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The commercialisation of genetically modified (GM) crops is being accompanied by a debate with scientific, social, ethical, legal and metaphysical dimensions. In the face of this complex debate, governments need to regulate GM crops in a way that minimises negative impacts on biological and social environments. This paper is a critical examination of Australia's regulatory framework for the deliberate environmental release of GM crops, specifically in terms of its ability to advance ecologically and socially sustainable agriculture. Following a description of the novel nature of GM crops, I discuss how the approach selected, the definition of key terms and the parties being granted influence exclude social and ethical concerns from regulatory deliberation and threaten the development of socially sustainable agriculture. Threats to ecologically sustainable agriculture from the framing of GM crop regulation are discussed in relation to how the selected approach deals with ecological uncertainties and the baseline being used for acceptable risk comparisons.

Keywords

risking, we, sustainability, crops, australia, modified, genetically, regulation

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Australia's Regulation Of Genetically Modified Crops: Are We Risking Sustainability?

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Abstract

The commercialisation of genetically modified (GM) crops is being accompanied by a debate with scientific, social, ethical, legal and metaphysical dimensions. In the face of this complex debate, governments need to regulate GM crops in a way that minimises negative impacts on biological and social environments. This paper is a critical examination of Australia's regulatory framework for the deliberate environmental release of GM crops, specifically in terms of its ability to advance ecologically and socially sustainable agriculture. Following a description of the novel nature of GM crops, I discuss how the approach selected, the definition of key terms and the parties being granted influence exclude social and ethical concerns from regulatory deliberation and threaten the development of socially sustainable agriculture. Threats to ecologically sustainable agriculture from the framing of GM crop regulation are discussed in relation to how the selected approach deals with ecological uncertainties and the baseline being used for acceptable risk comparisons.

Key Words: Sustainable agriculture, genetically modified crops, risk assessment.

Introduction

The commercialisation of genetically modified (GM) crops is a socially contested technological development that is being accompanied by a debate which has scientific, social, ethical, legal and metaphysical dimensions. This paper uses the criteria of social and ecological sustainability to critically examine the way Australia is currently regulating the deliberate environmental release of these controversial organisms. These criteria come from a 'triple bottom line' approach to the notion of sustainability. In the triple bottom line approach, there are seen to be three primary components to the sustainability concept: that is, economic sustainability, ecological sustainability and social sustainability. There has been much debate in Australia over the issue of the economic sustainability of agricultural systems employing GM crops, particularly the economic sustainability of growing GM canola in Australia, and while this is an area that is certainly worthy of further research, the consideration of Australia's GM crop regulation from a position of economic sustainability is not within the scope of this paper. In this paper I critically examine Australia's regulation of GM crops using the other two components of a triple bottom line approach to sustainability, the social and ecological criteria.

In referring to socially sustainable agriculture, this paper is concerned with the ability of our current regulatory approach to address concerns within our society relating to GM crops and to advance a form of agriculture which is capable of maintaining social trust and support. While socially sustainable agriculture may be defined more broadly than this to include aspects such as maintaining the structure and vitality of rural communities, in this paper I limit my definition of social sustainability to the consideration of social concerns and the maintenance of social trust and support.

Ecologically sustainable agriculture is being defined in this paper as agriculture which does not threaten the long term health and functioning of ecological systems and processes and which does not create irreversible negative impacts on the environment. In using these criteria of socially and ecologically sustainable agriculture to examine Australia's regulation of GM crops, this paper discusses the regulatory approach which has been selected, the definition of key terms, the parties being granted influence, the handling of ecological uncertainties and the baseline being used for acceptable risk comparisons. Firstly though, it is important to establish why GM crops can be understood as novel organisms.

The Novel Nature Of GM Crops

Proponents of biotechnology often argue that the genetic modification of crop plants is not a new phenomenon because traditional plant breeding programs have been altering the genes of crop plants for thousands of years (Tester 2001). It has also been emphasised that biotechnology, which may be broadly understood as the use of living organisms for the creation of goods and services, has been in operation for centuries through such well accepted processes as the brewing of beer and the making of cheese (Agrifood Awareness Australia 2002). However, the modern biotechnological technique of recombinant DNA technology, a technique more commonly called genetic engineering but perhaps more accurately referred to as genetic modification, can be distinguished as a significantly different development. In proposing that this technique and the organisms created through it are significantly novel, I refer to the types of genetic combinations now possible and the way in which these combinations are achieved.

One of the broad classification systems of living organisms used by biologists is that of the 5 kingdoms: plants, animals, fungi, monera (a kingdom that contains all prokaryotes, which are

distinguished as unicellular organisms with internal parts not bound by membranes, such as bacteria) and protista (simple eukaryotes, or simple organisms with a membrane bound nucleus such as algae and protozoa) (Campbell 2002, p. 522). Many of the GM plants currently being commercialised represent 'transkingdom' genetic crosses because their creation has involved the transfer of genetic material from bacteria and viruses into the genetic makeup of crop plants, or in other words, into crop plant genomes. Conventional plant breeding programs have only been capable of combining genetic information from closely related species. This new ability to combine genetic information from across biological kingdoms means that the range, and nature, of genetic combinations made possible by this recombinant DNA technology are significantly different from those combinations achievable through conventional breeding. GM crops can therefore be seen as novel organisms in the sense that humanity has not previously been capable of creating transkingdom genetic combinations and transkingdom GM crops have not previously existed in the environment on a scale equivalent to that of commercial production.

While this new ability to combine genetic information from across biological kingdoms makes the crop varieties produced through recombinant DNA technology significantly different from those produced through conventional breeding, it is important to note that certain bacteria are also capable of achieving some degree of transkingdom genetic combination. For example, crown gall disease in plants is the result of a particular bacterium, *Agrobacterium tumefaciens*, inserting its own bacterial DNA into a plant's genome. Indeed many biotechnologists use this particular bacterium to deliver their DNA of choice into the genetic makeup of crop plants. It may be argued that this ability of some bacteria to cross their own genetic information with that of organisms from another biological kingdom represents a challenge to the claimed novelty of the transkingdom nature of GM crops. What I was suggesting in the above paragraph, however, was that the ability to cross biological kingdoms is a new capability for *humanity* and therefore, that GM crops could be distinguished as significantly different from those crops developed through conventional breeding.

In addition to representing a new human capability, however, transkingdom genetic combinations as achieved by humanity also differ from those achieved by bacteria in the sense that the DNA from more than one species is often being transferred. When a biotechnologist creates a transkingdom genetic combination, this often involves what is called a gene cassette, or a collection of bits and pieces of DNA taken from various organisms, such as a combination of viral and bacterial DNA. This use of a mixed cassette of genetic information when creating transkingdom genetic combinations can be seen to distinguish the human process from that undertaken by bacteria. It is also pertinent to highlight that in nature, the frequency of transkingdom crosses and the pathways available for the creation of these types of combinations have been described as being very limited (Nielsen et al. 1998; Droge, Pühler & Selbitschka 1998).

Transkingdom GM crops can be seen to represent novel organisms then in the sense that human beings have not previously been capable of directing transkingdom genetic crosses to suit our own desires. Additionally, the range of combinations made possible through the development of recombinant DNA technology also represents a novel development in transkingdom genetic crosses, as DNA from viruses, bacteria, plants etc can now all be packaged together as a mixed cassette of DNA and transferred into an organism's genetic makeup. This ability to combine genetic information from across various biological kingdoms makes recombinant DNA technology and the types of organisms achievable through it, significantly novel. The process for achieving this transfer of DNA across biological kingdoms

also represents another important aspect of the novelty of GM crops and one to which we now turn our attention.

Using either physical (e.g. gene gun or electroporation) or biological (e.g. agrobacterium) means, the process of genetic engineering involves a transfer of foreign DNA into an organism's genetic makeup, but the exact location at which the transferred DNA is incorporated into the genome is not controlled. This random insertion process represents another important element of the novelty associated with GM crops. The random insertion process used in recombinant DNA technologies has raised a number of concerns about the potential for pleiotropic and epistatic effects. In a general sense, these concerns can be understood as relating to how the random insertion of foreign DNA will impact on the organism's overall genetic structure and function.

A pleiotropic effect would be one in which the transferred DNA does not just produce the trait desired, but interacts with the rest of the genetic code to produce additional unintended effects. An epistatic effect would be where the random insertion process results in the other elements of the crop plant genome affecting the expression of the transferred DNA, such as when that transferred DNA is silenced. While many of the negative impacts of a random insertion process may be found before commercialisation during the screening and testing phase, it should be highlighted that the screening and testing of GM crops currently focuses on important agronomic and nutritional traits, and therefore may not detect all the changes that may have occurred in the plant's secondary metabolism. A plant's secondary metabolism refers to the processes occurring within the plant which are not associated directly with plant growth, or in this case, which do not relate directly to important agronomic traits.

The novel nature of GM crops, which is a result of both the type of genetic combination and the process used to achieve it, means that there is no real precedent for understanding how the new transkingdom genetic combinations will affect the organism involved and its future evolution, or the way that organism and its new genetic makeup will interact with other biological systems, particularly when released into the environment on a large scale. There has been no long and established history of the safe use of transkingdom GM crops and what little empirical research is available on their ecological interactions has been hotly contested, with the interpretation of results being heavily debated within the scientific community. The novel nature of transkingdom GM crops and the lack of experience and data on their potential ecological interactions, means that the impact these crops will have on the environment is an area with a high degree of scientific uncertainty (Wolfenbarger & Phifer 2000), and arguably even ignorance (Functowitz and Ravetz 1992).

The novel nature of GM crops has also raised a host of new social and ethical questions. Many of the social and ethical questions being raised by the commercialisation of GM crops relate to much broader questions about how we conceptualise the natural world and the human relationship to it. One aspect of this is how the commercialisation of this new technology presents a challenge to a traditional concept of nature. In a traditional concept of nature, genetic information is seen as being predominantly transferable in a vertical sense from generation to generation, rather than in a horizontal sense between species or kingdoms. Indeed, in a traditional concept of nature what designates a group of organisms as a 'species' is primarily their ability to interbreed and exchange genetic information. The development of recombinant DNA technology is forcing society to reconceptualise the notion of species boundaries and accept that nature is now infinitely malleable (Midgely 2000). This challenge to a traditional concept of nature has seen a debate develop around whether these crops can be considered 'natural' and whether they represent the conduct of an ethical

relationship between humanity and the rest of the biotic community. An example of this type of debate can be observed when the 'Playing God' argument is invoked by opponents to gene technologies because it is essentially an argument about what can be considered 'natural' and what constitutes an ethical relationship between humanity and the rest of the natural world.

In many cases, the ethical questions being raised in relation to GM crops are connected to the current social context surrounding and influencing the technology's development and deployment. By this, I mean that many of the ethical concerns being raised in the GM debate are concerned with what is right and wrong in relation to socio-political and economic arrangements. Debates over what are ideal socio-political and economic structures are certainly perennial debates extending well beyond biotechnology. However, many opponents to biotechnology see it as a technological development which embodies a particular socio-political program (Wynne 1991). The technology's development and commercialisation therefore raises interconnected social and ethical concerns relating to the appropriateness of the socio-political and economic arrangements being embodied by the technology. The involvement of large multinational corporations (particularly chemical corporations) in the creation of agricultural biotechnologies and the use of intellectual property in the form of patents, are just two areas where the commercialisation of GM crops is raising new and interconnected social and ethical questions.

Various analysts of the debate over the deliberate environmental release of genetically modified organisms have suggested that this is not simply a debate between the ignorant and the scientifically informed. Instead, it is variously described as a debate about values and attitudes (Kershen 2003), a debate involving philosophical ideas, ideology and politics (Regal 1996), a quarrel about dogmas (Rehmann-Sutter 1993) or a debate involving deeper concerns related to alternative visions of reality (Bruce 2002). In this sense, the debate over GM crops can be seen to be trans-scientific (Weinberg 1985), a debate that involves questions beyond which science is capable of answering. This includes questions of value, questions of environmental ethics and questions about what constitutes appropriate social arrangements. Amidst all of the broad scientific, social and ethical questions being raised in the GM debate, governments are responsible for providing a regulatory framework for GM crops, which is capable of minimising negative impacts on both the biological and social environments. To assist the development of socially and ecologically sustainable agriculture, the regulatory framework would need to be capable of incorporating and considering all aspects of the GM debate, scientific, social and ethical.

Australia's Regulation Of GM Crops

As a means of assessing and regulating the commercial release of GM crops, Australia has adopted what can be described as a science-based risk assessment approach to regulation. In 2000 the *Gene Technology Act* (hereafter referred to as the Act) created the federal regulatory body, the Office of the Gene Technology Regulator (OGTR). The object of the Act is described as "to protect the health and safety of people, and to protect the environment, by identifying risks posed by or as a result of gene technology, and by managing those risks through regulating certain dealings with GMOs" (Commonwealth of Australia 2000, p. 1). The Act has therefore framed Australia's regulation of GM crops in terms of risk, where risk assessment is seen as a technical endeavour involving scientific quantification. Indeed, the risk analysis framework used by the OGTR explicitly states that "risk assessment is a scientific process that does not take political or other non-scientific aspects of an application to use a GMO into account" (Office of the Gene Technology Regulator 2002, p. 12). Framing

regulatory considerations in terms of risk and using a risk analysis framework that denies the consideration of political and non-scientific aspects of risk debates, means that moral and social concerns are effectively excluded from explicit consideration in regulatory decision making.

In a more general sense, a risk analysis framework which claims that risk assessment is a purely scientific process is a particularly technocratic approach to the notion of risk and one which completely fails to acknowledge the influence subjective judgements have on the risk assessment process itself and how this process is framed. This purely science-based approach to understanding risk assessment ignores the values and politics which are embedded in the framework adopted for decision making (Jasanoff 1999), how values enter the scientific process through the way experiments are structured and organised, as well as what meaning is determined from the observations (Shrader-Frechette 1991), and the subjective elements that inevitably enter any risk assessment process when decisions must be made about what constitutes acceptable evidence. While the explicit consideration of social and ethical concerns is not currently occurring in Australia's regulation of GM crops, the framework being used for decision making and the way the risk assessment process proceeds are not entirely value-free as is currently being implied in the risk analysis framework.

This exclusion of social and ethical considerations in GM crop regulation is also reflected in how the environment is defined. The definition given to 'the environment' effectively sets the scope for what issues can be considered in any risk assessment process that considers 'risks to the environment'. The *Gene Technology Act* has a less comprehensive definition of the environment than other governmental documents such as the *Environment Protection and Biodiversity Conservation Act 1999* and State of the Environment reporting (Vanclay 2003). The shortened definition of the environment in the *Gene Technology Act* excludes any mention of people and communities as forming part of the environment, as well as excluding any mention of social, cultural, aesthetic or economic qualities of an understanding of what constitutes the environment. It is worth highlighting this point by reproducing the definitions in their entirety here.

The *Gene Technology Act 2000* (Section 10) defines 'the environment' to include:

- a) ecosystems and their constituent parts; and
- b) natural and physical resources; and
- c) the qualities and characteristics of locations, places and areas.

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) (Section 528) defines the environment as including:

- a) ecosystems and their constituent parts, including people and communities; and
- b) all natural and physical resources; and
- c) the qualities and characteristics of locations, places and areas, however large or small, that contribute to their biological diversity and integrity, intrinsic or attributed scientific value or interest, amenity, harmony and sense of community; and
- d) the social, economic, aesthetic and cultural conditions that effect, or are affected by, things mentioned in paragraphs (a) to (c).

While it may be argued that point (c) of the *Gene Technology Act's* definition may be understood as referring to broader social and ethical aspects of what is defined as 'the environment', the explanatory memorandum to the Act suggests otherwise (Vanclay 2003). In the explanatory memorandum (p 48) it is stated that, 'It is intended that the definition of environment include all animals (including insects, fish and mammals), plants, soils and ecosystems (both aquatic and terrestrial)'. Through providing a much narrower definition of the key term 'the environment' than other pieces of environmental legislation, the *Gene Technology Act 2000* frames Australia's regulation of GM crops in a way that further denies any consideration of social or ethical factors from entering the risk assessment process as performed by the OGTR.

Australia's regulatory framework does include advisory committees which have been established to consider social and ethical aspects of biotechnological applications; these are the Gene Technology Community Consultative Committee (GTCCC) and the Gene Technology Ethics Committee (GTEC). However, the Act has legislated that it is only the committee of scientific experts (the Gene Technology Technical Advisory Committee GTTAC) that must be consulted during the risk assessment process for all applications for deliberate environmental release (Commonwealth of Australia 2000, pp. 33-34). It is clearly stated in section 51 of the Act that "the Regulator must take into account...any advice in relation to the risk assessment provided by the Gene Technology Technical Advisory Committee" (Commonwealth of Australia 2000 p.34), but no mention is made in this section of the GTEC or GTCCC. Indeed, the Regulator is not required by legislation to take into account any advice offered by these committees in relation to risk assessment. Of course the Regulator *may* take the advice of these committees into account, but under current legislation there is no requirement that this advice be routinely sought on individual applications or taken into account when offered. The fact that the GTEC and the GTCCC do not have to be consulted on individual applications and that their advice does not have to be taken into account by the regulator when it is made, is a factor of regulatory framing which severely limits the influence these committees have over the decision making process.

We can observe this lack of influence that the non-scientific advisory committees to the OGTR have in decision making in at least two instances. Before approval was given for the commercial release of GM canola in 2003, the GTCCC chose to advise the Regulator that "a state of unreadiness exists concerning the risks to the environment of the commercial release of GM canola, so significant that the applications should be declined at this time" (GTCCC communiqué 2003). As evidence of the lack of influence the GTCCC has on regulatory decision making, this advice was not taken and the first GM canola crop received regulatory approval. The lack of influence held by the non-scientific advisory committees is further evidenced by transkingdom GM crops being approved for commercial release before the GTEC has completed its investigation into the ethics of transkingdom crosses (GTEC communiqué 2003). With the Regulator granting approval to GM crops before investigations from the non-scientific advisory committees have been completed and not acting on advice given when those investigations are complete, it becomes obvious that even though community consultative and ethics committees exist within Australia's regulatory framework, they have not been granted the same degree of influence over the decision making process as that granted to the committee of scientific experts.

The framing of Australia's regulatory approach to GM crops has effectively excluded social and ethical considerations from explicitly entering the decision-making process through the type of approach selected, the definition of key terms and what parties have been granted influence. This exclusion of social and ethical considerations denies the concept of a social

risk. Social risks can be defined as the risks of negative impacts on social structure or the violation of basic moral tenets (Wynne 1983). In research looking at how comfortable Australians are with current technological developments, Gilding and Critchley (2003) discovered that most Australians are uncomfortable with genetic engineering technologies. If concerns in the community about GM crops relate to how the commercialisation of these novel organisms will impact on social structure or basic moral tenets, then these are concerns that are not currently able to enter and influence the decision making process. This disenfranchisement of legitimate social and ethical concerns from regulatory decision making on these novel organisms can be viewed as a serious threat to the advancement of socially sustainable agriculture. The development of socially sustainable agriculture is also threatened by Australia's current regulatory framework for GM crops in the sense that continuing to approve GM crops for commercial release - without acknowledging the potential for social risks and without allowing social and ethical concerns to penetrate the decision making process - may encourage the development of agricultural systems which are not capable of maintaining the trust and support of the majority of Australian citizens.

Framing the current regulatory approach to GM crops as one of scientific risk assessment also potentially threatens the development of ecologically sustainable agriculture. There has been widespread agreement among ecologists that the current body of ecological knowledge is insufficient to enable an accurate prediction of the impact that large scale commercial releases of GM crops may have on the environment (Käppeli & Auberson 1997; Johnson & Hope 2000; Beringer 2000). The novel nature of genetically modified organisms and the existence of little actual ecological data on their environmental impact, means that regulatory decision making is heavily reliant on OGTR risk evaluators and GTTAC scientists who are being asked to make inferences and draw conclusions from very little actual data. As novel organisms, the risks from transkingdom GM crops are not necessarily known risks with a quantifiable degree of uncertainty. Risk assessment in this data deficient context begins to take on a character more like educated guesswork than precise and certain scientific quantification.

Recognising the difficulties of performing accurate risk assessment when there is little familiarity with the organisms involved, when these organisms are being released into complex systems and when there is little actual data available, the CSIRO recently held a workshop on the ecological risk assessment of genetically modified organisms (GMOs) and came up with a ten point plan for best practice ecological risk assessment (CSIRO 2002). Three of these ten points relate to how uncertainties should be handled, and point five of this ten point plan states that "It is essential to include a transparent analysis of uncertainty" in risk assessments performed on GMOs (CSIRO 2002). While there are a number of models available for analysing ecological uncertainties (Linacre 2003), not one of these models has been transparently employed in risk assessments performed by the OGTR. There is currently no clear and transparent acknowledgement of scientific uncertainties and areas of ignorance in Australia's GM crop regulation and this is despite the government's primary scientific research institution suggesting that this is a vital element of best practice ecological risk assessment for GMOs.

Compounding this problem of not transparently analysing ecological uncertainties, the OGTR has not imposed detailed ongoing ecological monitoring as a condition of licence for all crops that have been approved for commercial release. While applicants are required to report any negative environmental impacts of which they become aware, requesting that negative environmental impacts be reported by the licence holder when they are noticed is not the same thing as requesting that detailed ecological monitoring for negative impacts be

conducted a condition of licence approval. Without acknowledging where our knowledge deficits are substantial and without long term independent ecological monitoring of these novel crops being enforced for all approved GM crops, our ability to foresee, quantify and manage any negative ecological impacts these crops may have, and therefore our ability to ensure the ecologically sustainable development of agriculture, has been substantially compromised.

The baseline of comparison used by the OGTR for what level of risk is acceptable also raises concern about the appropriateness of the current approach to GM crop regulation for advancing the goal of sustainable agriculture. A potential risk to the environment from a GM crop is deemed to be acceptable by the OGTR if that level of risk is seen as no greater than that posed by conventional chemically intensive agriculture. The rationale behind this baseline for acceptable risk comparisons is that the risks posed to the environment by conventional agricultural practices have already been accepted by society and therefore, as long as the levels of risk posed by GM crops are no greater, then they too should be considered acceptable. This ignores literature on risk from the social sciences that suggests that people use a range of different factors to decide what an acceptable level of risk is, factors such as familiarity, controllability and reversibility (Slovic, Fischhoff & Lichtenstein, 1982). If these factors were included in considerations of acceptable levels of risk for GM crops, we may very well find that the Australian people are not prepared to accept a lower level of physical risk to the environment from GM crops in comparison to the risks from conventional agriculture because the risks from GM crops are seen as unfamiliar, uncontrollable and irreversible. One could also argue that setting chemically intensive conventional agricultural practices as the comparative baseline for risk acceptability is setting a particularly low standard by which to judge the environmental impact of GM crops, especially given the unfamiliar, uncontrollable and irreversible nature of these impacts.

An even more fundamental critique of using conventional chemically intensive agriculture as the baseline of comparison is that this assumes that the public does indeed consider the levels of risk to the environment from conventional agriculture as acceptable. One could however argue that if the Australian public was fully informed about the practices occurring in conventional agriculture or if the public were given a choice between intensive chemical use and a more benign alternative, then the level of risk to the environment from conventional agriculture could in fact be rejected as unacceptable. Setting chemically intensive agriculture as the sole baseline for acceptable risk comparisons is assuming that the public is fully informed about current agricultural practices, and that even if given a choice, these practices and the levels of risk they pose to the environment would be deemed acceptable by the broader public both now and into the future. I would argue that this is a highly questionable set of assumptions.

Through failing to acknowledge and adequately address the high degree of uncertainty that surrounds the long term environmental impact of these novel crops, and through the selection of chemically intensive conventional agriculture as the only baseline of comparison for deciding what represents an acceptable level of risk, the framing of Australia's regulatory decision making for GM crops does not support the development of an ecologically sustainable agriculture.

Conclusions

As it is always easier to be critical rather than constructive, I would like to conclude by suggesting that there are a number of ways in which the regulation of GM crops in Australia could be altered to help advance the development of socially and ecologically sustainable

agriculture. The option requiring least disturbance to existing institutions would be for the GTCCC and the GTEC to be given a broader role to play in risk assessment and decision making. This would enable social and ethical considerations to be incorporated into regulatory deliberations, enhancing the ability of the regulatory system to advance the development of socially sustainable agriculture. Another way to assist ecological and social sustainability with minimal institutional change would be for areas with a high degree of scientific uncertainty, such as the impact of GM crops on soil communities and fertility, to be made more transparent and subject to broader consultation with the community. Within the *Gene Technology Act*, the Regulator is permitted to undertake any action considered appropriate for making a decision on an application, including holding a public hearing (Commonwealth of Australia 2000, p.36). Both socially and ecologically sustainable agriculture may be better advanced if public hearings were to be held to discuss how decisions should be made in areas where scientific uncertainties are substantial and where the potential for irreversible effects exists. Alternatively, the *Gene Technology Act* could be amended to incorporate advancing the goal of sustainable agriculture as an objective, as Norway has done (Myhr and Traavik, 2003), and indeed, as was suggested by the Australian Conservation Foundation and the Australian Democrats during the Senate inquiry into the Gene Technology Bill which proceeded the development of the Act (Senate Committee 2000).

As a substantially different approach, we could begin to shift away from a risk assessment framework of decision making towards an approach such as Alternatives Assessment (O'Brien 2000) or Multi-criteria Mapping (Stirling & Mayer 1999). Either of these approaches would enable a broader range of concerns and comparisons for impact assessment to be incorporated into the decision making process. Alternatively, we could begin to develop far more proactive approaches to regulation and innovation based on shared future visions or technological trajectories (for e.g. see Costanza, 2000). An interesting Australian example of how a shared future vision may begin to be articulated and incorporated into governmental decision-making can be seen in Tasmania's "Tasmania Together" project. Widespread community consultation was undertaken in Tasmania to unearth and document the visions local citizens had for various aspects of the island's future. This document was generated to serve as a guide to State and Local political decision-making. While the adequacy of the process of the document's generation and the extent to which it has influenced policy decisions can of course be debated and potentially improved upon, the existence of this project shows that the idea of generating shared social visions as a way of guiding policy decisions is not a totally foreign concept in Australia. All of these suggestions indicate that there are ways in which Australia's regulation of GM crops could be altered to aid the advancement of socially and ecologically sustainable agriculture.

Despite all the inherent difficulties with the concept of sustainable development, the term remains important for its ability to open a space for the synthesis of ecological, economic and ethical considerations in political decision making. This is a synthesis that desperately needs to be brought to Australia's currently narrowly framed, fragmented and largely undemocratic approach to the regulation of controversial transkingdom GM crops.

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