *'beliefs about the approval of engagement by friends and family'* (Poliakoff and Webb 2007). One of the participants of our elicitation study also noted:

> Many colleagues who devote most of their time to research and teaching recognize that also public outreach and involvement in policy-making are important (Respondent 10).

Table 11 Subjective norms related beliefs of PRRI members regarding their engagement in policy-making (November 2013 and December 2013, N=139)

	All scientists (N=139)	
	M	SD
1. Most people who are important to me think I should engage in policy	3.47	.83
2. My friends and family approve of my policy engagement	3.58	.76
3. My boss supports my policy engagement	3.17	1.06
4. My colleagues think that I should engage	3.53	.80
5. I feel that my institute wants me to engage in policy-making	3.30	.85

Notes: Response scale: Strongly agree (5) – Strongly disagree (1),
M=Mean value, SD=Standard deviation

Table 11 provides an overview of statements that were used to assess scientists' subjective norms. The general results indicate that scientists tend to feel moderately supported in their policy engagement by friends, family, colleagues, their boss and the institute they work at. To check whether there are any differences in answers among scientists who come from different geographical locations we conducted a Kruskal-Wallis test.

This test did not confirm any significant differences. Next, we also tested whether differences in answers occur between scientists who work at the public sector research institutes and those who work at the universities. The Kruskal-Wallis test indicates that there are no significant differences.

4.4.4 Identification and results regarding beliefs influencing scientists' perceived behavioural control

The TPB implies that control beliefs may be relevant for understanding of scientists' perceived behavioral control regarding policy engagement. Our literature review and the elicitation study revealed a number of control beliefs that may be relevant. Time constraints were reported to be the most limiting factor to scientists' engagement in science outreach activities (Mathews, Kalfoglou, and Hudson 2005b, Sturzenegger-Varvayanis et al. 2008, Andrews et al. 2005). Many scientists feel that they do not have enough time to engage in non-research related activities and that they do not feel institutionally supported to do so. Some scientists also refer to the lack of funding to engage. Therefore, *'control beliefs about time availability'; 'control beliefs about available funding'* and *'control beliefs about institutional support'* may be important determinants of scientists' perceived behavioral control for policy engagement. Concerns about the lack of time, the lack of institutional support and the lack of funding were also articulated in the elicitation study amongst agricultural biotechnologists. One participant responded to the question: "What factors would make it difficult for you to engage in policy-making regarding biotechnology" as follows:

> Lack of time and lack of financial resources. My university needs to see benefits (financial or otherwise) in my engagement (Respondent 6).

Another respondent replied to the question "What factors would enable you to engage in policy-making regarding agricultural biotechnology" as follows:

> Some support/funding from the university and the recognition that also this activity is useful to society, though I perfectly understand it is not easy to quantify (Respondent 10).

The lack of communication skills was also shown to influence scientists' decision whether or not to engage in science outreach activities (Poliakoff and Webb 2007). Therefore, scientists' *'beliefs about their communication skills'* may influence their assessment regarding

perceived behavioral control. The results from the elicitation study also show that communication skills are important for policy engagement. One respondent noted:

> I personally believe the critical factor for successful engagement of scientists in policy-making is communication competence. Only scientists with proper training and experience, and most importantly, the right personality, should be involved in such activities (Respondent 5).

In order to assess scientists' perceived behavioural control we asked the PRRI members to respond to six statements (Table 12 and 13). The general results indicate that most scientists who participated in our study are inclined to agree that they lack funding and time to engage in policy-making. The answers to the question assessing the time allowance for engagement provided by the employer imply that scientists feel moderately supported by their employer. To examine whether there are any significant differences in answers among scientists who come from different geographical regions the Kruskal-Wallis test was carried out. The results indicate that there are no significant differences in answers about funding, time and perceived institutional support among scientists from different geographical locations.

However, the results concerning the perceived level of communication skills differ significantly among scientists from different geographical locations (results from the Kruskal-Wallis test). The results indicate that while North American scientists feel most confident in their communication skills, African and Asian scientists have the least confidence in their communication skills. Results presented in Table 13 also indicate that both Asian and African scientists generally agree that the lack of communication skills prevents them from policy engagement.

Table 12 Perceived behavioural control related beliefs of PRRI members regarding their engagement in policy-making (November 2013 and December 2013, N=139)

	All scientists (N=139)	
	M	SD
1. Engagement in policy-making requires funding.	2.31	.99
2. I feel that I lack funds to engage in policy-making.	2.61	1.00
3. I do not have enough time to engage in policy-making.	2.86	1.05
4. My employer does not provide me with a time allowance to engage.	3.13	1.02

Notes: Response scale: Strongly agree (1) – Strongly disagree (5), M=Mean value, SD=Standard deviation

Table 13 Beliefs related to communication skills among European, North American, South American, Asian and African PRRI members (November 2013 and December 2013, N=given in brackets per continent)

	Europe (54)		North America (17)		South America (15)		Asia (27)		Africa (20)	
	M	SD	M	SD	M	SD	M	SD	M	SD
I feel I lack the necessary communication skills to engage	3.63	.88	4.18	.65	3.93	.80	3.03	.76	2.95	1.00
The lack of communication skills prevents me from engagement	3.85	.83	4.18	.64	3.60	.99	2.85	.91	2.95	1.15

Notes: Response scale: Strongly agree (1) – Strongly disagree (5),
M=Mean value, SD=Standard deviation

4.4.5 Which of the identified factors can predict scientists' future motivation to engage in policy-making regarding agricultural biotechnology?

In order to examine which of the factors proposed by the TPB (Attitude, Subjective norms, Perceived behavioural control) influence the future motivation of scientists to engage in policy-making we examined a series of regression equations. First, we tested a model that included all scientists who participated in our study. Second, we tested a model that took into account regional differences. Finally, we tested a model that differentiated between scientists who work at public sector research institutes and those who work at universities based on the assumption that these groups of scientists may have different conditions for engagement in policy-making. Prior to the regression analysis, we examined the internal consistency of the measured variables.

Attitude towards policy engagement was measured by four statements, which attempted to measure the perceived usefulness of engagement in policy-making and the perceived intrinsic value from policy engagement. In addition to these generally used statements to assess attitude towards policy engagement (Francis et al. 2004), we also included two statements that measured scientists' perceptions about their role in policy-making. Statements 1,2,8,9,11 presented in Table 10 (p. 77) were used to measure attitude (Cronbach's alfa = .610, M=3.99, SD=.495). These statements were responded on a five point Likert scale ranging from Strongly agree (5) to Strongly disagree (1). Literature recommends that inclusion of moral norms, as an additional predictor of motivation may be important when engagement in the behavior of interests has a moral dimension (Armitage and Conner 2001). Pielke (2007) also suggests that scientists may have different views about their moral

duties in society and that these views may influence their attitude towards policy engagement and consequently their motivation to engage. Therefore, we included an extra variable that measured scientists' perception about their moral duties in society. Statements 3 and 4 presented in Table 10 (p. 77) were used to measure scientists' perceived moral duties (r= .273, p=.000, M=.425, SD=.652). Our results from the elicitation study also indicated that the perceptions about scientific literacy of policy makers might be relevant. Therefore, we also included a variable measuring the perceived scientific literacy of policy makers. This variable was measured by two statements presented in Table 10 (p. 77) (Statements 6 and 7, r=.50, =.000, M=4.37, SD=.67)

Statements assessing the subjective norms. In order to assess whether scientists' social environment was supportive or not supportive of their engagement we asked our respondents to assess five statements concerning approval of their policy engagement by friends, family, colleagues and their employer. Statements 1,2,3,4,5, presented in Table 11 (p. 78) were used (Cronbach's alfa=.772, M=3.450, SD=.573). These statements were responded on five point Likert scale ranging from Strongly agree (5) to Strongly disagree (1).

Statements assessing the perceived behavioral control. To assess scientists' perceived behavioral control we asked them to respond to four control beliefs statements measuring perceived time and funds availability and perceived institutional support. Statements 1,2,3,4 presented in Table 12 (p. 80) were used in the analysis (Cronbach's alfa=.714, M=.270, SD=.743). Our literature review revealed that perceived level of communication skills might be also relevant for understanding scientists' perceived behavior control. Statements presented in Table 13 (p.81) were used in the analysis (r=.718, p=.000, M=3.537, SD=.887). These statements were responded on a five point Likert scale ranging from Strongly agree (1) to Strongly disagree (5), reverse coded.

Statement assessing scientists' motivation to engage in policy-making. In order to assess scientists' motivation to engage in policy-making in the future we asked them to respond to one statement that was assessed on a five point Likert scale ranging from strongly agree (5) to strongly disagree (1). This statement read as follows: "I want to actively engage in policy-making regarding agricultural biotechnology in the forthcoming year". This variable represented the depended variable in our regression analysis.

4.4.6 General model for predicting scientists' future motivation towards policy engagement

Table 14 presents the means, standard deviations and correlations between studied variables. Overall, scientists had a positive attitude towards policy engagement, believed that their social environment was supportive of their policy participation, and agreed that scientific literacy of policy-making was rather low and generally felt that they had the necessary communication skills for policy engagement. Largely, agricultural biotechnologists also agreed that it was their moral duty to contribute to societal well-being and that engagement in policy-making provided them with the opportunity to do so. However, these scientists did not feel that they had enough time, funding and institutional support from their employer for policy engagement. Overall, scientists had a moderate motivation to engage in policy-making in the forthcoming year.

Results regarding the correlations between the studied variables (Table 14) show that Motivation has a moderate positive correlation with Attitude (r=.45) and Subjective norms (r=.35) and weak positive correlation with Perceived behavioural control (r=.16), Communication skills (r=.15) and Moral duty (r=.21). The results further indicate that Attitude has a moderate positive correlation with Subjective norms (r=.33) and Moral duty (r=.36). Finally, Perceived behavioural control has a moderate positive correlation with Subjective norms (r=.22) and moderate negative correlation with Scientific literacy of policy makers (r=-.28). The negative correlation between variables measuring the Perceived scientific literacy of policy makers and Perceived behavioural control implies that the more scientists agree that scientific literacy of policy makers is low the lower assessment of perceived behavioural control they have. This perhaps indicates that scientists feel that the low scientific literacy of policy makers necessitates availability of more time and funds than they currently have at their disposal.

Table 14 Correlations between all measured variables that were used to study the motivation of PRRI members towards policy engagement (November 2013 and December 2013, N=139)

Variable	Mean	SD	M	AT	SN	PBC	CS	MD
Motivation (M)	3.89	.87						
Attitude (AT)	3.99	.50	.45**					
Subjective norms (SN)	3.45	.58	.35**	.33**				
Perceived behavioral control (PBC)	2.73	.75	.16*	.01	.22**			
Communication skills (CS)	3.54	.89	.15*	.16	.13	.02		
Moral duty (MD)	4.25	.65	.21*	.36**	.16	-.06	-.85	
Scientific literacy policy makers (SL)	4.37	.70	.04	.10	-.06	-.28**	.04	.20*

Notes: Motivation = Dependent variable, Attitude, Subjective norms, Perceived behavioral control, Communication skills, Moral duty, Scientific literacy policy makers = Independent variables

Variables responded on a five point Likert scale ranging from Strongly agree (5) to Strongly disagree (1), Perceived behavioral control and Communication skills reverse coded.

Correlations reported on a scale from -1 to 1 with r<.30=weak correlation, .30< r <-.50 moderate correlation, r>50 = strong correlation

SD = Standard deviation

**p<0.01, *p<0.05

Next, in order to understand the influence of studied variables on the scientists' future motivation to engage in policy-making a stepwise regression was used. The independent variables were entered in two blocks. In the first step, the independent variables proposed by the TPB (Attitude, Subjective norm, Perceived behavioural control) were entered. In step two, the variables measuring the perceived level of communication skills, the perceived moral duties and perceived scientific literacy of policy makers were entered.

At step one, the predictors proposed by the TPB were all significant in predicting scientists' future motivation to engage in policy-making. The model was significant at .000 confidence level interval and accounted for 30 % of variance in PRRI scientist's expressed future motivation towards policy engagement. Scientists' attitude towards policy engagement had the largest positive influence on scientists' future motivation (β=.394, p<.001), followed by Subjective norms (β=.191, p<.05) and Perceived behavioural control (β=.127, p<.1). The results are presented in Table 15.

Table 15 General results from the regression analysis regarding the motivation of PRRI members towards policy engagement

Step	Variables	B	SE B	β
1	(Constant)	-.282	.604	
	Attitude towards engagement	.695	.139	.394***
	Subjective norm	.288	.121	.191**
	Perceived behavioural control	.146	.087	.127*
	R^2 = .265			
	F = 16.209***			
	N = 139			
2	(Constant)	-.908	.819	
	Attitude towards engagement	.635	.149	.360***
	Subjective norm	.276	.122	.183**
	Perceived behavioural control	.165	.091	.143*
	Communication skills	.067	.073	.070
	Moral duty	.081	.109	.060
	Scientific literacy policy makers	.061	.103	.047
	R^2 = .274			
	F = 8.305***			
	N = 139			

*p<0.1, **p<0.05, ***p<0.001

B = unstandardized beta coefficient, SE B = standard error of beta, β = standardized beta coefficient

At step two, additional independent variables (scientists' perceptions regarding their moral duties, scientific literacy of policy makers and their communication skills) were entered. Although these variables had a weak correlation with motivation their addition did not prove to be significant in predicting scientists' future motivation towards policy engagement. Table 15 presents the results.

4.4.7 Influence of geographical location on predicting scientists' motivation towards policy engagement

Since our sample included agricultural biotechnology scientists who came from different geographical locations, next we examined whether there were any difference between continents. Table 16 presents the descriptive statistics of all studied variables among European, North American, South American, Asian and African scientists. The Kruskal-Wallis test indicates that attitude differs significantly at least at one geographical location. The results presented in Table 16 indicate that European scientists have the lowest attitude towards policy engagement.

Table 16 Descriptive statistics of variables per continent that were used to predict the motivation of PRRI members towards policy engagement (November 2013 and December 2013, N=provided per continent in brackets)

	Attitude		Subjective norms		Perceived behavioural control		Moral duty		Scientific literacy		Com. skills	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Europe (54)	3.78	.52	3.35	.53	2.70	1.13	4.10	.68	4.33	.71	3.74	.78
North America (17)	4.17	.44	3.37	.54	2.78	.77	4.14	.61	4.50	.69	4.17	.56
South America (15)	4.19	.48	3.37	.54	2.78	.77	4.40	.63	4.60	.47	3.77	.80
Asia (27)	4.10	.41	3.53	.46	2.58	.55	4.56	.45	4.39	.66	2.95	.74
Africa (20)	4.17	.41	3.45	.77	2.81	.59	4.35	.67	4.55	.56	2.95	1.02

Notes: M=Mean, SD= Standard deviation

Next, we carried out regression analysis to examine whether the influence of TPB predictors on motivation differs in different geographical locations. The results presented in Table 17 show that the attitude towards policy engagement has the largest positive influence on the motivation of European (N=54, β=.408, p<.05) and South American scientists (N=15, β=.726, p<.05) while Subjective norms have the largest positive influence on the motivation of African (N=20, β=.707, p<.05) and Asian scientists (N=27, β=.417, p<.05). The motivation of North American scientists is influenced by attitude towards policy engagement (β=.519, p<.05) and their Perceived behavioural control (β=.419, p<.1). Next, we tested whether the

variables measuring perceived scientific literacy of policy makers, moral duty and communication skills were significant in influencing the motivation of scientists in different regions. Our results indicate that while none of these variables is significant for predicting motivation of European, South American, North American and African scientists, the measure regarding scientific literacy of policy makers has a positive influence on the motivation of Asian scientists towards policy engagement (β=.350, p=0.058). Our analysis further indicates that none of the additional variables is significant when employer differences are taken into account.

4.4.8 Predicting scientists' motivation towards policy engagement: Public sector research institutes versus Universities

Since our sample mostly included scientists who work at Public sector research Institutes (PRI) (N = 48) and Universities (N =66), we wanted to examine whether there are any significant differences between these two groups regarding motivational factors. To examine any potential differences, we conducted regression analysis of which results are presented in Table 18. The results indicate that while motivation of scientists working at a PRI is mostly influenced by perceived behavioural control (β=.318, p<.05) the motivation of scientists working at universities is mostly influenced by their attitude towards policy engagement (β=.318, p<.05) and their evaluation of subjective norms. The variables that measured 'moral norms', 'scientific literacy of policy makers'and 'communication skills' did not prove significant in predicting the future motivation of these two groups of scientists.

Table 17 Results from the regression analysis regarding the motivation of PRRI members towards policy engagement per continent

Continent	Variables	B	SE B	β
Europe	(Constant)	-.027	.916	
	Attitude towards engagement	.695	.232	.408**
	Subjective norm	.124	.238	.074**
	Perceived behavioural control	.247	.151	.211
	R^2 = .256			
	F = 5.749**			
	N = 54			
North America	(Constant)	.298	1.513	
	Attitude towards engagement	.852	.355	.519**
	Subjective norm	-.109	.240	-.106
	Perceived behavioural control	.271	.147	.419*
	R^2 = .428			
	F = 3.246*			
	N = 17			
South America	(Constant)	-5.441	3.214	
	Attitude towards engagement	1.958	.604	.726**
	Subjective norm	.185	.541	.078
	Perceived behavioural control	.246	.398	.148
	R^2 = .501			
	F = 3.674**			
	N = 15			
Asia	(Constant)	-.122	1.334	
	Attitude towards engagement	.430	.604	.285
	Subjective norm	.565	.541	.417**
	Perceived behavioural control	.146	.398	.129
	R^2 = .315			
	F = 3.524**			
	N = 27			
Africa	(Constant)	3.327	1.983	
	Attitude towards engagement	-.524	.428	-.250
	Subjective norm	.788	.223	.707**
	Perceived behavioural control	.014	.280	.010
	R^2 = .339			
	F = 4.243**			
	N = 20			

*p<0.1. **p<0.05. ***p<0.001
B = unstandardized beta coefficient, SE B = standard error of beta, β = standardized beta coefficient

Table 18 Results from the regression analysis regarding the motivation of PRRI members towards policy engagement per employer

Employer	Variables	B	SE B	β
PRI	(Constant)	2.358	1.135	
	Attitude towards engagement	-.060	.300	.031
	Subjective norm	.275	.217	.201
	Perceived behavioural control	.305	.138	.318**
	R^2 = .172			
	F = 3.056**			
	N = 48			
University	(Constant)	-1.015	.828	
	Attitude towards engagement	.754	.181	.444***
	Subjective norm	.497	.179	.298**
	Perceived behavioural control	.044	.130	.034
	R^2 = .386			
	F = 12.977***			
	N = 66			

*p<0.1. **p<0.05. ***p<0.001
B = unstandardized beta coefficient, SE B = standard error of beta, β = standardized beta coefficient

4.5 Conclusions and Discussion

Policy fields that are characterized with low value consensus and a high level of political uncertainty, such as that of agricultural biotechnology, would seem to call for more active engagement of scientists as stakeholders in policy debates in order to ensure that scientific knowledge is adequately reflected in policy outcomes. However, little is known about why scientists do not engage more actively and in larger numbers in policy debates, particularly given the limited empirical work that has been carried out on this topic. Our study provides first insights into understanding of the motivations among scientists who have an experience with engagement in policy-making regarding agricultural biotechnology. Measuring the perceptions of an international group of scientists, 1) we identified the critical beliefs/factors that may be relevant for understanding of scientists' motivation towards policy engagement and 2) assessed their significance in influencing the future motivation of scientists towards policy engagement. In this section, we discuss our results and propose directions for future research.

Using the theory of planned behaviour and the results from literature review and an elicitation study we found that indeed the agricultural biotechnology scientists' motivation to engage in policy-making may be influenced by a complex mix of beliefs related to their

attitude, subjective norms and perceived behavioural control. First, we found that these scientists' attitude towards policy engagement is likely to be influenced by various behavioural beliefs regarding: 1) the roles for scientists in policy-making, 2) scientists' moral duties towards society, 3) perceived scientific literacy of policy makers and 4) the intrinsic value from policy engagement. Not surprisingly, the results from our quantitative study suggest that scientists who have an experience with policy engagement foremost believe that scientists are important policy stakeholders, that it is a moral responsibility of scientists to contribute to societal well-being and that policy engagement provides them with the opportunity to do so. These findings support the theory of Pielke (2007) who proposes that scientist's decision about whether or not to engage with policy-making depends on his/her view about the role of scientists in society. Remarkably, our results that take into consideration continental differences imply that European scientists agree the least among all scientists that scientists are important policy stakeholders. The lowest score of European scientists on this question may perhaps be explained by the fact that European scientists do not believe that scientists play an important role in European policy-making on agricultural biotechnology. Our findings regarding the intrinsic value of policy engagement also points out that most European scientists do not find engagement in policy-making pleasant.

Our research also provides insights into the importance of subjective norms. Scientists' perception about the approval of their policy engagement by friends, family, colleagues and institute they work at influence to some extent their motivation towards policy engagement. Our empirical results imply that agricultural biotechnology scientists feel moderately supported in their policy engagement and many scientists did not agree nor disagree with statements assessing subjective norms. This result contrasts the findings of Poliakoff and Webb (2008)[6] who reported that scientists who participated in their study felt well supported by their friends, family and colleagues. This difference may be due to the addition of questions in our questionnaire that were assessing the perceived approval for policy engagement by

[6] The study of Poliakoff and Webb (2008) was carried out with scientists at the University of Manchester (N=169). All career stages were represented: 9% of the samples were students, 30% were post- doctoral, 12% were lecturers, 22% were senior lecturers or readers, and 18% were professors.

scientists' superior and the institute they work at. The high number of neutral responses may indicate that many scientists are insecure to make this judgement.

Furthermore, our findings about perceived behavioural control imply that time constraints, the lack of funding and the lack of communication skills are also critical for understanding scientists' motivation regarding policy engagement. The general results suggest that most scientists who participated in our study tend to agree that they lack time and funding for policy engagement. These findings are consistent with Mathews et al. (2005), Sturzenegger-Varvayanis et al. 2008 and Andrews et al. (2005). Our results regarding the influence of perceived communication skills show that scientists who come from different geographical locations have different perceptions about their communication skills. While North American scientists feel the most confident about their skills to communicate with non-scientific audiences, African and Asian scientists feel the least equipped. This may be due to differences in education but it could also be a reflection of self-confidence and/or the influence of social hierarchies in different cultures.

After identifying which beliefs may be relevant for determining scientists' Attitude, Subjective norms and Perceived behavioural control regarding policy engagement we carried out a regression analysis to explore which of these variables have a significant influence on the future motivation of scientists to engage in policy-making. To account for the possible continental differences and employer differences present in our dataset we carried out three series of regression analyses. The results from our general model (model that included all scientists who participated in our study) confirm that all three predictors proposed by TPB are significant in predicting scientists' future motivation regarding policy engagement. Attitude has the strongest significant influence (β=.394***) followed by Subjective norms (β=.191**) and Perceived behavioural control (β=.127*). However, not all attitude related beliefs and subjective norms related beliefs were significant for our sample of scientists. The variables we identified from literature and from the elicitation study (moral duty, communication skills and perceived scientific literacy of policy makers) did not prove significant in predicting the motivation of PRRI scientists towards policy engagement. However, we recommend that future studies on this topic do include these variables in the analysis since they may prove significant in explaining the motivation of scientists who come from different study populations. Figure 4 (p. 94) presents the summary of our main findings. We propose that the presented conceptual framework can be employed to guide future studies regarding this

important topic. The variables in bold squares were statistically significant in predicting the motivation of scientists who participated in our study.

Since our sample included scientists from different geographical locations we also used the regression model for different continents. The results indicate that while motivation of European, North American and South American scientists can be best predicted by scientists' attitude towards policy engagement, the motivation of Asian and African scientists can be best predicted by scientists' assessment of Subjective norms. In addition, our results that took into consideration regional differences also indicate that the variable assessing the perceived scientific literacy of policy makers is significant in predicting the future motivation of Asian scientists. To further elaborate on this topic more research data need to be collected.

Furthermore, our sample mostly included scientists who work at public sector research institute and universities. We speculated that these two public sector institutes might provide different conditions for scientists' policy engagement since they fulfil different roles in society and policy-making. While the main mission of universities is research and education, the mission of public sector research institutes often includes support for public policy and technology transfer. The results from regression analysis that took this difference into account imply that different motivational factors are relevant for these two groups. While the motivation of scientists' who work at public sector research institutes can be predicted by perceived behavioural control, our partial model indicate that the motivation of academic scientists develops from attitude and subjective norms.

In conclusion, the overwhelming majority of our respondents agree that scientists need to actively translate scientific results for their use in policy-making. These results are consistent with recent findings by (Rainie et al. 2015). Motivation of scientists to be involved in policy tend to fore mostly depend on scientists' attitude towards policy engagement followed by scientists' subjective norms and perceived behavioural control. These in turn are dependent on different factors, such as perceived communication skills and time allowance for engagement, which may differ in different regions and at different public sector institutes. Such results indicate how scientists can be further facilitated in their efforts to engage. The findings from our study can contribute to deliberation about the various ways institutional support for engagement in policy-making could be organized and supported. We believe these conclusions can also be valid for engagement in science outreach activities. Providing time for policy involvement and organizing communication skills training may help. However, as the

major motivating factor turns out to be 'attitude towards policy engagement' institutional measures are needed that recognize the importance of the role of scientists in policy-making and facilitate engagement of scientists in this activity. We recommend embedding these measures in educational programs of young scientists, especially in those scientific fields that are subject to controversy. Besides the significant effect of attitude on scientists' motivation our study also shows that the perceived behavioural control (access to funds, time availability by employer) is important. Therefore, we advise that public sector research institutes and universities consider how could scientists' policy engagement be encouraged institutionally.

To support the effective scientists' involvement in policy-making, we recommend that future research focus on the following questions: How is scientists' engagement in policy-making currently governed, if at all? How much time do scientists currently dedicate to this activity? How could scientists be assessed for these activities? But also 'Are scientists who engage in policy-making accountable to their institute for the policy statements/positions they make and if so how is this enforced in practice?'

Finally, we would like to add a note about the study limitations. Since PRRI presents a special group of scientists the findings from this study can not be generalized to all public sector scientists without further research. Our partial model regarding geographical locations should be also considered as indicative due to the small sample sizes and therefore should be further tested with larger populations of scientists. Despite these limitations, we believe that our study provides an important building block for future studies on this topic, as it points out to the areas that may be most relevant for understanding of scientists' motivation regarding policy engagement.

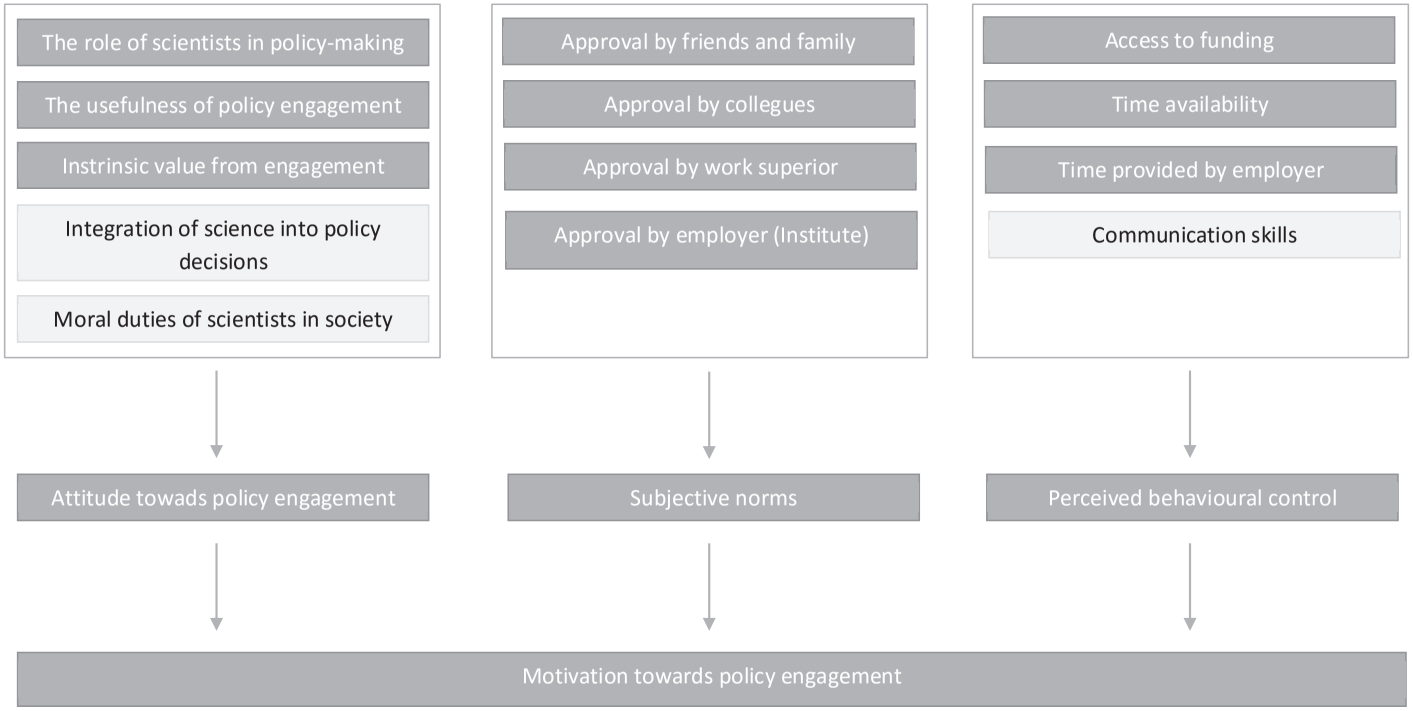

Figure 4 A conceptual framework on factors that can predict the motivation of scientists towards policy engagement (based on the theory of planned behaviour)

Notes: the figure presents beliefs identified in this study regarding scientists' attitude, subjective norms and perceived behavioural control. All variables in dark grey were significant for agricultural biotechnology scientists who participated in this study; with attitude having the strongest influence followed by subjective norms and perceived behavioural control

Chapter 5

Do agricultural biotechnology scientists feel empowered to engage in policy-making?



This chapter is currently under review in New Biotechnology as:

Van der Werf Kulichova Z., Coumou H.C., Wehrmann C. and Osseweijer P., "Do agricultural biotechnology scientists feel empowered to engage in policy-making? Uncovering scientists' perceptions about institutional support and the necessary traits for meaningful policy engagement."

Abstract

The engagement of scientists in science outreach activities has been recognized as important activity for bridging the gap between science and society. A so-called 'scholarship of engagement' has become integrated in many university strategies. Yet, when it comes to the evaluation of the performance of scientists who work at the public sector research institutes and universities the benchmark evaluation criteria often comprise of the number of publications and teaching activities. Furthermore, scientists' engagement in policy-making as a part of the scholarship of engagement has not been explored in the literature, despite the fact that science plays an important role in informing contemporary policy-making. This paper focuses on the case of agricultural biotechnology policy-making to explore whether agricultural biotechnology scientists feel institutionally empowered to contribute to policy debates regarding this topic.

5 Do agricultural biotechnology scientists feel empowered to engage in policy-making? Uncovering scientists' perceptions about institutional support and the necessary traits for meaningful policy engagement

5.1 Introduction

Agricultural biotechnology has been recognized to play an important role in ensuring food security in the world of growing population, increasing environmental pressures and scarcity of resources (Godfray et al. 2010). Despite this recognition the applications of agricultural biotechnology have been surrounded by a lot of controversy. One of the problems is the questioning of science that assesses the safety of agricultural biotechnology applications. Another problem is the use of science for policy and regulatory purposes. As a result, genetically modified crops (GM) crops have been approved as safe and widely adopted in many countries while other countries have been rather reluctant to allow their commercial approval (James 2014). Some countries and international organizations criticized this so-called asynchronous approval of GM crops, i.e. the world trade organization has appealed to the EU, which is strictly refusing the use of GM crops, to end the deadlock on GM crops approval (de Faria and Wieck 2015, Davison 2010, Margarita 2012).

While 30 years of scientific research worldwide regarding the safety of GM crops indicates that genetically modified crops do not pose more harm to humans, animals and the environment than their conventional counterparts, scientific claims presented by individual scientists and/or some interest groups suggesting otherwise are often articulated during policy-making debates (Hartung and Schiemann 2014, Miller, Morandini, and Ammann 2008). Despite that these claims do not reflect the consensus of international scientific communities they are reflected in some regulatory frameworks and negatively influence the progress in agricultural biotechnology sector (Bernauer and Meins 2003, Arts and Mack 2003, Ammann 2014). For example, the high compliance costs with biosafety regulations discouraged some small firms and public sector research institutes from pursuing biotechnology research with marginal crops and/or caused delays in commercialization of potentially valuable products (Bayer, Norton, and Falck-Zepeda 2010, Atanassov et al. 2004c, Nang'ayo, Simiyu-Wafukho, and Oikeh 2014). Given this background the present paper is motivated by a question about

how can the impact of scientific knowledge, which represents the consensus of a wide scientific community, be strengthened in agricultural biotechnology policy-making.

Some scholars advocate that in order to strengthen the impact of scientific knowledge on policy decisions scientists should take a more engaged role in policy-making (Foote, Krogman, and Spence 2009b, Meyer et al. 2010, Weiss 1991a, Holmes and Clark 2008). For example, some propose that complex policy-making problems, which are characterized by a low consensus on values (such as that regarding agricultural biotechnology), require that scientists become actively involved in policy-making processes (Pielke 2007a, Nelson and Vucetich 2009, van der Werf Kulichova, Flipse, and Osseweijer 2014). Others also articulate that policy stakeholders dealing with complex policy problems would like to see scientists taking more participating role in policy-making (Steel et al. 2004). As such, scientists can participate in policy-making as stakeholders via various consultation platforms (i.e. EU stakeholders' consultation fora), via contribution to online regulatory discussions (i.e. Cartagena protocol on biosafety) or by providing of written comments on draft policy proposals. Earlier research also shows that agricultural biotechnology scientists recognize that engagement in policy-making is important in order to properly integrate science into policy decisions (Van der Werf Kulichova et al. forthcoming). While there is ample evidence that participation of scientists in policy-making is important for strengthening the integration of science into policy decisions (Foote, Krogman, and Spence 2009b, Pielke 2007a, Weiss 1991a, Meyer et al. 2010, Steel et al. 2004, De Greef 2004b, Funk and Rainie 2015, Mathews, Kalfoglou, and Hudson 2005b) limited empirical research exists that addresses the question whether scientists do feel empowered to take an active role in policy-making.

The present paper extends the literature on green biotechnology policy-making in general and the engagement of agricultural biotechnology scientists in policy-making in particular. It focuses on the perceptions of agricultural biotechnology scientists about the institutional support for policy engagement at universities and public sector research institutes and the traits/competences that are necessary for a meaningful contribution of scientists to policy-making debates. We focus on policy-making regarding agricultural biotechnology since it has been a controversial policy field where many scientists feel that scientific knowledge is not well integrated into policy decisions (Ammann 2014, Cantley 2012, Cantley and Kershen 2013, De Greef 2004b, Dubock 2014, Strauss et al. 2010, Potrykus 2010, Vigani and Olper 2013). In this study, we employ a qualitative research approach to answer the following questions: 1) Do agricultural biotechnology scientists feel institutionally empowered to engage in policy-

making? 2) Which traits/competences are necessary for a meaningful contribution of scientists to policy-making regarding controversial science and technology as perceived by agricultural biotechnology scientists?

5.2 Background

5.2.1 The engaged scholarship and the gap between the recognition of its importance and the implementation of strategies to encourage it

The engaged scholarship emerged in 1990's and called on universities to reconsider their traditional reward merits that mostly focus on research and teaching (Boyer 1990, Whitmer et al. 2010, Barker 2004). Ever since, the engaged scholarship has motivated many universities to recognize that the full scope of academic work does not only include discovery and application but also societal integration and teaching (Boyer 1990). Some of the articulated possibilities for practising the engaged scholarship involve collaboration between academic scientists and other academics but also non academic societal partners, such as community organizations and decisions makers (Whitmer et al. 2010, 314). As such, practising engaged scholarship is seen as a mean to create scientific knowledge that is socially robust and politically relevant (Whitmer et al. 2010). Believers in the engaged scholarship suppose that engagement is not just charity that academics do in their free time, rather they see it as constituting scholarly practice that fulfils traditional academic functions (Barker 2004).

In spite of the wide recognition that the engaged scholarship could bridge the gap between science and society some research concludes that university strategies are hindering the true transition towards the engaged scholarship in the practical settings. This research shows that while the scholarship of engagement is recognized as an important aspect of the overall university strategies, the existing rewards schemes still consider the scholarship of discovery and teaching to be the main benchmarks for the evaluation of academic performance (Vargiu 2014, Colbeck and Michael 2006, Jacobson, Butterill, and Goering 2004, O'Meara 2005, Calleson, Jordan, and Seifer 2005). For example, the university ranking regimes were shown to be a major driver in influencing how much is the engagement in science outreach activities recognized and rewarded. Gonzales and Nunez reported that the existing ranking regimes in the US, Canada, the UK, Australia and few Asian and Latin American countries still promote a so-called 'homogenization', meaning that many universities award 'recognition' narrowly to particular forms of faculty work, especially particular publishing approaches' while little or no

recognition is given to the engagement in science outreach activities (Gonzales and Núñez 2014, 9). The empirical data that has been collected on this topic also points out that scientists feel hindered to engage in science outreach activities mostly by 1) the lack of institutional support for engagement, 2) the lack of time, 3) the lack of funding and 4) the lack of competences to do so (Poliakoff and Webb 2007, Sturzenegger-Varvayanis et al. 2008, Martín-Sempere, Garzón-García, and Rey-Rocha 2008, Ecklund, James, and Lincoln 2012, Dudo 2012, Mathews, Kalfoglou, and Hudson 2005b). While quantitative research identified that these four domains present the most frequently articulated obstacles to scientists' engagement in science outreach activities no qualitative studies have been carried out to explore these issues in more details.

5.3 Methodology

5.3.1 Data collection

In this study, we collected qualitative data to explore whether agricultural biotechnology scientists feel empowered to engage in policy-making. Given the results from the literature review regarding the possible obstacles to scientists' engagement in science outreach activities we built our interview guide along the four main themes. These were: 1) the perceived time available for policy engagement, 2) the perceived funding available for policy engagement, 3) the perceived overall institutional support for policy engagement and 4) the perceived traits/competences that are necessary for a meaningful contribution of scientists to policy-making.

The data for this study was collected from agricultural biotechnology scientists, many of whom had some experience with policy engagement. We included this group of scientists since scientists who do have experience with policy engagement or are interested in policy developments could directly evaluate the four themes of our interest. 82 European scientists working in the field of agricultural biotechnology were approached and asked to take part in the interview. Our choice to focus on the European scientists was motivated by the fact that Europe has been seen as having one of the strictest regulatory frameworks in the world that not only influence market release of GM crops but also research with them (Hartung and Schiemann 2014). Some of the scientists we approached (57) had engaged in policy-making in the past while other scientists (25) did not have much experience with policy engagement. In total 30 scientists responded positively and 17 interviews were scheduled. Our sample

included 15 life scientists, one scientist who became a science communication specialist and one economist both contributing to policy-making debates in this field. As indicated before, during the interviews we asked scientists to share their views regarding 1) perceived time availability, 2) perceived access to funding, 3) perceived institutional support and 4) the necessary traits/competences for meaningful policy engagement. We were particularly interested in the following questions: 1) Do you feel that you have (would have) sufficient time to spend on policy engagement? 2) Do you feel that you have (would have) sufficient funds available to engage in policy-making processes, 3) Does your organization have a strategy for facilitating involvement of scientists in policy-making? 4) What kind of traits/competences are, in your opinion, desirable for a meaningful contribution of scientists to policy-making debates? Table 19 presents the sample characteristics of the scientists who participated in the interviews.

Table 19 Sample characteristics of European agricultural biotechnology scientists who participated in the interviews

Gender	Age (years)	Employer	Countries
Male (13)	< 30 (0)	University (10)	Germany (2)
Female (4)	30 - 40 (1)	PRI (7)	Italy (1)
	41 - 50 (1)		The Netherlands (5)
	51 - 60 (9)		Belgium (3)
	> 60 (6)		United Kingdom (1)
			Switzerland (1)
			Spain (1)
			France (2)
			Hungary (1)
17 (100%)	17 (100%)	17(100%)	17 (100%)

Notes: PRI=Public sector research institute

5.3.2 Analytical approach

In order to analyse the data collected from interviews, we used Atlas Ti software, version 7.5.4. This software enabled us to code data according to the themes of our interest and also to sort out themes, which were repetitive throughout the whole dataset. We employed the following main codes in our analysis: Code1: How do scientists evaluate their time availability for policy engagement? Code 2: Do scientists feel financially empowered to engage in policy-making? Code 3: Do scientists feel empowered for policy engagement by their institute? Code 4: Which traits/competences do scientists perceive as desired for meaningful engagement in policy-making debates? These codes corresponded to the questions that we asked scientists

to answer during the interviews. The text was screened and coded by two researchers and the results of analysis were discussed in order to ensure the correct interpretation. The results are presented in the next section.

5.4 Results

5.4.1 General observations

First, the qualitative data we collected from 17 public sector scientists working in the area of agricultural biotechnology indicates that most scientists in our study feel restricted by the time that they have available to engage in policy-making. Nevertheless, most scientists believe that science communication is a part of their job as scientists. Two scientists in our group, however, pointed out that finding the right balance between the time invested in policy engagement and the time spent on research activities is important. These scientists reasoned that they could offer policy relevant science to policy makers only if they had spent sufficient time on research.

Second, the majority of scientists who participated in our study felt that there are funds available for policy engagement. Some of them explained that they could obtain funding from their research projects as these often include the obligation for science dissemination activities. Notably, the question about funding raised again concerns among scientists regarding the time restrictions they experience when they want to spend more effort on engagement activities indicating that not funding but time seems to be the obstacle to policy engagement.

Third, our results regarding the perceived institutional support for policy engagement revealed that only three out of 17 scientists feel that their institute has clear procedures for policy engagement. Two scientists said that although their institute does not have clear strategies for scientists' engagement in policy-making it supports science outreach activities through dedicated science communication department. One of the themes that emerged regarding the institutional support concerned the criticism of the institutional reward system. Three scientists explained that their institute does not professionally reward their policy engagement, and therefore when they do engage in policy-making they usually need to compromise their personal time to do so.

Finally, our interviews also provided insights about the necessary traits/competences that are seen as important by scientists for meaningful policy engagement. Among others, scientists thought that working experience in the international context or the membership in a larger scientific networks are prerequisites for successful policy engagement. Many scientists also expressed that certain communication strategies should be considered for meaningful policy engagement. Some of these included staying open minded and not trying to convince others but instead providing information in a diplomatic, polite and careful way. The next sections present the quotes from our interviews to illustrate our findings in more details.

5.4.2 How do scientists evaluate their time availability for policy engagement?

First, we were interested to evaluate scientists' perceptions about their time availability to engage in policy-making. Although, some of the scientists we interviewed regularly engage in policy-making, a majority of them feel that they do not have sufficient time available. Various reasons were articulated among which the need to focus on activities that are rewarded by their institutions, such as: 1) fund raising, 2) reporting, 3) supervision of PhD students, 4) research and 5) teaching. For example, three scientists stated:

> Yeah, that's very difficult, I mean, I have my tasks here as a Head of the Institute so forty co-workers. I have my tasks to advise and generate projects to raise money, to write reports to EU and different Ministries and so on, to provide opinions and so on. So I have a lot of different tasks, I have to set priorities. Even if I would like to spend more time in communication activities, it would not be possible (Interview 9, Germany, Regularly engages in policy-making).

> Yes and no. Yes because we are usually paid by for large part public money, so we have a responsibility in that sense, but no, because unfortunately we work very much on a project base. So for everything I do, I should be paid by a project and there is very little time to spend on things that are basically not financed but I think you should do as a public service. So yes and no in that case. Yes, the feeling of responsibility, but no, I cannot spend as much time on that as I would like to (Interview 14, the Netherlands, Regularly engages in policy-making).

> Well, actually what I said before, if you are scientist then you really have to focus on your scientific job. But I also think that you have the responsibility to

> communicate all the things that are happening in the scientific world. And I always had the passion for communicating, science communication. But I didn't find the time to do that. When you are at the bench you have to do so many things, because you have this pressure of publications and you have this pressure of performing and doing the research, otherwise you're just kicked out. And as a scientist you can't afford to spend your time on making a text or making opinions, a text on science or just communicate science. And after ten years I said: look, now it's time to do something else and I will step from the experience that I have from the bench and will step into communication and I'll try to do a communication job. So that's why I switched (Interview 10, Belgium, Regularly engages in policy-making).

Despite the fact that many scientists felt time constrained regarding their ability to engage in policy-making some of them felt that it is very important to continue this activities. Three scientists stated:

> I lack time for everything, I would need more time to supervise my PhD students, I would need more time to read papers, that's how you prioritize things. And if I get a question, whether it's from a person just in the public that sends me an email, or a politician or a student, I always give priority to answer those questions (Interview 17, Belgium, Regularly engages in policy-making).

> Yes, I don't have enough time but if it's really important, for example, for some policy makers they have a short question, I can do that! I think it's my responsibility to give highlights on a question for example, if I was requested to do that. And I would like that this work is part of my work. And I think that's the reason that a lot of scientists are not involved at all, in policy-making, in […], in this kind of meetings, because they say: we are losing our time! We are not evaluated for that to get money for research, for experiments, or for our salaries (Interview 3, France, Regularly engages in policy-making).

> I haven't got enough time, but I try to find it. So I tend to sleep less once upon a time (interview 7, Italy, Regularly engaged in policy-making).

> I think so, yes. I think… sometimes I feel that I should do it even more often, but it's a question of time sometimes. I think it's important because if I believe in

> what I'm doing, in a sense I have to be proud of what I'm doing, I have to explain why it's important what I'm doing. And I think it's our job to say, ok that's what I'm doing and that's why and to make… to give the opportunity to the other people to understand what I'm doing. I think (Interview 15, Spain, Little experience with policy engagement).

One scientist, however, noted that spending too much time on policy engagement could negatively influence the quality of data that can be provided to policy makers. Another scientist felt that spending much time on policy engagement would undermine his moral obligations as a scientist. These scientists stated:

> Well, I have to do my research and I have to teach. So there are issues that are… that only make sense… I only can contribute to the policy debate if I have something to say. And I only have something to say if I have done research. So this is fundamental. And that's why I think that ten percent [of the total time] is enough. Otherwise, I would not be able to say anything meaningful anymore, if I don't have the time to do my research and provide information (Interview 5, Germany, Regularly engages in policy-making).

> Well, I could spend 100% of the time, but then how do I feel good myself about being paid for teaching and following students and doing some research and other things if I do all the time something different. So I think I need to spend a decent, reasonable amount of time on my duties, my real duties, because I'm paid for that (Interview 7, Italy, Regularly engages in policy-making).

5.4.3 Do scientists feel financially empowered to engage in policy-making?

Second, we were interested to explore scientists' perception about available funding for policy engagement activities. Engagement in policy-making requires financial resources and the lack of finances was reported in literature as a possible obstacle to scientists public engagement. However, our results indicate that most scientists in this study feel financially empowered for policy engagement, although not all activities that they engage in are financially secured. Financial resources for policy engagement usually come from the larger scientific projects that have special budget for dissemination activities. Four scientists stated:

> Yes, so it costs time and that's money. So in the case I was asked to write this desk study, that took quite some time, and it was paid, because they paid hours

for me. But in the case that you organize a debate or you have a group thinking about it or you write something for non-scientific publication, then it is own time or time for projects that you think it is important that you tell about what you're doing. So there are also projects in which this is encouraged to do, the dissemination of what you're doing or the dissemination of your knowledge (Interview 12, the Netherlands, Regularly engages in policy-making).

That depends, when it is connected with a project it's coming out of the project, but that's small money, so we are never making problems out of that. Many times I paid that by myself (Interview 10, Belgium, Regularly engaged in policy-making).

It's usually paid by… for example we have… it's usually either paid by the organization or by the projects we have. For example we have projects funded for example by the European Union. [name colleague] has been involved in a EU project, very focused on communicating about GM, a GM project he ran. So within that project you get funding to this kind of thing (Interview 14, the Netherlands, Regularly engages in policy-making).

No, no personal money, except for lunch. I think it's my work; I don't have to spend my own money! But my own time, of course. My private time, of course (Interview 3, France, Regularly engages in policy-making).

5.4.4 Do scientists feel empowered for policy engagement by their institute?

Third, we asked scientists about their perceptions regarding institutional support for policy engagement. We were also interested in knowing whether their university or research institute has a clear strategy for engagement in policy-making activities. Our results indicate that three of the 17 scientists feel institutionally encouraged and they stated that their university has clear producers for engagement in science outreach activities. Some of them said:

Yeah, very much. So indeed in the strategy, so once every few years there is a strategy plan and one part of the strategy plan is to go into debate, to go outside and people are appointed. So I was appointed to a former group thinking about the bio based economy, not specifically GM, but bio based economy, what could we tell the world, how could we be part of debates, how could we write reports,

> or non-scientific articles. And there is also a group on GM. So it's very much encouraged and also organized. So it's not only do your best and that's it, but you're really asked to get a group of people around you and to talk and to report back what you're doing, etcetera (Interview 12, the Netherlands, Regularly engages in policy-making).

> Well, it's a little bit both, because we have a kind of evaluation, once in a while. And it's divided in different indexes. So one is like: how many articles you publish and the impact of these articles, if they are in good journals or reviews or whatever. Also, the kind of money you can get, so grants and contracts. But also there is a part that looks at how many conferences or this kind of work you do. So in a sense they encourage you to do it. They don't force you, but they encourage you. If you do it, you have a better index (Interview 16, Belgium, Regularly engages in policy-making).

> Well, it depends. If it's a long process [policy contribution requiring a longer commitment] I would get a contract as a consultant. I would buy out my time at university. So I could do that and I could buy out some time of my teaching for example. So they hire someone else to do that. Again, they are very flexible about that. I can buy a hundred hours for example for a contract [to assist policy-making] and just work full-time on my contract. Again, the university has very clear procedures for that (Interview 1, United Kingdom, Regularly engages in policy-making).

Two scientists did not feel strong institutional support for engagement in policy-making, yet they stated that their universities try to facilitate it. For example, one indicated that his institute has a science communication department to support science communication. This scientist said:

> Well, our university has a center for communication. And… so what they encourage us is for example if you have something interesting, if you have an interesting research paper, research project, or something, it is relevant… other people may find it interesting, the public, or for policy makers to inform them, then they channels this to their media contacts and then it will be launched on newspapers and on TV etcetera. So when you ask for a strategy, yes this is a

> strategy from the university for media (Interview 5, Germany, Regularly engages in policy-making).

Another scientist stated that his institute recognizes the importance of engagement but does not have clear procedures and reward systems. This scientist stated:

> Yes, the organization as a whole wants to increase, or maybe contain its visibility as being relevant and doing good science and being involved in relevant public discussions. So they need the individual scientists to do that. But they don't have an action plan or action group that gets assigned certain tasks, but that's because we're also very busy and working on projects (Interview 15, Spain, Little experience with policy engagement).

Although we did not ask scientists directly about the recognition and reward systems regarding their engagement in policy-making, some scientists spontaneously mentioned that science outreach activities are not rewarded at their institutes. For example, two scientists said:

> So for example, beginning of next year, the institute will be evaluated by [..], so Science Council it might be translated, and this will be very strong of course and very objective evaluation and if they will be using the same criteria they will be using for a university or for [name scientific society], then of course we might get a more negative scoring, because we don't have such a number of excellent publications, but we are publishing besides that a lot of excellent reports for policy makers and so on and so on, which are not published, and therefore might not be scored in a positive way. So I think that's the problem, the way how scientific activities are evaluated does not include or does not mainly include dissemination activities and other activities, so like cooperation in scientific societies and so on and so on (Interview 10, Belgium, Regularly engages in policy-making).

> Well, that's precisely the thing that makes it difficult, because when I was asked for the desk study I really got project hours, so that's ok. But the things that I do to give the lectures, I'm actually not obliged to give lectures, so this is sort of an extra thing, because I like it and also to organize this debate within the university,

> I also don't really get time or hours for it. I do these things because I think it's important (Interview 11, the Netherlands, Regularly engages in policy-making).

5.4.5 Which traits/competences do scientists perceive as desired for meaningful engagement in policy-making debates?

In the last section, we report the results from the interviews regarding the desired traits for scientists' engagement in policy-making. Our results point out that there are at least six traits that are desirable for successful policy engagement. These are: 1) Appropriate technical education, 2) Working experience in the international context, 3) Patience, 4) Understanding the policy-making process, 5) Being member of a larger scientific network and 6) Communication skills. In the next paragraphs, we illustrate some of the first five traits by interview quotes. The traits regarding communication skills were discussed across many interviews, and therefore, we dedicate a special section to those.

One scientist stated that having the right technical education and some working experience in the international context is important for policy engagement. He said:

> Well you have to have right education for that. The right technical background. I think a very thorough education at a Master's or PhD level personally. I think it's essential to engage actively with research in the lab or in the field. [..]. It's also very important to work in different countries. As soon as I got my PhD I went to work in the United States for several years. Then I went to Germany. Then I went to work in Australia, France, Malaysia. Then you begin to get a bigger perspective. If you just work in one lab in one place in one country, it's much more difficult. You may get paid to get an idea about your small problem, a small academic research problem. But then to go beyond that, the big picture, the social implications, policy, you really do need to work internationally. Especially now, because we are in a globalized society (Interview 1, United Kingdom, Regularly engages in policy-making).

Another scientist thought that to be a part of a larger scientific network is important to get access to policy-making. She stated:

> Sometimes it's difficult to reach the most important people, so as an individual scientist it's difficult sometimes to reach the people that are

> making the decisions, so these kinds of networks are very good, because if you go all together it's better to reach something. [..] there are so many scientists from different places and I think this kind of things help a lot, because you as an individual, it's very difficult. Maybe you can do something more locally, but sometimes you're a little bit lost. But if you get into contact with all these networks, that's a very good way of making things more… to give some strength (Interview 16, Belgium, Regularly engages in policy-making).

Other recommendations included that having enough patience is also very important mostly because some of the policy debates can be quite frustrating. Two scientists said:

> [..] one important property that you should have is that you should probably have patience (Interview 15, Spain, Little experience with policy engagement).

> If there is a room of fifty people, and one or two of them understood the message, I think that each time few people understand the message; I think that's good. So it's a question of going and doing it again (Interview 16, Belgium, Regularly engages in policy-making).

One scientist thought that understanding of policy-making process was also important. He stated:

> And of course you have to have an understanding of the level at which you have to present your science, whether the listeners understand or not. So you have to be sensitive to that. And probably you have to understand the policy-making process itself in order to know what will have impact and what will be useless (Interview 15, Spain, Little experience with policy engagement).

5.4.6 Which communication strategies do scientists perceive as desirable for meaningful engagement of scientists in policy-making?

As mentioned before, many scientists discussed communication skills as being an important trait for engagement in policy-making. The main findings regarding desired communication strategies included: 1) Use short and focused messages, 2) Stay unbiased and objective, 3)

Maintain credibility, 4) Be open minded – do not stick to your positions, 5) Be able to translate science into accessible words, 6) Do not try to convince others just provide information, 7) Be able to engage with people, 8) Be honest and critical about your position, 9) See the big picture, 10) Be diplomatic, polite and careful, 11) Tell the truth, and 12) Employ humor into your communication style. The following quotes illustrate some of these findings.

> Yeah, so I mean what I learned, is that all the messages you are providing should be very short, very precise. You should take care that what you are saying is not misused, so therefore you really have to focus, and it should be unbiased, so you really should try to be objective. Also, very important is, how to say, the credibility, in the public debate, and the way you are acting. In a lot of cases it's more important even than the arguments you are providing (Interview 10, Belgium, Regularly engages in policy-making).

> Pooh, that's a difficult one, I think being as neutral as possible, and also being open for negative arguments. There are some colleagues from the ag biotech, also from university who are so emotionally attached to GMOs that they… yeah, it's like the opposite of the anti-GMO activists. So these activists are not open for any good arguments, and the really dedicated or really enthusiastic scientists are also not open for any other arguments. So I think you really have to be neutral and to listen to both parties and give also a very balanced opinion to politicians to create some credibility (Interview 1, United Kingdom, Regularly engages in policy-making).

> I don't like to convince you at all. Because I believe you can make up your mind by yourself. I can give information and that information is always colored. And I understand that you understand that. So when you are mixing all colors together then you can make up your own mind. And that's where I'm interested in; I'm not interested in convincing everybody in the world (Interview 13, United Kingdom, Little experience with policy engagement).

> You know, humor is a wonderful mean. [..]. Besides humor, [..], is having mercy in public on a podium. To have mercy with your opponents (Interview 4, Switzerland, Regularly engages in policy-making).

5.5 Conclusions and discussion

The present study qualitatively examined the perceived institutional support for scientists' policy engagement and the traits/competences that are necessary for a meaningful contribution of scientists to policy-making debates. We interviewed 17 agricultural biotechnology scientists most of whom have engaged in policy-making in the past to uncover their perceptions regarding these important topics. In this section we present and discuss the main conclusions of this study and provide directions for future research.

First, the quantitative studies found that the lack of time is considered to be one of the major reasons that prevent scientists from engagement in science outreach activities. The results from this study confirm that the majority of scientists we interviewed feel that they do not have enough time to engage in policy-making. Some scientists who participated in this study feel that making time for policy engagement means that they have to assign lower priorities to activities for which they are rewarded by their institutes, such as supervision of PhD students, teaching and publications. Despite this dilemma many scientists feel that it is important to make time for policy contribution. Our study indicates that despite the perceived lack of time scientists whom we interviewed have a strong sense of social responsibility to contribute to policy discussions. This finding is consistent with assumptions of (Haas 2004a) and (Sabatier 1988b) who articulated that strong normative beliefs play an important role in mobilizing scientists to engage in policy-making. This indicates that besides the perceived institutional support the scientists' recognition of their social responsibility is an important precondition for scientists' interest in policy engagement. A finding consistent with (Jensen et al. 2008, Andrews et al. 2005, Martín-Sempere, Garzón-García, and Rey-Rocha 2008, Mathews, Kalfoglou, and Hudson 2005b). Furthermore, two scientists indicated that the time spent on policy engagement should be in the right balance with the time spent on research activities. These scientists reasoned that for a meaningful contribution of scientists to policy-making debates scientists need to spend sufficient time on research to be able to deliver policy relevant scientific knowledge. Given this finding, we recommend that the future research could expand our understanding about how much time should be allocated to engagement in science outreach activities in general and engagement policy-making in particular. Future research could also examine how much time (if at all) is currently allocated to these activities in strategies at different universities. In addition, exploring how this time should be divided among the university research groups offers another avenue for future research work.

Second, the lack of funding was also reported to be an obstacle to scientists' engagement in science outreach activities. Most scientists who participated in this study felt that they have funds available for their policy engagement. This can be perhaps explained by the fact that our study focused on the European scientists. Many university projects in Europe are funded by the European Commission Framework Programs that have a strong emphasis on dissemination activities. Since allocation of funding for science dissemination activities can differ outside of Europe (i.e. in developing countries), we advise that future studies include also non-European scientists to obtain a more complete picture. Nevertheless, our study shows that not all European universities focusing on life science research give science dissemination activities an equal importance when it comes to the evaluation criteria and institutional reward schemes. Our results confirm the discrepancies articulated in the literature between institutional strategies and the institutional reward schemes at universities and public sector research institutes (Vargiu 2014, Colbeck and Michael 2006, Jacobson, Butterill, and Goering 2004, O'Meara 2005, Calleson, Jordan, and Seifer 2005).

Third**,** some scientists whom we interviewed felt institutionally supported and indicated that their institute has a clear procedures to facilitate their engagement in policy-making. For example, one scientist stated that he could buy out hours from his university that he can spend on engagement in policy-making. Another scientist said that his university appoints periodically scientists who are responsible for a wider engagement with public and policy makers. However, majority of scientists did not feel institutionally encouraged to engage. Despite that, some of them explained that their university/institute facilitates connection between science and society through dedicated science communication department but does not encourage scientists to engage with public and policy makers. These findings illustrate that different models are used by universities to facilitate science outreach activities and that the engagement of scientists in these activities is not yet fully supervised by clear institutional strategies. This situation is raising important questions regarding the conditions under which scientists should present their policy statements. Future research could address the following questions: 1) Should scientists who engage in policy-making be accountable to their employer for the statements they make? This question is particularly important when it comes to a protection of credibility of individual scientists but also of the institute as a whole. 2) Should engagement of scientists in policy-making be recognized as a part of professional performance assessment criteria? Or 3) Should scientists engage in policy-making on their personal title in

their free time? Future research could also explore the various university strategies on policy engagement and study the efficiency of different models.

Fourth, even well designed institutional strategies regarding time management and funding will not suffice when scientists do not possess the necessary traits/competences to provide a meaningful contribution to policy-making debates. The results from our interviews indicate that there are at least six traits that should be given attention to ensure meaningful engagement of scientists in policy-making. These are: Appropriate technical education, Working experience in the international context, Patience, Understanding of the policy-making process, Being a member of a larger scientific network and having communication skills. These results point out that for meaningful engagement with non-scientific audiences scientists need to be aware that only neutrally formulated and informative messages about controversial scientific innovations which are placed in the broader context and delivered as a consensus of a wider scientific society can reach their audiences. Some of our findings regarding the necessary traits/competences for engagement could serve as selection criteria when appointing scientists who engage to represent institute/university in policy-making or be a subject of training and career development. Our study also provides a guidance for communication approaches and relevant personal skills, such as being able to stay open minded, avoid convincing everybody but rather provide information, being able to engage with people and employ humor into communication style.

Finally, our study indicates that engagement in policy-making regarding agricultural biotechnology seem to be primarily done by senior scientists who have a long research experience and are part of various networks. One of the possible avenues to encourage participation of younger scientists in policy-making could be a creation of and encouragement to participate in scientific societies across universities and public sector research institutes. Such participation could provide learning opportunities for younger scientists to recognize importance of and to engage in debates about broader societal and political implications of their work.

Chapter 6

Conclusions and Discussion



6 Conclusions and discussion

The biobased economy is presented as a potential solution for addressing the challenges associated with climate change and the growing human population. Thanks to advances in science and technology the biobased economy may provide additional food and renewable energy to meet the needs of the expected 9 billion people by 2050. However, the implementation of the biobased economy also carries along many questions about the transition paths, including the political and regulatory climate for new technologies that are necessary to accomplish this transition. Policy decisions and new regulations require input from the scientific community. While most policy stakeholders agree that we need new technologies that can reduce or eliminate greenhouse gas emissions we witness controversy about the best solutions to realise sustainable production. Scientists have the potential to play an important role in policy debates and processes, but presently their involvement is inadequate. This thesis explores how scientists perceive their role in policy-making and which factors are relevant for understanding of their motivation for policy engagement. It focuses on the case of agricultural biotechnology with its existing political controversy over the use of genetically modified crops. This field provides an opportunity to study a population of scientists many of whom regularly contribute to policy-making. Since these scientists have experience with engagement in policy making, studying their views, roles and motives provides insights about the factors that influence their motivation towards policy engagement but also about their views on how their active contribution to policy-making could be better supported. As such, this thesis provides valuable lessons about the difficulties regarding the integration of scientific knowledge into policy and regulatory decisions and hopes to contribute to a more adequate climate for practical applications of science and technology.

In this chapter, the main conclusions are presented and discussed and the main and specific research questions are answered. The full synthesis of the results leads to a new conceptual framework for facilitating scientists' participation in policy-making. The new model is built on the studies within the community of public sector agricultural biotechnologists and on the existing theories used for the analysis. In the discussion, the proposed framework is considered for its usefulness in a broader scientific context and the social relevance of this thesis is discussed. Finally, the last section of this chapter reflects on the study's limitations and provides possible directions for future research.

6.1 Answers to the specific research questions

6.1.1 What are the reasons for and against scientists' policy engagement as articulated in the interdisciplinary literature on science-policy interfaces and as seen by agricultural biotechnology scientists in particular?

The first specific research question explores the reasons for and against direct participation of scientists in policy-making. An interdisciplinary literature review was complemented by two online surveys to evaluate perceptions of agricultural biotechnology scientists about the different reasons for policy involvement. We observe that the reasons for and against scientists' policy engagement can be clustered into two categories that we will refer to as 'Instrumental' and 'Moral' reasons. Our definition of 'Instrumental reasons' assumes that science, as such, has a normatively positive effect on societal well-being, yet it needs to be safeguarded against societal and policy opposition. Our definition of 'Moral reasons' departs from the idea that scientists have a moral obligation towards society to take an active role in policy-making and public debates in order to inform policy makers and public about the potential applications of science but also about approaches to ensure that such applications are safe. This section presents the synthesis of both the theoretical and the empirical results in reflection of these two rationales for scientists' policy engagement.

Instrumental reasons for direct participation of scientists' in policy-making

The arguments presented in Chapter 2 indicate that scientists need to directly participate in policy-making due to the participatory character of many contemporary policy-making debates. In these policy-making settings various groups of stakeholders tend to make a reference to diverse sources of scientific knowledge to support their policy preferences. As such, when scientists do not directly participate in policy-making the scientific knowledge that is used, as a benchmark criterion for policy and regulatory measures might not reflect the general consensus of the wider scientific community. This in turn may create an unfavourable regulatory climate for research and commercial applications of scientific innovations. Our empirical research shows that the majority of agricultural biotechnologists who are interested in policy engagement feel that regulations on agricultural biotechnology do not facilitate progress in this sector. The majority of scientists also believe that policy makers do not have the necessary scientific literacy to properly interpret scientific results and many scientists

doubt that policy makers read scientific publications to inform their policy decisions[7]. Therefore, direct engagement of scientists in participatory policy-making provides scientists with the opportunity to present scientific findings and to ensure that these findings are well understood by all policy stakeholders and integrated into policy decisions. Our empirical data support the theory articulated by Pielke (2007) that policy-making contexts that are characterized with political uncertainty regarding the use and the interpretation of scientific knowledge are more likely to motivate scientists for policy engagement.

Moral reasons for direct participation of scientists' in policy-making

The arguments presented in Chapter 2 suppose that the public considers scientists working at public sector research institutes and universities to be the most trusted source of information regarding science and technology. This provides public sector scientists with a strong societal mandate to take a role in informing policy-making debates. Furthermore, the findings in Chapter 2 indicate that informing policy-making and engaging with policy stakeholders is part of the moral duties of public sector scientists since a large part of their research is funded from public funds. Yet, Pielke (2007) suggests that not all scientists are ready to accept the notion that it is their moral duty to participate in science outreach activities, and therefore scientists who sympathize with this view are likely to refrain from policy engagement.

The findings from our surveys indeed indicate that the majority of agricultural biotechnology scientists who are motivated to contribute to policy-making recognize the moral dimension of their work and agree that engagement in policy-making is their moral responsibility for ensuring food security and sustainable agriculture. These findings also resonate with the findings of Schuurbiers (2010) who concluded that scientists whose work is focused on application oriented research are likely to have a greater awareness about the social implications of their work, and therefore a higher level of moral awareness. Since our research focused on the population of scientists who are generally interested in policy participation, we propose that studies in the future also include scientists who do not show

[7] The nature of our survey samples enabled us to examine differences in perceptions among scientists who come from different geographical locations. The statistical test did not confirm any significant differences regarding these questions

an interest in policy engagement and examine whether moral beliefs of these scientists regarding policy engagement.

Instrumental reasons against scientists' policy engagement

Our literature review indicates that scientists may not feel well equipped to communicate with non-scientific audiences, and this may provide a reason to not engage in policy-making. Our empirical findings indeed indicate that scientists who come from different countries have different assessment of their communication skills. While North American scientists feel the most capable to communicate with non-scientific audiences, African and Asian scientists have the lowest assessment of their communication skills (Chapter 4). These results indicate that different cultural backgrounds influence the self-confidence of scientists regarding their communication qualities. Since our sample included small numbers of African (N=20) and small numbers of Asia scientists (N=27) we recommend that the future research examines the perceived level of communication skills with larger population of Asian and African scientists. Particular attention should be paid to how the hierarchical social structures that are characteristic for these societies influence scientists' self-assessment of communication ability and to what extent the communication skills with non-scientific audiences are addressed in education curricula in these countries.

Next to the concerns regarding scientists' communication skills our literature review (Chapter 2 and Chapter 4) also pointed out that scientists may feel that engagement in policy-making is not institutionally supported at their place of employment and this may provide another reason to refrain from policy engagement. The most articulated concerns in the literature regarding the level of institutional support involve the lack of time for policy engagement and the lack of funding. In order to assess how agricultural biotechnology scientists worldwide perceive the level of institutional support for policy engagement we asked them to assess their perceptions regarding time availability and the access to funding. Our results indicate that agricultural biotechnology scientists worldwide have different perceptions regarding the time that they have available for policy engagement[8]. This divide in

[8] 40% of PRRI scientists agreed that they lack time to engage in policy-making, 23% chose to respond neutrally and 33% disagreed. To understand if any of the demographic characteristics contributed to this division, we tested whether age, continents and employer were able to explain these differences. The statistical test did not confirm any significant relationships (ISAAA results are presented in the footnote on the next page)

results perhaps indicates that scientists have different opinions about how much time they should spend on policy engagement. Therefore, we propose that future research examines how much time scientists who regularly contribute to policy-making currently spend on policy engagement and which institutional strategies are in place (if any) to oversee the time allocation between research and non-research related activities.

Moral reasons against scientists' policy engagement.

The literature review in Chapters 2 and Chapter 4 concludes that many scientists feel that direct participation in policy-making harms their professional reputation and/or negatively influence their scientific credibility, and therefore, these scientists may not want to participate in policy-making. Our quantitative results indeed confirm that there is a divide among scientists regarding this question. While the majority of PRRI scientists is not concerned about the negative impact of policy engagement on their scientific credibility, the ISAAA subscribers have more divided opinions[9]. These findings stress the need for clear institutional strategies that will safeguard credibility of individual scientists in policy-making but also the credibility of research institute as a whole. In this regard, establishing clear criteria for what kind of scientific knowledge should be considered as legitimate to inform policy-making seems to be also relevant.

6.1.2 Which factors can predict the motivation of agricultural biotechnology scientists for future policy engagement?

In order to understand which of the reasons identified from our literature survey can predict the motivation of agricultural biotechnology scientists towards policy engagement we used the data collected from the online survey with PRRI scientists. We built on the theory of planned behaviour to organize various scientists' beliefs regarding policy engagement into

[8] 65% of ISAAA scientists agreed that they lacked time for policy engagement, 5% provided neutral response and 30% disagreed that time was a problem. To understand if any of the demographic characteristics contributed to this division, we tested whether age, continents and employer were able to explain these differences. The statistical test suggested that European scientists among ISAAA members feel the most time constrained

[9] To understand if any of the demographic characteristics contributed to this division, we tested whether age, continents and employer were able to explain these differences. The statistical test suggested that African and European scientists expressed the most credibility concerns while American and Asian scientists disagreed that policy engagement was detrimental to their scientific credibility.

three factors: the attitude towards policy engagement, subjective norms and perceived behavioural control. The attitude towards policy engagement was measured through the usefulness of policy engagement, intrinsic value from policy engagement and the views scientists had about their role in policy-making. In addition, we also included two separate variables that measured perceived scientific literacy of policy makers and perceived moral duties of scientists in society. The variable that measured scientists' subjective norms included statements that assessed the perceived approval of policy engagement by scientists' friends, relatives, scientific peers but also by scientists' superiors at work and the research institute in general. By including the last three referent groups we attempted to measure whether scientists felt supported by their professional peers and how this influenced their motivation. Scientists' perceived behavioural control was measured by statements that focused on institutional support for policy engagement in general, and the time availability and access to funding in particular. In addition, we also included two statements that evaluated scientists' perceived level of communication skills to engage with non-scientific audiences. To test whether these variables could explain the variation in scientists' future motivation towards policy engagement we carried out regression analysis.

The results from the regression analysis that included all scientists who participated in our study imply that scientists' *attitude* towards policy engagement has the largest influence on the future motivation. This indicates that scientists' positive views regarding their role in policy-making, the perceived influence of policy engagement on policy outcomes and the high intrinsic value from policy engagement are the most important determinants of PRRI scientists' future motivation to engage in policy-making. The variables measuring the perceived scientific literacy of policy makers, the moral duties of scientists in society and scientists' perceptions regarding communication skills did not prove significant for our study population. Yet, our analysis that took into account regional differences indicates that perceptions regarding the scientific literacy of policy makers are significant in predicting the motivation of Asian scientists indicating the importance of this factor for scientists who come from different political and cultural backgrounds. In addition, our results show that next to the attitude, subjective norms and the perceived behavioural control are also significant (although to a lesser extent). Since both of these variables included the measures of perceived institutional support, these findings highlight the importance of the role that research institutions should play in encouraging scientists' contribution to policy-making.

Due to the characteristics of our sample, which included an international group of scientists working at public sector research institutes and universities, we also examined the possible influence of continents and employer in our regression model. The results indicate that regional differences play a significant role in defining which of the factors are relevant for predicting scientists' motivation towards policy engagement. While the motivation of European, North American and South American scientists develops from their attitude towards policy engagement, the motivation of Asian and African scientists mostly depends on scientists' assessment of subjective norms. These results indicate that scientists coming from different cultural backgrounds evaluate the importance of social approval of their policy engagement differently, and therefore strategies to encourage policy participation of these scientists may require stronger emphasis on understanding of scientists' social environment.

Finally, our results regarding the differences between scientists who work at public sector research institutes and those who work at universities also point out that different motivational factors are relevant for these two groups. While the motivation of scientists working at the public sector research institutes is mostly influenced by perceived behavioural control, the motivation of university scientists' can be predicted from their attitude and subjective norms. These findings point out that tailor made motivation strategies are needed to encourage participation of scientists in policy-making in different regions and at different public sector research institutes (research institutes vs. academia).

6.1.3 Do agricultural biotechnology scientists feel institutionally empowered to engage in policy-making and which institutional approaches (if any) are currently in place to encourage scientists' contribution to policy-making?

In order to assess to what extent agricultural biotechnology scientists feel institutionally supported in policy engagement we carried out two online surveys and 17 in-depth interviews. To assess scientists' perceptions regarding institutional support we asked scientists to respond to several questions that assessed whether scientists received a time allowance for policy engagement and whether policy engagement had any professional benefits for them. To investigate what kind of institutional strategies (if any) are currently in place at public sector institutes and universities regarding policy engagement we asked scientists to respond to the following question: Does your organization have a strategy for facilitating involvement of scientists in policy-making?

Our results imply that scientists are divided on the question regarding the time allowance for policy engagement[10]. The Kruskal-Wallis test indicates that this variation can be explained by scientists' age where scientists who are between 51-60 years old agree that they can be involved in policy as a part of their work. The characteristics of our study population together with the findings presented above indicate that senior scientists seem to be currently best equipped to adopt an active role in policy-making.

The lack of institutional rewards for policy engagement was also recognized in the literature as a possible obstacle to scientists' engagement in science outreach activities. It is argued that many scientists (especially those who are in the early stages of their career) do not regard engagement in science outreach activities as important since this activity is not a part of their professional evaluation criteria. In order to assess scientists' perceptions regarding this issue we asked them to assess whether engagement in policy-making has any professional benefits for them. Our results show that the majority of PRRI scientists disagree that engagement in policy has no professional benefits for them[11]. This finding contradicts the results of Gonzales and Nunez (2014) who found that most universities do not reward engagement in science outreach activities. Since our results do not provide any detailed information about what scientists regard as professional benefits and how these benefits are received, we recommend that future research examines the following question: What institutional reward mechanisms (if any) are currently in place at public sector institutes and universities to evaluate scientists' engagement in science outreach activities?

To assess scientists' perceptions regarding the institutional support strategies for policy engagement we asked scientists to assess the following question: Does your university/research institute have a clear strategy for engagement of scientists in policy-making? Our results from interviews imply that only three out of 17 public sector scientists felt that their institute/university has a clear strategy. Other scientists in our study indicated

[10] While 29% of PRRI scientists agree that they do not receive any time allowance from their employer, 31% chose not to express their opinion on this question and 40% of PRRI members indicated that they do receive time from their employer to engage in policy-making.

[11] Our results suggest that 22% of PRRI scientists agree that engagement does not have any professional benefits for them, 15% of scientists provide neutral response and 63% of scientists disagree that policy engagement has no professional benefits for them. To test whether any demographic variable could explain the variation in answers we conducted a Kruskal Wallis test. The results suggest that none of the demographic characteristics can explain this variation.

that although their institutes recognize the importance of engagement in science outreach activities there are no established procedures or clear rewards schemes that would guide scientists' engagement in these activities. This finding points out to the gap between which activities are considered as important by research institutes and what concrete measures are in place to facilitate scientists' involvement in these activities.

6.1.4 What are the desirable traits/competences for meaningful engagement of public sector scientists in policy-making?

The last specific research question provides insights regarding traits/competences that are desirable for meaningful engagement of public sector scientists in policy-making from the perspective of scientists who have experience with policy engagement. Chapter 5 examined this question qualitatively. Scientists proposed six traits to be desirable for a meaningful contribution of scientists to policy-making. These included: 1) appropriate technical education, 2) working experience in the international context, 3) patience, 4) understanding of the policy-making process, 5) membership in larger scientific networks and 6) communication competence. The importance of communication competences was discussed during many interviews. Our results indicate that successful communication in the policy-making context requires that scientists 1) use short and focused messages, 2) stay unbiased and objective, 3) maintain credibility, 4) stay open minded, 5) are able to translate science into accessible words, 6) do not try to convince others but rather have an informative role, 7) stay honest and critical about their positions, 8) stay diplomatic, polite and careful and 9) try to employ humour into their communication style.

6.2 Answers to the main research questions

Successful transition to a biobased economy will not only require continuous progress in scientific innovations and technologies but also a favourable policy environment for implementation of the resulting applications. As the experience from agricultural biotechnology shows, the integration of scientific knowledge into policy decisions may become challenging as the number of policy stakeholders increases and their values regarding various policy options divide. This thesis aimed to answer the following main research questions: 1) *Which active roles can scientists adopt in controversial policy-making and which of these roles do agricultural biotechnology scientists prefer to take? and 2) Which factors are relevant for the motivation of scientists to engage in policy-making?*

This section attempts to synthetize the main thesis findings in light of the two theoretical frameworks that guided this work. As such, this thesis fulfils two main objectives. First, it provides a conceptual framework that can be used to identify which roles are available for scientists who are interested to participate in policy-making (and which of them is seen as socially desirable by scientists who have experience with policy engagement). Second, it offers a guide for institutions and/or organizations that want to encourage participation of scientists in policy-making by pointing to the areas that may require institutional interventions. Figure 5 (p. 128) presents the flow chart that can be used to navigate decisions that are necessary for facilitating scientists' participation in policy-making.

Pielke (2007) proposes that the characteristics of policy-making contexts are relevant for determining the role of scientists in policy-making. Based on the analysis of several policy-making problems in the American policy-making context (i.e. including the climate change policy), Pielke (2007) distinguishes between policy-making contexts with scientific certainty and political consensus versus those where one or both are absent. Our study focused on a policy field that is characterized by a *high level of certainty* regarding scientific knowledge and by a *low level of political consensus* (Rainie et al. 2015, Giller 2016)[12]. As such, we elaborated on Pielke's model distinguishing the variables regarding scientific certainty and political consensus. This is reflected on the top of the proposed flow chart with the objective to specify to which policy-making contexts our findings apply.

The left side of the flow chart depicts the possible roles for scientists in policy-making proposed by Pielke (2007) assuming that scientists are interested in policy engagement. Building on Pielke (2007) and our empirical results we assume that scientists who belong to this part of the flow chart share a positive attitude towards policy engagement. The positive attitude is derived from moral views about the role of scientists in society in general and the role in policy-making in particular. Based on the empirical findings presented in this thesis, we propose to extend Pielke's framework by adding an additional role for scientists in policy-making, a so-called *'integrative role'*. This role proves to be the most preferred by scientists and combines the features of issue advocacy and honest brokering and encourages scientists to inform policy-making by 1) collecting scientific evidence, 2) identifying all available policy

[12] For example, the findings reported by Rainie et al. (2015) indicate that while 88% of AAAS scientists believe that GM crops are safe to eat only 37% of US adult population shares this view

alternatives that are supported by science, 3) reaching scientific consensus on which of these alternatives is the most preferred from the scientific point of view and 4) communicate about these alternatives with all policy stakeholders and explaining the impacts of different solutions. Our results, however, also show that scientists are not taking this role in practice, indicating a need for further support. Therefore, in the next level of the flow chart, we propose that in order to facilitate that scientists adopt this role in practice institutional interventions are needed that address potential instrumental barriers that can be preventing scientists from taking this role. These barriers are empirically established, and theoretically supported by the theory of planned behaviour.

The right side of the flow chart presents the requirements that need to be considered for scientists who are not motivated to be engaged in policy-making. These requirements are also based on the theory of planned behaviour and supported by our empirical findings. This level suggests that research institutions and/or organizations that want to encourage policy contribution by scientists who are not motivated to participate in policy-making need to focus on increasing awareness of scientists regarding the moral aspects of their work (attitude). However, this does not necessarily mean that all scientists need to be engaged in policy-making. Therefore, we recommend that institutes also consider establishing criteria to decide which scientists are best positioned to take a policy role. These criteria may consider scientists' seniority, scientists' interpersonal skills and scientists' confidence about their communication competences. We also recommend that attention needs to be paid to the questions regarding the impact of policy engagement on scientists' credibility (subjective norms) as these may be of high importance to scientists who are not interested in policy engagement.

In the next part of the flow chart, we propose that institutions focus on instrumental barriers to scientists' policy engagement (perceived behavioural control). These may include i.e. lack of time for policy engagement and the low level of self-confidence regarding communication skills. In the next section, we discuss what institutional strategies can be designed to support policy engagement and provide directions for future research.

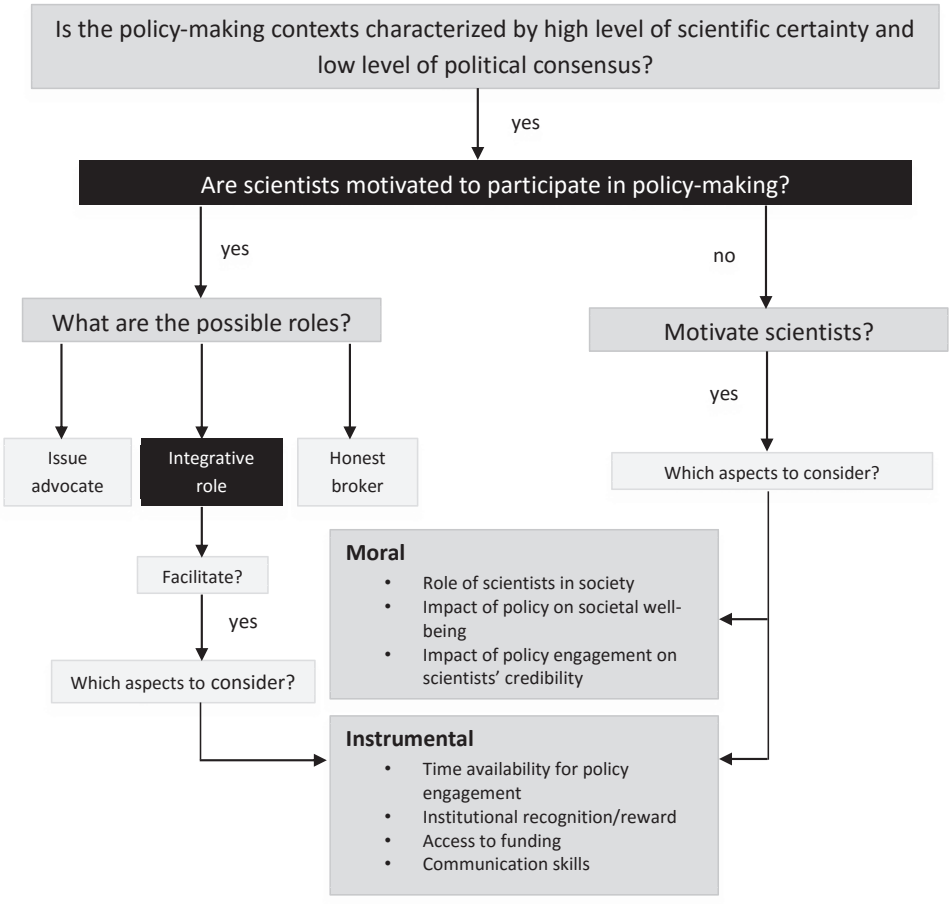

Figure 5 Flow chart indicating the preferred role of scientists in policy-making contexts that are characterized with high level of scientific certainty and low level of political consensus including recommendations of aspects that are important for encouraging scientists' contribution to policy-making (Based on Pielke, 2007 and Ajzen, 1991).

6.3 Discussion

In this section, we discuss institutional interventions that can be employed in order to encourage scientists' participation in policy-making. These are discussed in light of the theoretical propositions from the theory of planned behaviour.

Strategies focusing on creating positive attitude towards policy engagement

The empirical results presented in this thesis point out that scientists' motivation to engage in policy-making might be influenced by various behavioural beliefs regarding policy engagement. Our results demonstrate that scientists whose research progress is influenced by the difficulties with regulatory compliance are likely to feel morally obliged to contribute to policy-making in order to ensure that their research is utilized for the well-being of the society. On the contrary, scientists who do not (yet) face regulatory difficulties, for example scientists who work on fundamental research that has not yet any clear societal application, may feel less motivated to spend time on policy engagement. Nevertheless, we argue that these scientists should also become more aware about the importance of science integration in policy debates.

For example, (Michalopoulos et al. 2011) showed that the most cited reports that were initially considered to assess the desirability of biofuel use were mostly written by intergovernmental and non-governmental organizations and included only limited number of citations to the primary scientific data. There was much debate on the use of biofuels in spite of scientific reports that questioned the assumptions presented in these documents. Only recently, scientists working in this field directly articulated scientific arguments in policy-making and this has started to change the moral assessment of biofuel use. This further highlights the importance of the arguments presented in this thesis that scientific data published in scientific journals can not be assumed sufficient to inform policy decisions. Early engagement of scientists in policy debates, through an integrative role, can contribute to designing of policy measures that reflect both societal as well as scientific views.

In order to stimulate scientists who are not interested in policy engagement we propose that institutions need to focus on increasing the awareness of scientists about their role in society and about the potential impact of policy measures on the progress in their scientific field. This could be accomplished through dedicated training modules or through integration of attitude and moral related questions in existing courses and education curricula of young

scientists. In addition, scientific communities such as the Royal Academy or (inter)national domain related scientific organisations could organise special sessions or workshops to address these points.

Finally, as articulated earlier not all scientists have to be involved in policy-making, yet we argue that it is desirable that all scientists are aware about the social implications of their scientific work. Therefore, we invite institutions to consider an approach (i.e. through dedicated courses in master curricula) that educate young scientists about the social and political aspects of their work.

Strategies focusing on enhancing scientists' subjective norms regarding policy engagement

The results from our research also indicate that engagement in policy-making could negatively influence scientific credibility of scientists as perceived by their colleagues and employer. Therefore, creating an institutional environment that is supportive of scientists' contribution to policy-making is also significant. In addition, a question regarding how scientists' credibility in policy-making could be safeguarded is also important for strengthening the voice of science in policy-making. The results presented in this thesis suggest that scientists' participation in large scientific networks, which are presenting the consensus of a wider scientific society, may positively influence scientists' credibility in policy-making. In addition, our results also indicate that scientists believe that public sector research institutions should play an important role in ensuring the credibility of scientific advice that is used to inform policy. Most scientists who participated in our online survey agreed that scientists who contribute to informing of policy decisions should be accountable to the research institute for the policy statements they make. This is also reflected in our research regarding institutional arrangements for scientists' policy engagement, where a strategy was suggested to appoint a senior scientist (for a certain period) who takes the responsibility for coordinating scientific contributions to policy-making. Attention to policy engagement in education programs will also help to create better understanding among scientists' peers and colleagues about the importance of scientists' policy contribution.

Strategies increasing scientists' perceived behavioural control

The results presented in this thesis repeatedly pointed out that the ability of scientists to participate in policy-making is strongly influenced by the time scientists have available for policy engagement. Scientists who feel supported in their policy engagement by their employer have a higher motivation to engage in policy-making in the future – in spite of potential negative experiences. And indeed, scientists who feel that engagement in policy-making negatively influence their professional development may be less inclined to engage. This means that designing institutional strategies that recognize the importance and reward scientists' policy engagement will be critical to facilitate scientists' contribution to policy-making. The results from our interviews also stress that public sector research institutes should establish guidelines to decide how much time scientists should spend on policy engagement tasks.

Communication competence was repeatedly mentioned as a necessary precondition for scientists' policy engagement. Our results suggest that scientists' communication styles play an important role in influencing scientists' credibility in policy-making but also in establishing the dialogue between scientists and other policy stakeholders. To facilitate a dialogue with all policy stakeholders scientists will need to learn to translate scientific data into accessible words and to stay open to critically consider and carefully respond to all arguments provided against their scientific positions, distinguishing between scientific facts and unfounded assumptions. Hence programs focusing on advancing scientists' communication skills should be included in the science education programs.

6.4 Scientific and societal relevance

This thesis contributes to science policy studies, science and technology studies, science communication studies and studies focusing on institutional organization. These contributions can be observed both on theoretical and practical levels. On the theoretical level, the presented studies advance the model of Pielke and connect it to the theory of planned behaviour. Earlier science policy studies literature and the science and technology studies literature theoretically explored the roles that scientists may take in policy-making yet limited studies have been carried out to explore how scientists feel themselves about these roles. In a similar vein, science communication literature attempted to assess the motivation of scientists to engage in science communication activities yet it neglected the importance of

scientists' communication in the policy-making settings, neither did it provide an account as to how this could be done in practice. On the practical level, this thesis synthetizes knowledge from these fields to attempt the first conceptualization and empirical evaluation of the preconditions that are necessary for facilitating scientists' policy engagement. Such engagement is desirable from a societal perspective, as it ensures that scientific innovations that are funded from taxpayers' resources meet with scientifically sound regulatory environments. The case of agricultural biotechnology explored in this thesis suggests that unjustified regulatory frameworks may result in inefficient allocation of resources as well as delaying the needed societal and environmental benefits.

6.4.1 Study limitations and opportunities for future research

As with all studies we need to acknowledge this thesis' limitations and hence want to suggest possible directions for future research. These limitations mostly concern the characteristics of the samples that were collected for this research.

The quantitative data collected for the purpose of this pilot study is based on two scientific networks, including agricultural biotechnologists with a varying experience in policy engagement. While the inclusion of the network of PRRI enabled us to study opportunities and obstacles to scientists' policy engagement from the perspective of scientists who have experience with policy engagement, it also has some limitations. Case study research has been recognized to suffer from a generalization problem meaning that the conclusions from our case studies are only valid for these two scientific networks and without further research can not be generalized to all scientists. In addition, both our samples are skewed towards more senior scientists perhaps indicating that senior scientists predominantly engage in science outreach activities. However, to validate this assumption future research needs to include more junior scientists in the study population.

The study approaches (qualitative and quantitative) employed in this study can likely suffer from social desirability response bias, meaning that some participants in our study could have provided answers to our questions that they consider to be socially desirable rather than answers that reflect their true situation or views. Some of the methods that address this issue have been developed, including the method of force choice item, neutral questions and randomized response technique. Yet, a complete elimination of social desirability response bias seem to be difficult to achieve in practice (Nederhof 1985). Therefore, it is important that results are interpreted bearing the social desirability response bias in mind.

The scientists who participated in our qualitative study were European scientists, and therefore the views they expressed cannot be generalized to scientists who live outside Europe. For this reason, we recommend that future qualitative research also includes scientists from other regions than Europe. Case studies examining scientists' views regarding policy engagement in different countries could provide a more complete picture about the perceived opportunities and perceived obstacles regarding policy engagement and how other cultures deal with scientific evidence in policy-making.

Since some of the questions in our questionnaire had a high number of neutral responses we speculate that some of the scientists had difficulties to properly understand these questions. Therefore, we stress that future studies ensure that questionnaire design is well tested with a sufficient amount of scientists, especially if the study populations includes scientists who come from different cultural backgrounds.

The results show a clear need for institutional organisation, for which we made some suggestions. Further research should identify the best strategies and how they can be implemented most successfully.

Finally, this thesis focused on the views of public sector scientists regarding policy engagement. Yet, policy-making debates regarding science and technology are also relevant to scientists who work in industry or who work for non-governmental organizations. Therefore, collecting views from these scientists would provide a more complete picture about scientists' policy engagement and perhaps identify discrepancies regarding their views about how scientists' policy engagement should be organized.

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Summary



Summary

The Why's and How's of Scientists' Policy Engagement: The lessons from agricultural biotechnology

This thesis explores the reasons for scientists' policy engagement and proposes a new role that scientists can take in policy-making. Learning from the case of agricultural biotechnology, which has been characterized by long lasting controversy regarding the level of regulatory oversight on the use of GM crops, it aims to answer the following main research questions: 1) Which active roles can scientists adopt in controversial policy-making and which of these roles do agricultural biotechnology scientists prefer to take? and 2) Which factors are relevant for the motivation of scientists to engage in policy-making?

To answer these questions, two online surveys and 17 in-depth interviews are carried out with public sector agricultural biotechnology scientists many of whom have experience with policy engagement.

Chapter 1 provides the general introduction to the thesis where the overall context in which this research took place is explained. As the world's population increases and creates more pressure on already depleted resources our society has started to realize that we need to change the way we think about the production and consumption of food, feed, fibre, chemicals, pharmaceuticals and energy. In this context, the biobased economy has been recognized as having the potential to contribute to a more sustainable development. Despite its great promises, the implementation of the biobased economy depends on many factors, among which, innovations in agriculture to secure continuous and sustainable production of biomass. The techniques of genetic engineering that have been advanced since the 1970's opened up new possibilities to increase crops yields while decreasing inputs into production, to change crop composition to better fit industrial purposes, to produce crops that are fortified with necessary vitamins and to engineer crops that are able to withstand harsh climate conditions. However, it is widely recognized that the benefits of agricultural biotechnology have not been fully deployed. One of the reasons causing the disparity between potential and available products on the market has been the complexity, costs and the length of the biosafety regulation procedures. Some claim that the regulations that have been introduced in some countries, such as the European Union, ignore the available scientific insights in the risk assessment procedures. One of the potential reasons for the neglect and misinterpretation of scientific knowledge is the underrepresentation of the scientific

community during policy negotiations. Therefore, this thesis argues that in order to strengthen the integration of science into policy decisions scientists need to actively engage in policy processes regarding the safety assessment of new technologies. Chapter 1 further presents the general research questions and provides an overview of the two theories that were used to guide this thesis: The theory of planned behaviour (Ajzen, 1991) and The stakeholder model of science in policy (Pielke, 2007)

Chapter 2 presents the results from an interdisciplinary literature review on science-policy interfaces regarding the theoretical reasons for and against scientists' policy engagement. Identified arguments in favour of scientists' policy engagement include, i.e. the moral duties of public sector scientists towards society and the need to translate research results in policy-making due to low scientific literacy of policy makers. This chapter also considers the potential barriers to scientists' policy engagement, i.e. the impact on scientists' credibility and the lack of available competences that are needed for a meaningful policy contribution. All identified reasons for and against scientists' policy engagement are discussed in detail. Chapter 2 concludes with five areas that may require further attention to facilitate scientists' policy engagement. These include 1) Motivation, 2) Task coordination, 3) Communication competence, 4) Recognition and 5) Credibility.

Chapter 3 presents a study that explores the potential roles that scientists can take in policy-making. This chapter discusses the differences between the linear model of science and policy and the stakeholder model of science and policy and provides the theoretical arguments in favour of the latter. Consequently, scientists' views and their preferences regarding the two active roles that can be adopted in policy-making are empirically evaluated. These roles comprise of the 'Issue advocacy role' and the role of "Honest broker of policy alternatives'. Qualitative and quantitative data is collected from public sector scientists in agricultural biotechnology on their perception regardingtheir preferred roles in policy-making. Chapter 3 concludes that the majority of agricultural biotechnology scientists sympathize with the stakeholder model of science and policy and would prefer 'an integrative role' for scientists in policy-making. This new role combines the aspects of issue advocacy and the honest brokering of policy alternatives and proposes that scientists should inform policy-making by 1) collecting scientific evidence, 2) identifying all available policy alternatives that are supported by science, 3) reaching scientific consensus onwhich of these alternatives is the most preferred from the scientific point of view and 4) communicate about these alternatives with all policy stakeholders and explaining the impacts of different solutions.

Chapter 4 presents a study that investigated which factors influence the motivation of agricultural biotechnology scientists to engage in policy-making. Grounding the study in the theory of planned behaviour, we carried out an online survey with public sector scientists in agricultural biotechnology in order to assess their attitude related beliefs, subjective norms related beliefs and perceived behavioural control related beliefs regarding policy engagement. The significance of these beliefs in predicting the future motivation to engage in policy making was evaluated quantitatively by using regression analysis. The results indicate that the *attitude* towards policy engagement (measured through scientists' views about their role in society and the perceived influence of policy engagement) is the most important factor in predicting scientists' future motivation. The measures of subjective norms (perceived approval of policy engagement by scientists' social environment) and the perceived behavioural control (time availability and access to funding) also proved significant, though their influence was much lower. The characteristics of the studied sample (international group of scientists working at public sector research institutes and universities) allowed us to make a further differentiation between regional cultures and employers. Our analysis revealed that different motivational factors are significant when these characteristics are taken into account. For example, while the motivation of European, North American, and South American scientists is mostly influenced by their attitude towards policy engagement, the motivation of Asian and African scientists mostly develops from scientists' assessment of subjective norms.

Chapter 5 presents a study that qualitatively explored the perceived institutional support for scientists' policy engagement. Special attention was devoted to scientists' perceived time availability for policy engagement, perceived access to funding and the exploration of specific strategies that are currently employed by universities and public sector research institutes in Europe to facilitate scientists' policy engagement. This study finds that the majority of European agricultural biotechnology scientists do not feel institutionally supported in their policy engagement. Although some explained that engagement in science outreach is recognized as an important activity by their institutions the actual involvement in these activities is not specifically rewarded or supported. Besides the interest in the perceived institutional support this chapter also explores which traits/competences are desirable for a meaningful contribution of scientists to policy-making as perceived by agricultural biotechnology scientists themselves. These include 1) appropriate technical education, 2) working experience in the international context, 3) patience, 4) understanding of the policy-

making process, 5) membership in larger scientific networks and 6) communication competence.

Chapter 6 presents and discusses the main study findings and conclusions. It answers the research questions and synthetizes the results in light of the two theories that were used to guide this work. Agricultural biotechnology scientists prefer 'an integrative role' in policy-making, but in general do not adopt this role in practice. Important factors that can change this situation include support by institutional interventions focusing on time provision for policy engagement along with recognition and rewards for engaging in this activity. The results also indicate that in order to motivate scientists for policy engagement it is important to address the role of scientists in society and the impact of policy on societal well-being. In addition, communication skills are also seen as an important factor for meaningful policy engagement. While considering that not all scientists have to be involved in policy-making we do observe that currently there is a lack of institutional strategies to address the involvement of scientists in policy-making.

As a result of this thesis, a flow chart is presented that includes the new integrative role for scientists in policy-making and the factors that are important to motivate and support scientists in taking up this role. The flow chart elaborates on the stakeholder model of science in policy proposed by Pielke (2007) and integrates the motivational factors defined by the theory of planned behaviour proposed by Azjen (1991). The flow chart can be used to facilitate policy engagement of both groups of scientists those who are already motivated to contribute to policy development and those who do not (yet) show interest in this activity. Finally, Chapter 6 concludes with a discussion about the studies' limitations and with proposals for future research.

Appendices



Appendix A: Elicitation study with PRRI members

10 scientists were approached individually to take a part in this small open-ended questionnaire

1) What do you believe are the reasons for scientists to engage in policy-making?

2) What do you believe are the reasons for scientists not to engage in policy-making?

3) Is there anything else you associate with your own views about active engagement of scientists in policy-making?

4) Are there any individuals or groups who approve/support your active engagement in policy-making?

5) Are there any individuals or groups who disapprove/don't support your active engagement in policy-making?

6) Is there anything else you associate with other people's views about active engagement in policy-making?

7) What factors or circumstances would enable you to engage in policy-making regarding agricultural biotechnology in the forthcoming year?

8) What factors or circumstances would make it difficult or impossible for you to engage in policy-making regarding agricultural biotechnology in the forthcoming year?

9) Are there any other issues that come to your mind when you think about active engagement in policy-making?

Appendix B: Online survey with PRRI members

Dear scientist,

Thank you for taking the time to complete this survey. Your input is very much appreciated. The completion of the survey should not take longer than 7 to 10 minutes. You will be asked to express your opinion about various statements. These statements relate to your experience with (or your perception of) active engagement of scientists in regulatory debates regarding agricultural biotechnology. Active engagement in regulatory debates can be understood as:

- Directly participating in meetings addressing diverse regulatory issues concerning the applications of agricultural biotechnology, such as biosafety, coexistence, legal liability and/or socioeconomic considerations. Such meetings can include but are not limited to: Meetings of the Parties to the Cartagena Protocol on Biosafety, European stakeholder consultation meetings, Online regulatory discussions under the Cartagena Protocol on Biosafety etc.

- Preparation and submission of written comments on proposed draft legislation regarding agricultural biotechnology regulations

The results of this survey will be used in my PhD project called “Empowering scientists for social responsibility in the policy context”. More information on this project and the study rationale will appear after the completion of the questionnaire.

Sincerely,

Zuzana van der Werf Kulichova

Your beliefs about active engagement of scientists in regulatory debates

Please indicate your opinion about the following statements.

1) Strict regulations prevent innovative research in agricultural biotechnology.	
Strongly agree	
Agree	
I don't know	
Disagree	
Strongly disagree	

2) Most policy makers lack the necessary scientific background and therefore may misinterpret scientific data.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

3) Misinterpretation of scientific data may result in strict regulations that lack scientific basis.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

4) Active engagement in regulatory debates gives me an opportunity to interpret* the results of my work to policy makers. * *To interpret means to explain the implications of scientific data for policy-making purposes. Interpretation can be verbal or in a written form.*	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

5) When I actively engage in regulatory debates, I feel that I contribute to societal well-being.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

6) When I actively engage in regulatory debates, I feel that I can learn new skills (i.e. communication with non-scientific audiences)	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

7) When I actively engage in regulatory debates, I feel that I risk my scientific credibility.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

Your beliefs about the role of science and scientists in society

Please indicate your opinion about the following statements.

8) Scientists are important policy stakeholders.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

9) All policy stakeholders should actively engage in policy-making to ensure that their interest is reflected in policies and regulations	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

10) It is scientist's moral duty to ensure that scientific findings are utilized for the well-being of society.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

11) Regulations that prevent scientific research are undesirable for the well-being of society.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

12) For an accurate integration of scientific results into regulations, scientists need to interpret* scientific results to policy makers. * *To interpret means to explain the implications of scientific data for policy-making purposes. Interpretation can be verbal or in a written form.*	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

13) As a scientist, I also value the opportunities to learn some non-research related skills (such as communication with non-scientific audiences).	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

Constraints to your active engagement in regulatory debates

Please indicate your opinion about the following statements.

14) I feel that I lack the necessary communication skills* to actively engage in regulatory debates. * *Having communication skills means having the ability to clearly express your wishes and objections, while remaining respectful towards the other party.*	
Strongly agree	
Agree	
Neutral	
Disagree	
Strongly Disagree	

15) The lack of confidence in my communication skills prevents me from an active engagement in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

16) I never followed a communication-training course in the past.	
True	
False	

17) Active engagement in regulatory debates takes a lot of time.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

18) I feel that extensive teaching obligations negatively influence my ability to actively engage in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

19) In order to actively engage in regulatory debates, I feel I need time allowance from my employer.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

20) Active engagement in regulatory debates requires funding.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

21) I feel that I lack funds to actively engage in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

22) I feel that active engagement in regulatory debates does not have any professional benefits for me.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

23) The perceived lack of professional benefits prevents me from an active engagement in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

24) I feel that active engagement in regulatory debates does not have any economical benefits for me.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

25) The lack of economical benefits prevents me from active engagement in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

26) I do not have enough time to actively engage in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

27) My employer does not provide me with a time allowance to engage in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

28) I expect to receive a high teaching load in the forthcoming year.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

Influence of the social context on your active engagement in regulatory debates

Please indicate your opinion about the following statements.

29) The approval of my active engagement in regulatory debates by my friends and family is important to me.	
Extremely important	
Very important	
Neutral	
Low importance	
Not at all important	

30) The approval of my active engagement by my boss is important to me.	
Extremely important	
Very important	
Neutral	
Low importance	
Not at all important	

31) The approval of my active engagement by my colleagues is important to me.	
Extremely important	
Important	
Neutral	
Low importance	
Not at all important	

32) A support from a scientific society is important for my active engagement in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

33) Most people who are important to me think that I should actively engage in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

34) My friends and family would approve of my active engagement in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

35) My boss supports that I actively engage in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

36) My colleagues think that I should actively engage in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

37) I feel that the institute I work at want me to actively engage in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

38) I am aware of scientific societies that are supportive of my active engagement in regulatory debates.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

General evaluation of active engagement in regulatory debates

Please indicate your opinion about the following statements.

39) Active engagement in regulatory debates is influential.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

40) Active engagement in regulatory debates is mostly a pleasant experience.	
Strongly agree	
Agree	
I do not know	
Disagree	
Strongly disagree	

41) Active engagement in regulatory debates is worthwhile.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

42) Active engagement in regulatory debates is personally rewarding.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

Past experience and the future intention

Please indicate how many times did you actively engage in regulatory debates in the past and what are your future intentions.

43) In the past 12 months, how often have you actively engaged in regulatory debates via direct participation in meetings? Examples: the EU stakeholder consultation meetings, the meeting of the parties under the Cartagena Protocol on Biosafety and similar.	
0 x	
1 x	
2 x	
3 x	
More	

44) In the past 12 months, how often have you actively engaged in regulatory debates via contribution of written comments on draft legislation?	
0 x	
1 x	
2 x	
3 x	
More	

45) In the past 12 months, how often have you actively engaged in regulatory debates via participation in online regulatory discussions?	
0 x	
1 x	
2 x	
3 x	
More	

46) In the past 12 months, how often have you contributed to regulatory debates via engagement in other activities? (e.g. maintaining website, engaging with national policy makers)	
0 x	
1 x	
2 x	
3 x	
More	

47) I expect that I will actively engage in regulatory debates in the forthcoming year.	
Very likely	
Somewhat likely	
I don’t know	
Somewhat unlikely	
Not likely	

48) I want to actively engage in regulatory debates in the forthcoming year.	
Strongly agree	
Agree	
Neither agree or disagree	
Disagree	
Strongly disagree	

49) How many times during the forthcoming year do you expect to actively engage in regulatory debates?	
0 x	
1 x	
2 x	
3 x	
More	

Your personal details

Please select an appropriate option.

50) Gender	
Male	
Female	

51) Age	
<30	
30-40	
41-50	
51-60	
>60	
52) Your nationality. Please, select below.	

53) I currently work at:

54) My current employer is classified as:	
Public sector research institute	
University/Academia	
Other (Please Specify)	

55) Your professional occupation. Please, select below.	
PhD (junior research fellow)	
Postdoc (senior research fellow)	
Assistant professor (Completed PhD and Postdoc)	
Associate professor (4-8 years after assistant professor)	
Junior full professor (leading a research group)	
Senior full professor (leading a department of university/research institute)	
Other (Please Specify):	

56) Years of experience in research	
<5	
5-10	
11-15	
16-20	
>20	

57) Are you available for a short follow up interview? If so, please leave your email address here:

General comments and remarks

Please add any comments and remarks you may have regarding your active engagement in regulatory debates regarding agricultural biotechnology.

Thank you for competing the questionnaire. If you are further interested in this project you can find regular updates on http://tudelft.academia.edu/ZuzanavanderWerfKulichova
or contact me via email: z.vanderwerf-kulichova@tudelft.nl

The study rationale
Scholarly literature addressing the role of scientists in policy-making suggests that scientists should take more engaged role in policy-making debates. Yet, scholars also report that scientists may be hesitant to actively take up this role. In my previous research (van der Werf Kulichova et al. 2013; under review) I identified five factors, which may need to be taken into consideration for a successful engagement of scientists in policy-making. These are motivation, task coordination, communication competence, recognition and credibility. However, it is not known which of these factors influence the ability of scientists to engage actively in policy-making the most. Using the theory of planned behaviour this study investigates the following question: Which factors influence the ability of scientists to engage in regulatory debates regarding applications of agricultural biotechnology? The findings of the study will be used to identify areas that require attention during the design of intervention strategies for encouragement of more actively engaged role of scientists in policy-making.

Appendix B: Online survey with ISAAA subscribers

Dear scientist,

Thank you for taking the time to complete this survey.

Objective: This survey attempts to understand factors that influence scientists' intention to engage (or not to engage) in policy-making regarding agricultural biotechnology. It is a part of a larger project (Empowering scientists for societal responsibility in the policy context) and it is funded by the BE-Basic foundation http://www.be-basic.org/.

Time to complete: 7 - 10min

Definition:
Participation in policy-making may be understood as:

- Participation in policy consultation platforms where various regulatory issues (such as biosafety, legal liability, co-existence) are discussed with all stakeholders
- Cooperation with policy makers and others to integrate scientific results in policy decisions (i.e. by providing comments on draft legislation)

We appreciate your contribution.

Sincerely,

Zuzana van der Werf Kulichova (Delft University of Technology)
Mahaletchumy Arujanan (ISAAA, Malaysian Biotechnology Information Centre)
Patricia Osseweijer (Delft University of Technology)

Your perception about the current regulatory climate for agricultural biotechnology

Please indicate your opinion about the following statements.

1) I feel that regulatory frameworks in my country:					
	Strongly Agree	Agree	I don't know	Disagree	Strongly disagree
Facilitate deployment of benefits from biotechnology in timely manner					
Ensure consumers' free choice					
Ensure farmers' free choice					
Encourage public sector research in agri biotech (laboratory conditions)					
Encourage public sector research in agri biotech (experimental field trials in open environment)					
Encourage commercialization of agri biotech products					
Facilitate approvals of agri biotech products for import					

2) Regulatory standards in my country are mostly based on:					
	Strongly Agree	Agree	I don't know	Disagree	Strongly disagree
Available scientific evidence regarding environmental and human safety of GM crops					
Political preferences					
Public preferences					
Anti GMO activists preferences					

3) I think most policy makers					
	Strongly Agree	Agree	I don't know	Disagree	Strongly disagree
Have access to scientific knowledge					
Read scientific publications					
Have scientific literacy to interpret results of my work					
Consider results of public sector research in their regulatory decisions					
Are influenced by anti GMO activists					

Your beliefs about the role of scientists in society

Please indicate your opinion about the following statements.

4) I believe that participation of public sector scientists in policy-making regarding agri biotech is ... (please indicate your opinion below) for creating agri biotech regulations.					
	Strongly Agree	Agree	I don't know	Disagree	Strongly disagree
Important					
Necessary					
Influential					
Essential					

5) My engagement in policy-making is:					
	Strongly Agree	Agree	I don't know	Disagree	Strongly Disagree
My social responsibility					
Detrimental to my scientific credibility					
Detrimental to my professional career					
Part of my job scope					

6) My engagement in policy-making regarding agri biotech is:					
	Strongly Agree	Agree	I don't know	Disagree	Strongly disagree
Worthwhile					
Enjoyable					
Personally rewarding					
Opportunity to learn					
Opportunity to make my research more impactful					
Opportunity to make my research visible					
My responsibility towards ensuring food security, poverty alleviation and sustainable development					

Perceived constraints to your engagement in regulatory debates

Please indicate your opinion about the following statements.

7) If I wanted to engage in policy-making regarding agri biotech, I feel I would lack:					
	Strongly agree	Agree	I don't know	Disagree	Strongly disagree
Communication skills					
Training					
Funding					
Time					
Institutional support					
Economic benefits					
Professional benefits					

8) I never followed communication training course.	
True	
False	

Perceived approval and support for engagement

Please indicate your opinion about the following statements.

9) I think that scientists' engagement in policy-making should be:					
	Strongly Agree	Agree	I don't know	Disagree	Strongly Disagree
Done on a personal title in scientist's free time					
Governed institutionally (through clear institutional policies)					
Recognized as a part of scientific performance criteria					
Done by dedicated science-policy specialist					

10) I believe that scientists who engage in policy-making should be accountable to the university/research institute for the statements they make.	
Strongly agree	
Agree	
I don't know	
Disagree	
Strongly disagree	

11) My university/research institute has policies that support engagement in science outreach activities.	
Strongly agree	
Agree	
I don't know	
Disagree	
Strongly disagree	

Institutional support

12) I think that these people/entities would be supportive of my policy engagement.					
	Strongly Agree	Agree	I don't know	Disagree	Strongly disagree
My boss					
My scientific peers					
The institute I work at					
Other policy stakeholders - Industry					
Other policy stakeholders - NGOs					

Past experience and the future intention

13) How many times during your scientific career have you participated in science outreach activities?

14) How many times during your scientific career have you participated in policy-making regarding agricultural biotechnology?

15) If you answered 'Zero times' to question 13 and/or 14 could you provide at least one reason why you did not engage?

16) I would like to actively engage in regulatory debates in the forthcoming year.	
Strongly agree	
Agree	
Not sure	
Disagree	
Strongly disagree	

17) I will do my best to engage in regulatory debates in the forthcoming year.	
Strongly agree	
Agree	
Not sure	
Disagree	
Strongly disagree	

18) I have planned to engage in regulatory debates in the future.	
Strongly agree	
Agree	
Neutral	
Disagree	
Strongly disagree	

Your personal details

Please select an appropriate option.

19) Gender	
Male	
Female	

20) Your nationality. Please, select below.

21) How old are you?

22) My current employer is classified as:	
Public sector research institute	
University/Academia	
Industry	
Other (please specify)	

23) Your professional occupation. Please, select below.	
Junior research fellow (including PhD candidate)	
Senior research fellow (including postdoctoral research)	
Assistant professor (Completed PhD and Postdoc)	
Associate professor (4-8 years after assistant professor)	
Junior full professor (leading a research group)	
Senior full professor (leading a department of university/research institute)	
Other (Please Specify):	

24) Your years of experience in scientific research

25) I currently work on.. (Please indicate you current research focus)

26) My project is located at this stage:	
Laboratory research	
Confined field trials	
Release into environment	
Pre-commercial testing	
I am social scientist (Please specify your field)	

27) How many years has your research project been running?

28) Are you member of any organization that facilitates engagement of scientists in policy-making?	
Yes	
No	
If you answered yes could you specify which organization?	

General comments and remarks

Please add any comments and remarks you may have regarding your active engagement in regulatory debates regarding agricultural biotechnology.

29) Comments and Remarks

Thank you for completing the questionnaire. If you are further interested in this project you can find regular updates on http://tudelft.academia.edu/ZuzanavanderWerfKulichova
or contact me via email: z.vanderwerf-kulichova@tudelft.nl

Appendix C: Interview guide

Background information

Interview	Date:
Gender	1. Male 2. Female
Age	3. < 30 4. 30-40 5. 41-50 6. 51-60 7. > 60
Nationality	
Research field	
University or Institute Place Country	
Function	8. Technician 9. PhD 10. Postdoc 11. Assistant Professor 12. Associate Professor 13. Junior Full Professor 14. Senior Full Professor 15. Other: …
Years of experience in academic research	16. 0-5 years 17. 6-10 years 18. 11-15 years 19. 16-20 years 20. > 20 years
Other work experience	21. Industrial: … 22. Governmental: … 23. Educational: … 24. Other: …

Introduction

Thank you very much for allowing me to interview you. This interview will take about an hour and consists of four parts. First, I would like to ask you some general questions. Secondly, I would like to discuss what role scientists could take in policy-making regarding genetically modified organisms and what your attitude is towards this role. Then, I would like to discuss how social judgments of others, such as your academic peers, influence your decision whether or not to involve in policy-making as a scientist. Finally, I would like to discuss how you perceive your ability to involve in policy-making. Therefore, I would like to ask for your cooperation to answer the questions as concise as possible. I will ask for more information when necessary. Thank you very much.

Part 1

1) Could you explain me in 2-3 sentences something about your research?

2) Do you come in contact with EU legislation and policy-making regarding GMOs?

3) Are you involved in policy-making regarding GMOs? If so, how? What kind of activities? Via institutions/organizations/individually?

Part 2 Attitude towards policy engagement

Now, we will start the second part of this interview. I would like to discuss your opinion about policy-making and the involvement of scientists in this process. During the whole interview, we will discuss solely about academic biotech scientists (so not scientists from industry) and about European policies regarding genetically modified organisms.

1) Do you think that scientists have responsibility to not only publish, but also interpret research results for policy makers? Why?

2) Do you think that scientists should personally involve in policy-making or that science and policy-making should be separated processes? Why?

3) Some scientists advocate on specific policy decisions they prefer and thereby use science to reduce the scope of choice available to policy makers. In general, do you think positively or negatively about this? Why?

4) It is argued that scientists should seek to clarify the scope of choice available to a policy maker, so not to advocate a single “best” course of action, but to address the question: what policy alternatives are consistent and inconsistent with scientific results? In general, do you think positively or negatively about this? Why?

5) We discussed your opinion about several roles for scientists in policy-making. You told me before you are involved in policy-making. What role do you take?

When scientist was not involved in policy-making the question was: Which role would you like to take?

6) Do you see this as a part of your job?

When scientist was not involved in policy-making the question was: Would you see this role as a part of your job?

7) How important is it for you to be involved in policy formation? Why?

When scientist was not involved in policy-making the question was: Do you think it would be useful to take this role in policy-making? Why?

8) Could you express your feelings about involvement in policy-making debates? After this steering question: enjoyment, satisfaction, fear, anger, grief, worries, and sadness…

9) What do/would you hope to achieve from this involvement? Can you explain why and how it is/it would be useful? After this steering question: Is it useful? For your research? For academic research in general? For society?

10) How do/would you evaluate your effort that you put into the involvement in policy-making? After that steering question: You mentioned before you spend.. Do you think this is too much or not enough time? Does it have effect on your professional career? Why?

Part 3 Judgment of social context

We discussed your opinion about policy-making. I would like to discuss with you what you believe the opinion of other people is about policy-making and especially your involvement as a scientist in this process.

1) How do you think your academic peers would evaluate your involvement in policy-making? Who are these academic peers? How does this influence your decision to involve in policy-making?

2) How do you think other stakeholders in policy debates would evaluate your involvement in policy-making? Who are these other stakeholders? How does this influence your decision to involve in policy-making?

3) How do you think the general public would evaluate your involvement in policy-making? How does this influence your decision to involve in policy-making?

4) Are there other people in your personal environment, such as family and friends whose opinion influences your decision to involve in policy-making?

5) We discussed several things that affect you when deciding to involve in policy-making (Summarize). Could you indicate which of these factors influences mostly your decision whether to involve in policy-making?

Part 4 Perceived ability to involve in policy-making

Thank you for sharing your opinions and feelings with me. In the final part of this interview I would like to discuss with you what factors influence your ability to involve in policy-making.

1) What competences does a scientist need to have to involve in policy-making? Do you think you have the right competences?

2) You mentioned before you spend.. (time). Does your organization have a strategy to do these kinds of activities? Or do you do this in your personal time? Do you have sufficient time?

When scientist was not involved in policy-making the question was: Does your organization have a strategy to do these kinds of activities? Or would you need to do it in your personal time?

3) Does it cost money to involve in policy-making? How do you get this money? From funding or do you pay personally? Do you have sufficient money available to involve in policy formation?

When scientist was not involved in policy-making the question was: Would it cost money to involve in policy-making? How could you get this money?

4) Are there any other factors that (would) influence your ability to engage in policy-making?

I have a final question for you. We discussed about the importance, usefulness, your personal feelings, and social judgements and about your perceived ability to involve in policy-making. Which of these factors influences mostly your decision whether or not to engage in policy-making? Why?

Acknowledgments



Acknowledgements

This thesis has been a long journey that started well before the official start date of my contract. Back in 2007, I had to decide which master thesis project to pursue in order to graduate for my master degree at the Wageningen University. I found the project advertisement by PRRI of which the overal objective was to map the worldwide progress of public sector research in agricultural biotechnology. I got in touch with the PRRI sectretariat and started my journey on this exciting subject: Regulatory constraints on the market release of genetically modified crops in developing countries. Thanks to my engagement in this project, in 2008, I was able to attend the Fourth Meeting of the Parties to the Cartagena Protocol on Biosafety. This experience opened up a new world about how policy discussions regarding the applications of agricultural biotechnology were unfolding. Thanks to this experience I also found my first job at the TU Delft. With this in mind, I would like to thank to Kim Meulenbroeks for all the support and friendship she shared with me since 2008.

Another important person who inspired me to start this project was Piet van der Meer. For more than two years before I started this Phd project Piet was my mentor and I can not express with enough words how grateful I am for having the opportunity to learn from him, to travel the world and to experience the real policy-making on biotechnology.

The third important person on my journey was Patricia Osseweijer. Without her this project would not exist. I want to thank you Patricia for having the faith in this idea and for making it possible to happen. I also thank you for having the trust in me as a person. Despite my four pregnancies you never doubted that I will finish this endeavour. I am grateful for everything I could learn from you.

When I started this project I received a great support from Robin Pierce. You supported me already during the preparation of the project proposal and asked me critical questions about the way I was thinking about it. Also during the preparation of my very first empirical paper I received a valuable support from you. Thank you for telling me about the scissor method and much more. Thank you for being ready to provide feedback anytime I asked for it.

Another person who deserves my ‘thank you’ is Steven Flipse. He motivated me to get my first data in a good shape and bring it into a publication. This was an important milestone for me that encouraged me to gain a confidence that I can do this.

This thesis has been also strongly influenced by my master student Hilde Coumou. Hilde, thank you for giving me valuable lessons on personal competences and self-reflection and providing me with a great support during the data collection phase and during the preparation of our articles.

I would like to also thank to my dear friend Silvia Augustin who was ready to support me with the preparation of the book cover despite her work load during that period.

My PhD journey would not be complete without my dear BTS colleagues. Thank you Tanja, Anne-Lotte, Laurens, Daan, Steven, Serene, Susanne, Urjan, Annick, Sebastian, Richard, Mar, Matti and Anka for all those moments we shared together.

Finally, I would like to thank to my family. Thank you Johannes and Margriet, my dear parents in law for your great support. Without your help I would not be able to complete this huge task. I also would like to express my gratitude to my three girls who were very patient and let me work for hours during the last phase of this project. And as the slovak saying says.. “the best comes the last”… Peter, my dear husband without you I would never get this far. I love you for your optimism, compassion and much much much more.

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Curriculum Vitae

Zuzana van der Werf Kulichova was born on June 25, 1983 in Piešťany, Slovakia. After graduating from high school with an economic major, Zuzana started her university degree in 2002 at the Slovak Agricultural University. Next to specializing in the economics of agribusiness she also obtained knowledge on plant and animal production, management, marketing, micro and macroeconomics and econometrics. In 2005, inspired by her working experience abroad, Zuzana started her short-term student exchange program at Wageningen University. This short-term program motivated her to initiate her second master degree at Wageningen University focusing on the Environmental Science. In 2008 and in 2009, she graduated at Wageningen University and the Slovak Agricultural University, respectively. Shortly after her graduation in 2008, she started to work at Delft University of Technology as the Project Leader of the European Commission Project "Science4BioReg". During this period she coordinated activities of a large scientific network, organized and participated in various meetings regarding biosafety regulations, presented the project activities on various occasions and coordinated financial administration of the project. During this period she also contributed to the National Biosafety Strategy for Slovakia as a co-author. After the successful "Science4BioReg" project completion in 2010, she spent a few months on research about the different stakeholders' perspectives on the use of biofuels, which resulted in a peer reviewed publication. In November 2010, she started her PhD at Delft University of Technology, with the title "Empowering scientists for a social responsibility in the policy context". The Centre for the Life Science and Technology and the Be Basic Foundation financed the project and this thesis is the result of this project.

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The biobased economy is regarded as a possible solution for addressing the challenges associated with climate change and the growing human population. Due to progress in science and technology the biobased economy can provide additional food and renewable energy to meet the needs of the expected 9 billion people by 2050.

However, the implementation of the biobased economy also raises many questions about the transition paths, including the political and regulatory climate for new technologies that are necessary to accomplish this transition. Policy decisions and new regulations require input from the scientific community. While most policy stakeholders agree that we need new technologies that can reduce or eliminate greenhouse gas emissions, we witness controversy about the best solutions to realize sustainable production. Scientists have the potential to play an important role in policy debates and processes, but presently their involvement is not adequate.

This thesis explores how scientists perceive their role in policy-making and which factors are relevant for their motivation for policy engagement. Using the empirical data from the research with agricultural biotechnology scientists this thesis identifies and describes a new role for scientists in controversial policy-making and provides recommendations for institutional strategies that are needed to facilitate that scientists adopt this role in practice.

ISBN 978-94-6299-449-2