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## **The role of scientists in policy-making regarding agricultural biotechnology: from traditional to alternative views**

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**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 characterised 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 sympathise 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.

**Keywords:** agricultural biotechnology; regulations; policy-making; scientists.

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Mahaletchumy Arujanan is the Executive Director of the Malaysian Biotechnology Information Centre. Her passion to bring biotechnology closer to the society and engaging them as a partner in the development of this industry has seen a number of innovative approaches in public understanding of biotechnology. She sits on various panels and committees at both the national and international level, and is a regular speaker at biotechnology events. She is a recipient of 2010 TWAS Regional Prize for Public Understanding of Science for East, Southeast Asia and Pacific Region.

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## 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 utilised to identify and understand complex relationships (Engels, 2005; Woodhouse and Nieuwma, 1997; Haas, 1992; Holmes and Clark, 2008), to identify and assess potential risks (Allio et al., 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 politicisation 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 et al., 2009; Weiss, 1991; Meyer et al., 2010; Allio et al., 2006; De Greef, 2004; Strauss et al., 2009; van der Werf Kulichova et al., 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 utilised 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-90s in the literature and was summarised by Pielke (2007) as a stakeholder model of science and policy. 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), p.14]. The stakeholder model of science in policy seems to relate to the Ostrom's (2009) 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. The lack of consensus about the desired policy outcomes poses challenges to the proper integration of science in policy decisions (Smyth et al., 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, 2007). Pielke (2007, pp.17–18) 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. 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.

## **2 From linear to the stakeholder model of science and policy**

The conventional view on the science-policy interface conceptualises 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 utilised in policy-making is completely left to policy makers” (Holifield, 2009; Steel et al., 2004; Chilvers and Evans, 2009; Pielke, 2007). 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” [Schuurbijs, (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 recognise that the major premises on which it builds cannot be maintained in practice. The seminal work of US 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 recognised 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, 1988), epistemic communities (Haas, 1992) 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 recognised 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 organise 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 1 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 1** The roles for scientists in policy making

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

*Source:* Pielke (2007)

### **3 Case study: how do agricultural biotechnology scientists perceive their role in policy-making?**

#### *3.1 Case study rational*

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 organisations (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, 2004; 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 US has increased over the time [Strauss et al., (2010), p.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., 2009, 2010). 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 et al., 2006). Given this background, agricultural biotechnology can be seen as a case study for policy-making related to science that is characterised 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.

#### *3.2 Methodology*

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.prrri.net](http://www.prrri.net)). The membership in PRRI is free of charge. Any scientist interested in a PRRI membership can join the organisation 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 organisation

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 2. 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?

**Table 2** Interviewees sample characteristics (phase 1 – interviews)

<i>Gender</i>	<i>Age (years)</i>	<i>Professional occupation</i>	<i>Countries</i>
Male (13)	< 30 (0)	University (10)	Germany (2)
Female (4)	30–40 (1)	Public sector research institute (7)	Italy (1)
	41–50 (1)		The Netherlands (5)
	51–60 (9)		Belgium (3)
	> 60 (6)		UK (1)
			Switzerland (1)
			Spain (1)
			France (2)
			Hungary (1)
17 (100%)	17 (100%)	17 (100%)	17 (100%)

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 PRRI, 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 (<http://www.isaaa.org/inbrief/default.asp>). 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 3. The sample characteristics of ISAAA subscribers are presented in Table 4. The data was collected between December 2013 and February 2014.

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.

**Table 3** Sample characteristics (phase 2 – online survey PRRI)

<i>Gender</i>	<i>Age (years)</i>	<i>Employer</i>	<i>Continents</i>
Male (77%)	< 30 (3.7%)	Public sector research institute (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%)

Note: \*Intergovernmental organisations, retired academics

**Table 4** Sample characteristics (phase 3 – online survey ISAAA)

<i>Gender</i>	<i>Age (years)</i>	<i>Employer</i>	<i>Continents</i>
Male (75.93%)	< 30 (0%)	University (59%)	South America (0%)
Female (24.07%)	30–40 (16%)	Public sector research institute (19%)	North America (35.18%)
	41–50 (20%)	Other* (22%)	Europe (35.20%)
	51–60 (31%)		Africa (24.07%)
	> 60 (33%)		Australia (1.85)
			Asia (3.70%)
54 (100%)	54 (100%)	54 (100%)	54 (100%)

Note: \*Intergovernmental organisations, retired academics

These statements were assessed on a five point Likert scale ranging from strongly agrees 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 politicisation 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 utilised 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 5.

**Table 5** Results form the online survey with PRRI scientists

<i>Theme</i>	<i>Statement</i>	<i>SA</i>	<i>A</i>	<i>N</i>	<i>D</i>	<i>SD</i>	<i>(N)</i>
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%	10.0%	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
Politicisation 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
Feelings of social responsibility	It is scientists' moral duty to ensure that scientific findings are utilised 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 6. The data was collected between February 2015 and April 2015.

**Table 6** Results from online survey with ISAAA subscribers

<i>Theme</i>	<i>Statement</i>	<i>SA</i>	<i>A</i>	<i>N</i>	<i>D</i>	<i>SD</i>	<i>(N)</i>
Perceived roles	I believe that participation of public sector scientists in policy making regarding agricultural biotechnology is important.	70.0%	25.00%	3.33%	0.00%	1.67%	64
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).	12.5%	23.44%	10.94%	34.38%	17.19%	64
	I feel that regulatory standards in my country encourage commercialisation of agricultural biotechnology products.	7.81%	23.44%	9.38%	23.44%	35.94%	64
Politicisation 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.	25.00%	43.33%	5.00%	20.00%	6.67%	60

Notes: SA = strongly agree; A = agree; N = neutral; D = disagree; SD = strongly disagree; (N) = sample size

### 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.

## 4 Results

### 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 necessarily 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 politicisation of biosafety regulatory debates
- 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.

#### *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 Tables 5 and 6). 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).”

“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).”

“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).”

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).”

“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).”

#### *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

3 the feelings of social responsibility.

In the following sections, we present the results in line with these sub-themes.

#### *4.3.1 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 commercialisation 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).”

“[...] 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).”

The results from the two online surveys also indicate that most scientists perceive the regulatory environment for agricultural biotechnology as unfavourable for research and commercialisation. For example, 86% of scientists who are members of PRRI agreed that strict regulations prevent research progress in agricultural biotechnology (Table 5). 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 6).

#### *4.3.2 Perceived politicisation of regulatory debates*

The second sub-theme concerns the scientists' perceptions about politicisation 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).”

“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).”

“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).”

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 5). 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 6).

#### *4.3.3 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).”

“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).”

“I think I’m hugely passionate about science ... I strongly believe that you should do science to benefit the community (interview 13).”

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 utilised for well-being of society (Table 5). Also 83% scientists who are subscribers to ISAAA mailing list agreed that engagement in policy-making is their social responsibility (Table 6).

#### *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).”

“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).”

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).”

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).”

“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).”

#### *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).”

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).”

## 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-politicisation 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 politicisation of regulatory debates and restrictive regulatory environment for agricultural biotechnology research and commercialisation. 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 (Schuurbiens, 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 recognised 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 sympathised 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 recognised 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 et al., 2005; Andrews et al., 2005; Sturzenegger-Varvayanis et al., 2008, van der Werf Kulichova et al., 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 Núñez (2014) recently showed that the number of published articles is still a widely preferred metric when it comes to academic evaluation.

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.

## **6 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 generalising 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 organisations and private sector including scientists from these organisations 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.

## References

- Allio, L., Ballantine, B. and Meads, R. (2006) 'Enhancing the role of science in the decision-making of the European Union', *Regulatory Toxicology and Pharmacology*, Vol. 44, No. 1, pp.4–13, doi: [online] <http://dx.doi.org/10.1016/j.yrtph.2005.08.008> (accessed August 2015).
- Ammann, K. (2014) 'Genomic misconception: a fresh look at the biosafety of transgenic and conventional crops. A plea for a process agnostic regulation', *New Biotechnology*, Vol. 31, No. 1, pp.1–17, doi: [online] <http://dx.doi.org/10.1016/j.nbt.2013.04.008> (accessed August 2015).
- Andrews, E., Weaver, A., Hanley, D., Shamatha, J. and Melton, G. (2005) 'Scientists and public outreach: participation, motivations, and impediments', *Journal of Geoscience Education*, Vol. 53, No. 3, p.281.
- Ansell, C., Maxwell, R. and Sicurelli, D. (2006) *What's the Beef?: The Contested Governance of European Food Safety*, Chapter 5: Protesting Food: NGOs and Political Mobilization in Europe, David Vogel (Ed.), MIT Press.
- Cantley, M.F. and Kershner, D.L. (2013) *Successful Agricultural Innovation in Emerging Economies: New Genetic Technologies for Global Food Production*, Chapter 16: Regulatory Systems and Agricultural Biotechnology, Published in the United States of America by Cambridge University Press, New York, p.267.
- Chilvers, J. and Evans, J. (2009) 'Understanding networks at the science-policy interface', *Geoforum*, Vol. 40, No. 3, pp.355–362.
- De Greef, W. (2004) 'The Cartagena protocol and the future of agbiotech', *Nature Biotechnology*, Vol. 22, No. 7, pp.811–812.
- Dubock, A. (2014) 'The present status of golden rice', *Journal of Huazhong Agricultural University*, Vol. 33, No. 6, pp.69–84.
- Engels, A. (2005) 'The science-policy interface', *Integrated Assessment*, Vol. 5, No. 1, pp.7–26.
- Foote, L., Krogman, N. and Spence, J. (2009) 'Should academics advocate on environmental issues?', *Society and Natural Resources*, Vol. 22, No. 6, pp.579–589.
- Gieryn, T.F. (1983) 'Boundary-work and the demarcation of science from non-science: strains and interests in professional ideologies of scientists', *American Sociological Review*, pp.781–795.

- Gonzales, L.D. and Núñez, A.M. (2014) 'The ranking regime and the production of knowledge: implications for academia', *Education Policy Analysis Archives*, Vol. 22, pp.1–20, doi: 10.14507/epaa.v22n31.2014.
- Haas, P.M. (1992) 'Introduction: epistemic communities and international policy coordination', *International Organization*, Vol. 46, No. 01, pp.1–35, doi:10.1017/S0020818300001442.
- Holifield, R. (2009) 'How to speak for aquifers and people at the same time: environmental justice and counter-network formation at a hazardous waste site', *Geoforum*, Vol. 40, No. 3, pp.363–372, doi: [online] <http://dx.doi.org/10.1016/j.geoforum.2008.02.005> (accessed June 2015).
- Holmes, J. and Clark, R. (2008) 'Enhancing the use of science in environmental policy-making and regulation', *Environmental Science & Policy*, Vol. 11, No. 8, pp.702–711.
- Jasanoff, S.S. (1987) 'Contested boundaries in policy-relevant science', *Social Studies of Science*, Vol. 17, No. 2, pp.195–230.
- Lach, D., List, P., Steel, B. and Shindler, B. (2003) 'Advocacy and credibility of ecological scientists in resource decision making: a regional study', *BioScience*, Vol. 53, No. 2, pp.170–178.
- Liberatore, A. and Funtowicz, S. (2003) 'Democratising' expertise, 'expertising' democracy: what does this mean, and why bother?', *Science and Public Policy*, Vol. 30, No. 3, pp.146–150.
- Mathews, D.J.H., Kalfoglou, A. and Hudson, K. (2005) 'Geneticists' views on science policy formation and public outreach', *American Journal of Medical Genetics Part A*, Vol. 137, No. 2, pp.161–169.
- Maxwell, S. and Stone, D.L. (2004) *Global Knowledge Networks and International Development*, Vol. 7, Simultaneously published in United States and Canada by Routledge.
- McDougall, P. (2011) *Getting a Biotech Crop to Market*, CropLife International, Brussels, Belgium.
- McNie, E.C. (2007) 'Reconciling the supply of scientific information with user demands: an analysis of the problem and review of the literature', *Environmental Science & Policy*, Vol. 10, No. 1, pp.17–38.
- Meyer, J.L., Frumhoff, P.C., Hamburg, S.P. and de la Rosa, C. (2010) 'Above the din but in the fray: environmental scientists as effective advocates', *Frontiers in Ecology and the Environment*, Vol. 8, No. 6, pp.299–305.
- Miller, J.K. and Bradford, K.J. (2010) 'The regulatory bottleneck for biotech specialty crops', *Nat Biotech*, Vol. 28, No. 10, pp.1012–1014, doi: [online] <http://dx.doi.org/10.1038/nbt1010-1012> (accessed June 2015).
- Ostrom, E. (2009) *Understanding Institutional Diversity*, Princeton University Press, UK.
- Pellizzoni, L. (2011) 'The politics of facts: local environmental conflicts and expertise', *Environmental Politics*, Vol. 20, No. 6, pp.765–785.
- Pielke, R.A. (2007) *The Honest Broker: Making Sense of Science in Policy and Politics*, Cambridge Univ Press, USA.
- Potrykus, I. (2010) 'Constraints to biotechnology introduction for poverty alleviation', *New Biotechnology*, Vol. 27, No. 5, pp.447–448.
- Sabatier, P.A. (1988) 'An advocacy coalition framework of policy change and the role of policy-oriented learning therein', *Policy Sciences*, Vol. 21, Nos. 2–3, pp.129–168.
- Schenkel, R. (2010) 'The challenge of feeding scientific advice into policy-making', *Science*, Vol. 330, No. 6012, pp.1749–1751.
- Schuurbiers, D. (2010) 'Social responsibility in research practice', *Engaging Applied Scientists with the Socio-ethical Context of their Work*, Simon Stevin Series in Ethics of Technology, Delft University of Technology, Delft.
- Smyth, S.J., Kerr, W.A. and Phillips, P.W.B. (2013) 'Managing trade in products of biotechnology – which alternative to choose: science or politics?' *Agrobioforum*, Vol. 16, No. 2, pp.126–139.

- Steel, B., List, P., Lach, D. and Shindler, B. (2004) 'The role of scientists in the environmental policy process: a case study from the American west', *Environmental Science & Policy*, Vol. 7, No. 1, pp.1–13.
- Stone, D. (2002) 'Introduction: global knowledge and advocacy networks', *Global Networks*, Vol. 2, No. 1, pp.1-12.
- Strauss, S.H., Kershen, D.L., Bouton, J.H., Redick, T.P., Tan, H. and Sedjo, R.A. (2010) 'Far-reaching deleterious impacts of regulations on research and environmental studies of recombinant DNA-modified perennial biofuel crops in the United States', *BioScience*, Vol. 60, No. 9, pp.729–741, doi: 10.1525/bio.2010.60.9.10.
- Strauss, S.H., Tan, H., Boerjan, W. and Sedjo, R. (2009) 'Strangled at birth? Forest biotech and the convention on biological diversity', *Nature Biotechnology*, Vol. 27, No. 6, pp.519–527.
- Sturzenegger-Varvayanis, S., Eosco, G., Ball, S., Lee, K., Halpern, M. and Lewenstein, B. (2008) 'How university scientists view science communication to the public', *Proceedings de la Conference, PCST-10*, Malmö.
- 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*, Vol. 5, No. 4, pp.1–11.
- Vigani, M. and Olper, A. (2013) 'GMO standards, endogenous policy and the market for information', *Food Policy*, Vol. 43, pp.32–43 [online]  
<http://www.sciencedirect.com/science/article/pii/S030691921300105X>.
- Weiss, C.H. (1991) 'Policy research as advocacy: pro and con', *Knowledge, Technology & Policy*, Vol. 4, No. 1, pp.37–55.
- Wesselink, A. and Hoppe, R. (2010) 'If post-normal science is the solution, what is the problem? The politics of activist environmental science', *Science, Technology & Human Values*, 0162243910385786 [online]  
<http://sth.sagepub.com/citmgr?gca=spsth%3B0162243910385786v1>.
- Woodhouse, E.J. and Nieuwma, D. (1997) 'When expert advice works, and when it does not', *Technology and Society Magazine*, IEEE, Vol. 16, No. 1, pp.23–29.
- [www.ppri.net](http://www.ppri.net), *Public Research and Regulation Initiative: Mission and Organization* [online]  
<http://www.ppri.net/mission/> (accessed 28 March 2014).