THE BUMPY PATH TOWARDS KNOWLEDGE CONVERGENCE FOR PRO-POOR AGRO-BIOTECHNOLOGY REGULATION AND DEVELOPMENT: EXPLORING KENYA'S REGULATORY PROCESS[1]

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Introduction

This paper aims to explore the different strands of knowledge that accompany biotechnology regulation and further exposes embedded dynamics that must inform knowledge convergence efforts for exploitation of biotechnology science in a developing country context. Contestations over the regulatory trajectory that developing countries should take to embrace the benefits of agro-biotechnology[2] have been debated widely. Debates in the global arena have focussed on two competing regulatory approaches namely: the more permissive approach of the United States (US) that presents biotechnology as posing no risk to the environment or human health unless proven otherwise through scientific risk evaluation; and, the more restrictive approach of European Union (EU) that imposes precautionary restrictions on use of products of biotechnology even when scientific knowledge about risks is uncertain. There is now a wide body of literature looking at trade conflicts brought about by these divergent regulatory policies leading to regulatory polarization (Paarlberg, 2001, 2008; Bernauer and Aerni, 2007; Bernauer, 2005; Falkner, 2007; Murphy and Levidow, 2006). Arguably, these polarised debates only expose the political dynamics of biotechnology from a very narrow view, primarily trade imperatives (Clapp, 2006). Some analysts, departing from what they perceive to be a narrow approach to this subject, have attempted to explain the bumpy path to biotechnology deployment and regulation in developing economies that exhibit different characteristics. Millstone and van Zwanenberg (2003) for instance looking at GM policies in the South have shown that the scientific conflicts embedded in GM safety compel countries to pursue divergent regulatory choices. Research has also shown that local context dictates technological dynamics and should be given a place in biotechnology development and regulation (van Zwanenberg et al., 2008). Falkner and Gupta (2009) have also noted that despite the EU-US international regulatory conflicts, developing countries are responding to related pressures in different and unique ways.

Important for this paper are the dynamics brought about by regulatory pressures and what this means for knowledge use towards productive debates that could lead to pro-poor biotechnology development. There is a need to re-orient discussions around how actors in the respective value chains ought to respond to regulatory demands brought about by biotechnology, and how this impacts knowledge production dynamics. The paper argues that biotechnology development will only contribute to economic development if knowledge (regulatory, social and scientific knowledge), emanating from different knowledge nodes is allowed to converge to a point where it can consequently inform productive innovation policy processes. This argument is based on the understanding that requisite innovation capacities need to be built in order for actors to use the resources at their disposal towards behavioural change for biotechnology regulation (Hall, 2005). Knowledge is one of the resources and how it is applied is crucial for biotechnology innovation process or trajectory.

[2] Here I use the term biotechnology to mean the manipulation of living organisms to produce goods and services useful to human. I make distinction between traditional (or conventional) and modern biotechnologies. The traditional approach allows the development of new products (such as seed varieties) by the process of selection from genetic material already present within a species, while the modern (transgenic) approach develops products (such as seed varieties) through insertion of genetic material from different species into a host plant. These products are popularly known as Genetically Modified Organisms (GMOs).

This paper relooks at knowledge production dynamics through an empirical account that documents the agro-biotechnology regulatory trajectory in Kenya. The analytical context for the paper is backed by the political nature under which biotechnology development and biosafety regulation have co-evolved for almost two decades (Harsh, 2005; Sander, 2007; Kingiri and Ayele, 2009, Kingiri, 2010, 2011a, b). Analysis drawn from these papers suggests that scientific knowledge predominantly directs biotechnology development and regulation (cf Kingiri, 2010). In addition, the fragmented nature of actors' infrastructure and their belief systems derail the knowledge convergence efforts (Kingiri, 2011a). Although this process lacked legal direction in terms of policy (Biotechnology policy and Biosafety Act were only approved in 2006 and 2009 respectively), the paper suggests that lessons learnt in Kenya's regulatory process should move the country's biotechnology sector to a higher level - towards putting into use the research products in the pipeline. The objective of the paper therefore is to explore and understand how knowledge convergence can be attained towards moving biotechnology science forward towards innovation.

The paper is structured as follows. The political scenario under which biotechnology regulation occurs is discussed first in section 2. This is followed by the analytical context (section 3). Next, the paper illuminates the dynamics associated with biotechnology regulation using Kenya as an example (section 4). Then, the paper discusses the emerging dynamics associated with regulation and role of knowledge actors (section 5). It then concludes by drawing lessons that might inform a productive regulatory process towards knowledge convergence.

The political nature of biotechnology regulation

Agricultural production constraints like pests and diseases perpetuate the cycle of food insecurity and poverty in sub-Saharan Africa. Many ask whether biotechnology can be exploited as a possible solution to these and other production constraints. Proponents are optimistic about this while opponents are pessimistic citing safety concerns around human health and environment. Answers to these and related questions provide a more complex and charged debate about biotechnology development and regulation.

Despite the undisputed consensus about biotechnology as a tool for agricultural development in poor economies (FAO, 2004), political polarization on GMOs is increasing. The participation of many interested stakeholders in charting a supposedly sustainable regulatory pathway has confounded the process due to the value based nature of divergent perspectives (Paarlberg and Pray, 2007; Leach et al., 2007). It has been noted that policy processes in advanced economies particularly EU and USA have significantly shaped public opinion and regulation in African countries (Newell, 2003). The EU for instance has been associated with advocacy groups opposing biotechnology introduction even in regions where food security challenges persist (Herring, 2010; Paarlberg, 2001, 2008). Other analysts have explored the problem more broadly and suggest that a more holistic approach to the biotechnology debate is needed to embrace the context that varies with regions, localities and social preferences (van Zwanenberg et al., 2008; Glover, 2010).

This paper is in line with a holistic view of biotechnology regulation that takes account of the context-specific nature of domestic knowledge dynamics prompted by biotechnology. This includes the environmental and social economic context, political and cultural

context within which decision processes are pursued to promote legitimacy and transparency among others (Glover, 2010). These factors shape knowledge production dynamics.

Setting the scene: Conceptual and analytical context

Building on some of the studies on biotechnology governance in Kenya, this section draws attention to the importance of the technological, regulatory and social local contexts in which knowledge actors (including the organisations involved) and regulatory process are embedded. It seeks to provide the analytical context for the paper as well as to situate the multiple actors engaged in biotechnology research and development (R & D) for the last two decades within the process of regulation implementation. By doing this, the paper exposes the motivations and opportunities of actors as they engage with the biosafety regulatory process and the formulation of regulatory instruments.

The paper seeks to analyse how biotechnology regulation (which includes instituting a biosafety regulatory system for management of biotechnology) may have affected efforts to bring about a knowledge convergence in biotechnology regulation. Kenya was selected because of the rich political context that prevailed during the establishment of a regulatory system for management of biotechnology research & development (R & D).

Research context and methodology

Kenya presents an excellent case to investigate knowledge management associated with modern biotechnology in terms of regulatory policy environment and context. This is because the initiation of biotechnology R & D activities in the 1990's paralleled the establishment of the requisite regulatory process providing an exemplary context to investigate the dynamics around knowledge production with both technological and regulatory orientations. This parallel process engaged communities in research, policy and public arenas in an iterative manner bringing about interesting biotechnology and institutional innovations. Secondly, policy initiatives like the strategy for revitalising agriculture (RoK, 2005) and the Vision 2030 embrace an integrated approach to innovation towards economic development.

This context created a conducive environment to undertake qualitative in- depth semi-structured interviews with over 50 individual knowledge actors who had (or claimed to have) a stake in decisions on biotechnology as researchers, policy makers, employees of nongovernmental organisations (NGOs) and members of the public (mainly consumers and farmers). The research period was between 2006 and 2011. Interviews were complemented by observations carried out during different scientific and public workshops in biosafety and biotechnology held during this period, and by analysis of relevant secondary documents. Interviewees' points of engagement in the regulatory activities and decision processes are seen in the context of effort to provide knowledge (e.g. information, expertise and other resources) to influence policy outcomes. The data analysis captured the different ways knowledge is used in the regulatory processes and what factors come into play. Unless otherwise stated, codes are used to report all information cited in this paper in order to guarantee anonymity of some of the interviewees as requested. For instance, NGOco-NS4 refers to a non scientist interviewee from a civil society organisation.

An overview of Kenya's biotechnology development and regulation

Milestones in Kenya's biotechnology sector

Modern biotechnology has revolutionised many sectors including agriculture and embraces a wide range of applications including tissue culture, markers assisted selection and genetic engineering (GE) referred to in this paper as modern biotechnology. All are being applied in Kenya, but the latter is the focus of this paper. Just like many African countries, GE is relatively new, but GE products have been handled indirectly through trade in the form of food aid (Kagundu, 2008).

Agricultural R&D has long been recognised as central to knowledge creation, technology development and innovation. During the pre-independence period, the R & D agenda was set by the British colonial government, which recognised the importance of science and technology (S & T) in agricultural production (Ochieng, 2007). It was not until the early 1990's that biotechnology innovations in the form of tissue culture received considerable attention (Wambugu, 2001). Work involving advanced GE commenced in 1991 when Kenyan scientists went to USA and in collaboration with scientists there, engineered a virus resistant sweet potato (Odame et al., 2003). Thereafter in 1998, the transformed plants required regulatory approval for this research to continue in Kenya. However, the process of regulatory process and implementation had commenced prior to 1998.

To date, at least six GE R & D initiatives have been evaluated in public institutions in conjunction with local and international partners (see Kingiri, 2011a for details). These activities include Bt maize and Bt cotton engineered for resistance to insect pests, cassava for resistance to viruses and sorghum for resistance to striga weed. The recombinant rinderpest vaccine initiative targeted control of rinderpest disease in cattle and other viruses in small ruminants. Other initiatives are in the pipeline, for example sorghum fortified with nutrients funded by the Bill and Melinda Gates Foundation through the Africa Harvest Biotechnology Foundation International (see www.africaharvest.org). Since the approval of the first transgenic crop - the sweet potato in 1998, no product has reached farmers and the furthest the biotechnology activities have gone towards a product is to confined field trials (CFTs)[3]. It is hoped that with the establishment of a functional biosafety framework, the situation will change. In addition, food insecurity related issues have prompted the government to take drastic policy measures approving importation of GM maize to avert a food crisis in the country (Daily Nation, 2011).

[3] This is a field trial of GM plants not approved for general release in which measures for reproductive isolation and material confinement are enforced in order to confine the experimental plant material and genes to the trial site (Halsey, 2006:4).

Biosafety regulatory mechanism

Biosafety encompasses the regulatory mechanisms that the government has put in place for the governance of GE activities. Article (8g) of the Convention on Biological Biodiversity (CBD, 2000) and Article (16) of the Cartagena Protocol provide for establishment of appropriate mechanisms to regulate, manage and control risks associated with Living Modified Organisms (LMOs). The protocol emphasises risk assessment (RA) and risk management, and provides guidelines (Annex III). There are several ways in which risk identified during RA can be managed, e.g. confinement, restricted use, provision of guidance, technical advice and record keeping (Halsey, 2006).

At the early stages of biotechnology research activities, Kenya opted to use the existing infrastructure, the Science & Technology Act (RoK, 1980) to institute regulatory mechanisms through the drafting and adoption of the Regulations and Guidelines for Biosafety in Biotechnology in Kenya (RoK, 1998). There were concerns that these regulations came long before the biotechnology policy and are not legally binding as required by the law. In an effort to legalise the regulations as well as the biotechnology activities, the National Biotechnology Development Policy was drafted and later approved in 2006 (RoK, 2006). This was followed by the Biosafety Act, 2009 (RoK, 2009). Kenya signed and ratified the Cartagena Protocol in May 2000 and January 2002 respectively. This further obligated the government to set up regulatory structures to operationalise it. This Biosafety Act therefore primarily seeks to operationalise the Protocol. The controversial developments surrounding its formulation are at the centre of this paper. Kingiri (2011a) captures some of the main developments, revealing the dynamics that include the different actors and the nature of their engagement between 2002 and 2009. Within this period, various versions of the biosafety bill were drafted and discussed before the final version (RoK, 2009) was approved as an Act in Feb. 2009. Meanwhile, regulations to be appended to the Act were drafted under the Program for Biosafety Systems (PBS) support and recently became operational from July 2011 after signing by the Minister for Higher Education, Science and Technology.

Previously, all government actors and other nongovernmental players involved in biotechnology governance were brought together under the National Biosafety Committee (NBC) coordinated by the National Council for Science and Technology (NCST). NBC acted as a boundary organisation overseeing the management of biotechnology research through regulation. This role has since been taken over by the National Biosafety Authority (NBA) formed under the provision of the Biosafety Act.

Theoretical framework

To analytically situate the discussion in theoretical debates, this paper draws upon insights from the integrated knowledge management literature. Scholars try to explain the changing role of science in policy deliberations and the changing integrated knowledge production architecture prompted by new technological developments (Gibbons et al., 1994; World Bank, 2006). In the case of biotechnologies, this brings about governance challenges linked to biosafety regulation imposed to promote technological competitiveness and encourage public acceptance of these new technologies (Lyall, 2007).

Dynamics associated with biotechnology regulation: An empirical exploration of Kenya's case

In this section, practical reasons why and how stakeholders got entangled in Kenya's regulatory process is explored together with the kind of reactions this generated. This helps understanding of the challenges that hamper productive regulation towards knowledge convergence, which we have argued is essential for agro-biotechnology innovation.

Challenges confronting the evolving agricultural R & D and modern biotechnology governance terrain

Contract research

It is widely argued that biotechnology is a key tool for 21st century sustainable development. However, most people agree that this may remain a dream unless certain challenges are addressed that include political support through provision of incentives for research and regulation (cf Bananuka, 2007). In Kenya, government support for S & T including biotechnology R & D has been minimal (Beintema et al., 2003; Odame et al., 2003). Dwindling research funds and other policy reforms have encouraged collaborative research, technology development and deployment (RoK, 2005; KARI, 2005; RoK, 2007). Although the government continues to fund public agricultural research, significant support comes from donor organisations (Beintema, et al., 2003:5). Kenya Agricultural Research Institute (KARI) being the major research institute involved in modern biotechnology research (and the only one undertaking biotechnology CFTs) has undergone significant restructuring in response to these reforms and challenges. These changes have contributed to a rise in contract research characterised by increased donor funding (Beintema, et al., 2003:5). For instance all the agricultural GM trials are being undertaken through Public Private Partnership (PPPs) arrangements (Ayele et al., 2006).

A lot has also been documented regarding the tissue culture bananas contract research (cf Smith, 2004). However in the case of modern biotechnology, the nature of contractual research is still under-researched and is undergoing changes at an unprecedented rate due to the evolving institutional and regulatory contextual issues. What seems to be lacking is information on how actors in the value chain have been responding to the institutional changes associated with regulation of biotechnology science. This is crucial for related knowledge convergence efforts. I argue that collaborative research might impact knowledge convergence efforts if unchecked values and interests infiltrate the process. Contract research has been shown to influence scientists' behavior with regards to scientific reporting in favour of interests of funders (Waterton, 2005).

Biotechnology and biosafety capacity

According to Bananuka (2007), the need for regulatory capacity evolves alongside an operational biotechnology sector, and this has been the case in Kenya. Since the biotechnology programme was initiated in early 1990's, capacity in both modern biotechnology techniques and biosafety (human, infrastructural and institutional) has been built over the years. For instance, a modern biosafety Level II greenhouse has been put up at the KARI biotechnology centre. According to a report prepared for policy

makers (Handbook for Policy Makers, 2007), the number of scientists trained in biotechnology countrywide has gone up, with 45% of those trained being actively engaged in GE work. In addition, capacity in regulatory institutions like the Kenya Plant Health Inspectorate Service (KEPHIS), Kenya Bureau of Standards (KEBS), Department of Veterinary Services (DVS) and Department of Public Health (DPH) has been strengthened and, the report claims, are ready to oversee the implementation of biosafety regulations.

Arguably, these rhetorical claims were advanced by GMOs proponents in their endeavour to lobby for the enactment of the bill (Kingiri, 2011a, b). Despite these milestones, both infrastructural and human capacity remains far from adequate. This is attributed to several factors among them inadequate government support for research and the lack of regulatory policy environment to spur development (Wafula et al., 2007), that would further encourage and favour capacity building efforts. The increased cross-over of trained scientists from public institutes to international organisations locally and abroad has also contributed to unsustainable capacity building efforts, a trend which is prevalent in the whole of Africa. (Hastings, 2009).

Stakeholders' proactive role in regulatory process

From the foregoing analysis, it is emerging that various challenges have hampered the evolution of the twin processes - biotechnology innovation and regulatory regimes. These partly relate to technical and institutional capacities, but another important question relates to how the actors (individuals, organisations and related links) deal with the challenges. How challenges are dealt with is important in informing the dynamics around knowledge use and regulatory decision making processes.

This section tracks empirically Kenya's regulatory trajectory paying attention to the involvement of knowledge actors, exposing the tensions generated. It is important to note that many interviewees desired a regulatory environment that would enhance deployment of products of GE science. The Biosafety Bill was a gateway towards achieving that goal. Media reports analysed during field work confirm some activism by the scientific and non scientific communities in support or against the biosafety bill. The biosafety formulation process was a step in legalising the regulatory regime intensively engaged the scientific community. . Scientists collectively educated policy makers and journalists, sensitizing them on GE thus making 'a case for biotechnology' as well as advocating support (RSIn-GP2, Dec. 2007). However, this was viewed with suspicion by some interviewees, who were concerned with what they viewed as the pro-biotechnology promotional agenda and associated politics. Several documents obtained during field work and numerous media reportage by both proponents and opponents confirmed this pro-activeness (see Kingiri, 2011a for a detailed empirical account of dynamics involved).

Motivations, opportunities, interests and implications associated with biotechnology

When biotechnology research was initiated in the early 1990's it provided an incentive for researchers with many seizing the opportunity to pursue their knowledge and technology transfer endeavours. This triggered public reaction with this pro-biotech behaviour being interpreted by non-scientific communities from civil societies as unwarranted excitement and hype. To moderate the different interests and concerns,

amongst stakeholders, the government imposed biosafety regulations (RoK, 1998) to guide subsequent knowledge generation endeavours and decision making processes. Regulations were interpreted in different ways by different stakeholders (see Kingiri, 2011b). Perhaps because of conflicts between different motivations and opportunities presented by GE research, and the different challenges associated with biosafety regulations and implementation, the stakeholders exposed varying behavioural practices. This generated differing reactions as reported in the subsequent sections.

Scientists' credibility and transparency questioned

The conduct of GE trials was perceived to require a substantial level of credibility on the part of scientists due to public sensitivity about GE technology. Research scientists were perceived by some interviewees to be untrustworthy and dishonest. Credibility is one aspect that regulations promote, prompting regulators to emphasise appropriate monitoring of research trials and scientists: 'scientists...will do things that you cannot believe is possible.' (RSPu-PS7, Nov. 2008). However, credibility was found to be constrained by institutional obligations and compromises in policy and practice that scientists were forced to make. The interim regulations prior to the Biosafety Act were unclear about how credibility as an ethical practice is linked to compliance and monitoring. However, the Biosafety Act provides for intensive monitoring through designated biosafety experts (Articles 43 & 45).

Attitude towards regulations and regulators

Many interviewees in the policy arena including regulators described scientists as having a negative attitude towards regulations. The reasons behind this negative attitude were attributed to conflicting motivations like scientists interests in doing research, making scientists view regulation as 'hindrance to science' (LABp-NS8, Jan. 2008). Others explained that scientists find it difficult to adjust from their normative basic research behaviour to a supposedly demanding research practice like the one demanded by GE research. The attitude of researchers towards regulators, and vice versa, promoted suspicion and misunderstanding, constraining effective regulatory practice.

Poor public communication and biased reporting

This section reports on practices of scientists concerning dissemination of research information from biotechnology research trials. The regulatory instruments prior to the Biosafety Act and the Act itself are implicit about how this reporting process should be managed. They emphasise transparency to promote public trust. RoK (1998) in particular recommends "openness" to "safeguard public interest" through transparent handling of information and adhering to regulations (executive summary). In RoK (2009), NBA is wholly responsible for information handling and management including consequent public awareness. A register was to be maintained as a repository for biosafety information. However, it is however unclear how interested parties should access it. Accounts of interviewees suggested that scientists have poor public communication skills on biotechnology matters. In addition, when they communicate (as demanded by the sensitive nature of this technology), there are weaknesses that are revealed through the reports and the communication strategies they adopt. However, many interviewees were in agreement that scientists have a very important role to play in communicating scientific and technical facts to the public about their GE work. Some

perceived this as the only way to demystify the prevailing negative publicity around GE technology. But weaknesses were perceived which are explored next.

Communicating science versus public understanding of science

Some interviewees claimed that research scientists use "scientific jargon" that needed to be "toned down" for lay people to understand. The use of technical and scientific language was perceived to be an indicator of poor communication skills that purportedly differentiates pro-GE scientists from anti-GE activists. This suggests that scientists have not come to the level of the non scientists or the public when communicating technical aspects of GE research. However, the analysis does not explore the reasons behind this seemingly uncomfortable behaviour and also any repercussions.

Public communication constrained by fear of misinterpretation

Scientists argued that they deliberately avoid communicating scientific findings to the public because of fear of misinterpretation, propaganda and potential negative impact this may have, for instance on their careers and research reputation. Fear of propaganda was associated with activists, who some claimed unjustifiably fight biotechnology impacting on scientists' reporting behaviour:

> "So [research scientists] have avoided bringing negative stories and even when they see them they remove them and instead keep quiet. Experience has shown that, any negative you bring will be used against you. So we have to continue in the way I think we are at least less risky." (TAR-NSS1, researcher & technology advocacy, international NGO, Feb. 2008)

The fear of reporting non-factual and unverified or unconfirmed findings constrain effective and timely reporting, leaving room for misinterpretation by counter groups. Arguably, scientists are held back from freely sharing their findings with the public for fear of repercussions associated with misinterpretation. This has implications for practice on the part of the scientists in respect of information and knowledge management, and how this is interpreted by others.

Communicating the positives and transparency

The majority of scientists admitted that when scientists communicate about GE science, they focus on the positive and promotional information that highlights benefits more than risks. Misinterpretation was affecting the way scientists communicate, compelling them to talk more of tangible benefits and less on unverified or "unknown" risks. Several non scientist interviewees corroborated the "biased reporting" linked to provision of information inclined more to successes:

> "In Kenya, all we are hearing are the positive aspects. We know that no technology in this world is without risks. So why is the potential risk side [of GE technology] silent? That in itself sends alarm bells to us [civil society]." (NGOf-NS1, farmers' rights advocacy, civil society, Nov. 2007)

Defending this practice, some researchers argued that the nature of biological science training encourages them to pursue only facts, compelling them to withhold information that cannot be validated. This was discussed in connection with confidence and easiness in reporting facts as opposed to unverifiable information like cases of

uncertainty. They further argued that reporting on GE risks may cause panic among the public if negative non- validated aspects related to scientific "process" are highlighted. However other interviewees claimed that, scientist's withholding of some information was linked to "a normative rigid research practice" that compels them to vet what they report (ATp-PS3, Nov. 2007). This analysis seems to portray scientists as self centred, and tends to put to doubt their previous claims of fear of misinterpretation. Questionably, there is a disconnect between constrained communication and the unbalanced information consequently disseminated.

Unreliable & biased information and multiple obligations

Exogenous pressures were perceived by a number of scientists and most civil society interviewees as limiting the reporting freedom of researchers, prompting them to produce what was referred to as "biased" and "unreliable" information, presumably manipulated to suit certain interests. Many felt that reports emanating from research trials were unreliable because the partnership environment under which the trials are undertaken prompted reporting that favoured multiple obligations commensurate with different interests. This created tension amongst the civil societies: "it is difficult to say per se that in the current [donor] context the information from those researchers would be fully reliable" (NGOco-NS4, consumers' network, Jan. 2008).

These data suggest that both technical (e.g. scientific endeavours) and non technical factors (e.g. values, interest and obligations) influence the behavioural practices exhibited by scientists in knowledge production endeavours linked to biotechnology regulation. Some factors are associated with opportunities presented by GE science, while others are linked to challenges that confront actors including scientists as they engage in biotechnology research and regulatory process.

Technical experts and conflicts of interest

National efforts to establish a legally binding regulatory regime in compliance with the Cartagena Protocol engaged stakeholders in various ways. One of the roles of the National Biosafety Committee (NBC) according to RoK (1998) was to draw up policies and procedures to govern biotechnology. This gave NBC the legal powers to spearhead the policy-making process. However, NBC's coordination role in the biosafety bill formulation process was perceived to be blurred by the activism of other actors, a view shared by both scientists and non scientists. Arguably, the scientists and their allies became the main drivers of the bill formulation process:

> "The main players were the biotechnology industry, and the scientists make much of the industry. The whole process was supposed to be an initiative of the government but the interest was with people from the biotechnology industry rather than what we would call the broader section of Kenyan society." (JO- NS6, journalist, local daily, Apr. 2008)

NBC was also largely made up of scientists representing different organisations with just two representatives from civil society. It can be concluded that scientists and their affiliated institutions played vital roles as technical experts (see Kingiri, 2010). However, this role is threatened by perceived motivations and interests likely to bring about conflicts of interest. It was a concern of non-scientists from the civil society that technical information used in risk assessments (RA) and consequent decision making pertaining to GE trials was solicited by scientists from technology developers who are interested parties.

The relationships established around the regulatory process in the Kenyan context were mutual in that participating players expected benefits from improved regulation. Scientists and government were for instance receiving financial support from non state actors and donors. Such support and partnerships were perceived by many interviewees to have positively enhanced the regulatory process. Some interviewees agreed that the government has inadequate capacity to support the regulatory process, so other supporting parties were filling in that gap. From these accounts, resources and in particular financial support was a key incentive cementing these relationships.

The never ending controversy

The Biosafety Act (2009) approved in Feb 2009 may be seen as a victory for agro biotechnology development towards benefiting the poor. The formation of an administrative entity, the NBA to legally manage biosafety controversies under the provision of this Act may also be seen as a plus towards development endeavours. However, the broader food security issues as well as socio economic and political environment overshadowed smooth biotechnology development and regulation. On 14th February 2011, the Kenyan cabinet made a political pronouncement that approved immediate importation of GM maize to avert a looming food crisis. This development received considerable media reportage which subsequently generated wide public protests led by civil society (see Opiyo, 2011; Omondi, 2011; Kinuthia, 2011). The proponents of gm imports, that included scientists, did not see anything wrong with the importation citing scientific evidence that had shown GM products to be safe for human consumption. The opponents expressed scepticism citing unconfirmed risks to human health posed by these products. This controversy suggests that the debate surrounding biotechnology continues to remain polarised making it harder for the public to endorse biotechnology products. This is a major drawback to science advancement as well as a threat to its longstanding authority in providing solutions to societal problems.

Discussion

Empirical exploration of Kenya's regulatory process exposes controversial engagement in knowledge production dynamics. This is in part linked to weak governance structures in both biotechnology delivery and in related regulatory mechanisms, with implications for productive knowledge convergence efforts. Firstly, the Kenya case presents major participation and transparency challenges about which stakeholders should be involved in the regulatory process and how they should be engaged,. The regulatory process, although enlisting participation of both technical and non technical experts, sidelined public expertise and views (see also Kingiri, 2010). This implies that expertise and experiences of socio, economic and cultural contexts of Kenya's broader agricultural terrain could have been ignored in decision making processes. For instance, the public private partnerships that are currently evident in Kenyan biotechnology initiatives are largely triggered by technical and financial constraints (Intellectual Property Rights-IPRs, infrastructure, funding, individual scientists interests etc) as opposed to the needs and production constraints that can benefit farmers. Secondly, the resources that purportedly steered the regulatory dynamics (including knowledge and information shared and disseminated amongst players, regulatory instruments, legal and administrative structures, media as avenue for information dissemination and experts) were not devoid of conflicts of interests and influence. This has implications for

productive knowledge convergence efforts as it generates suspicion, luck of trust and perhaps potential rejection of science.

In a complex science policy terrain like biotechnology regulation, multiple contexts may work for or against the intended innovation and public policy. Thus, the following question posed by Haas, (1992:1) is very valid. Can policy makers or scientists themselves "identify national interests and behave independently of pressures of social groups they nominally represent?" He argues that, actors can indeed learn new patterns of reasoning informed by wider stakeholder needs and interests. The general argument advanced here is that technical experts that include scientists can genuinely play their part to influence positive change in policy-making through appropriate use of knowledge and information (Haas, 1992:3). The scientific community has a major role to play because they understand the complexities and uncertainties associated with biotechnology better than non-scientists and policy makers (Bradshaw and Borchers, 2000). In addition, inclusion of a wide range of expertise that encompasses non-technical professionals is a positive way to democratise the regulatory process towards a socially robust knowledge production infrastructure (Nowotny, 2003; Nowotny et al., 2001, 2003).

The behavioural practices exhibited by Kenyan scientific experts in generation and handling of biosafety related information could be a concern for a productive knowledge convergence that is intended to promote biotechnology development and adoption. This paper further suggests a change of attitude of actors towards a socially responsible process to promote credibility and transparency and consequently enhance trust associated with biotechnology. The scientific community, policy makers and those groups that claim to represent farmers and public must be honest with no hidden agenda (Ammann and Ammann, 2004). In addition, reflexivity should be encouraged. As a value based practice, reflexivity is the process by which individuals involved in knowledge production try to operate from the standpoint of all experts involved (Gibbons et al., 1994). The purpose of enhancement of knowledge convergence in biotechnology development requires that expertise from different stakeholders be considered in biosafety regulation and other decision making processes.

Lessons towards knowledge convergence

This section looks at insights from almost two decades of Kenya's biotechnology and regulatory regime co-evolution on which this paper can draw. Three distinct concepts are key to put the lessons discussed here into context:

i. Dynamism: Biotechnology innovation is advancing at an unprecedented pace, perhaps faster than the capacities of actors and institutions to adjust to accommodate the requisite changes needed to foster innovation and responsive engagement of stakeholders, including regulation (Tait et al., 2006:379). This calls for new styles of governance for participative decision making processes that consider all stakeholders' interests and values (Lyall and Tait, 2005).

ii. Multifaceted: Both biotechnology innovation and the embedded regulatory process involve many actors and each process is multifaceted. Consequently, the accompanying practices that actors chose to adopt or pursue are problematic. According to Murphy and Chataway (2005), this may be attributed to

influence of different policy cultures at the global level (e.g. EU versus US) and regional level (e.g. African Union). In the case of Sub Saharan Africa, this is also connected to influence of policy cultures at national levels (Mugwagwa, 2008).

iii. Complexities related to shifting regulatory practice: The entire biotechnology and regulation revolution involves complex trade related and institutional dynamics (Fukuda-Parr, 2006) which inevitably impacts on behaviour of actors like scientists. In Kenya, the behavioural shifts are sometimes encouraged by the inadequate and specialised biotechnology-biosafety knowledge capacities needed to move the regulatory process forward. This may be construed as a good thing because within a dynamic and functional system like biotechnology, it may promote cumulative knowledge and learning. However, how learning and knowledge are managed is important for practice.

Considering these dynamics, a number of lessons can be drawn in relation to knowledge use and policy making as explored next.

Harnessing the positive aspects and dealing with the negative aspects

We cannot ignore the important learning that has taken place in Kenya's evolving biotechnology regulatory system for almost two decades both at the institutional and individual levels, much of which constitute tacit knowledge. The government has to look for ways of using this accumulated knowledge. One way it can do this is to compile a list of experts who have been involved, and perhaps include and consider them as official experts. They would then be called upon from time to time in biotechnology and biosafety awareness campaigns and capacity building efforts targeting the wider stakeholder communities. In addition to sensitising people about specific technical subjects, they would also be requested to talk about their experiences in biosafety regulatory process, providing a platform for meaningful deliberations that can bring about knowledge convergence promoting pro-poor and pro-biotechnology innovation agenda.

It is possible that the regulatory dynamics discussed in Section 5 above may have a negative impact on future biotechnology deployment and adoption. For instance, the scientific community's active participation in the regulatory process may have resulted in more technical and scientific knowledge informing policy deliberations. This may have drowned out other relevant knowledge which may enhance convergence efforts. These possible negative aspects cannot be ignored and have to be factored into future decision- making processes. How can this be done?

i. The government has a major role to play by adopting a governance approach to public policy processes through weighing and analysing the types of knowledge that inform the process. The objective would be to ensure that socially desirable knowledge informs the final policy outcome (Nowotny et al., 2001).

ii. The government needs to build and sustain technical capacities of a wide pool of experts from which to draw expertise. It should also spread its wings to other academic and non academic institutions to solicit expertise not only for regulatory instruments, but also for overall risk assessment and environmental safety reviews.

Reconceptualising the policy formulation process

The significant shift in behavioural practices associated with knowledge actors that accompany the biotechnology and biosafety revolution are demonstrated empirically in the Kenyan case and lead to a compelling urge to reconsider how policy and regulatory formulation processes are conceptualised and articulated. If the regulatory process is to achieve greater effect in reconciling the governance agenda of modern biotechnology on the one hand, and role of actors in providing evidence-based expertise into the process; it must factor into the process this shift in behavioural practice. Consequently, strategies should be devised that encourage a reflexive and responsive behaviour (Lyall, et al., 2009: 261). This may enrich how policies are implemented considering that cultural practices in biotechnology are linked to values and interests (Laurie et al., 2009).

Conclusion

This paper aimed at exploring the different strands of knowledge that accompany biotechnology regulation. Using Kenya's case in regulatory process, it finds that the different ways communities of practice involved in the process respond to regulatory demands dictates how knowledge is generated and used. This consequently influences biotechnology innovation trajectory, sometimes negatively, which may impact the exploitation of biotechnology products for beneficial use by the poor. The paper appeals to these communities who are in the policy, public and scientific arenas to adopt a reflexive approach to biotechnology regulation in order to enhance convergence of knowledge for sustainable development.

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