

## GM CROPS IN THE UK – WHAT HAPPENS NEXT?

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### ABSTRACT

Amidst uncertainty about the future role of genetically modified (GM) crops in the UK, this paper considers the information required for a regulatory impact assessment of potential post-trial scenarios with specific consideration of the situation in Scotland. We consider the extent to which cost-benefit analysis (CBA) could move the GM debate forward and discuss the challenges of using CBA as a tool for informing the policy options and their impact. Specifically we describe the issues relating to choice of scenarios and outline the range of market and non-market costs and benefits for consideration. The implications of a precautionary approach are also discussed. We draw on submissions and preliminary conclusions from two recent UK consultation exercises and emphasise the need for consideration of the costs and benefits of GM crops in this increasingly fraught policy arena.

### INTRODUCTION

The last round of farm scale evaluations of GM crops has recently been announced (Scottish Executive, 2002) and the key question now, regarding GM crops in Scotland, is 'what happens next?'. Options include additional field trials, roll-out of commercial GM crops or a continuation of the moratorium on GM crops in Europe<sup>1</sup>. Any additional field trials will have to be managed with regard to the findings of an Agriculture and Environment Biotechnology Commission report that criticised the way the initial trials had been established and the extent of effects they were designed to monitor (AEBC, 2001). In the meantime a definitive decision on whether or not GM crops will be allowed at some time in the future seems unlikely. In the short term any decision has been stalled to make time for public debate and await the finalising of European legislation.

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On the international front, the conflict between the EU and the US has deteriorated further with the US threatening to take the EU to court over the refusal of Brussels to import GM crops (Teather, 2003). The European Union seems to be inclined to heed consumer calls for segregation and labelling and the US government and industry are impatient to reap the financial returns to massive investment in supply-led biotechnology research, development and production. International arguments at this level serve to reinforce a public perception that the technology is in fact beyond the control of domestic regulation and consumer influence. This in turn links anti-GM protests to the wider anti-globalisation agenda.

Actual consumer attitudes to GM food are unclear since consistent market behaviour cannot be observed. They appear to be characterised by strong concerns about the lack of choice regarding whether or not to consume GM foods and the lack of public involvement in decisions regarding the location of GM trials. It has been suggested however that acceptability is enhanced when specific benefits are clarified. But such messages are difficult to discern in a passionate debate that has become polarised between disenfranchised consumers and communities and the pro-technology lobby.

Many preferences of the anti-GM side of the debate are difficult to quantify because they hinge on a desire for precaution based on the prospect of irreversible and potentially catastrophic environmental change. From an economic perspective the absence of coherent cost and benefit information precludes a rational assessment or appraisal of policy options and prevents the quantification of opportunity costs of opting for precaution. These opportunity costs are significant to the economic debate because they may provide a basis for considering what society's 'willingness to pay' for precaution needs to be. That is, they are a basis for considering whether the magnitude of preferences prominent in the current anti-GM positions outweigh the benefits foregone as a result of opting for a precautionary approach and halting further development.

This paper considers the challenges faced in valuing the perceived risks and benefits relating to a future where GM crops are present in the landscape. The main part of the paper considers whether

cost-benefit analysis can advance the debate in order to move away from the current polarisation of positions. We also discuss how benefit transfer, the precautionary principle and multi-criteria analysis might be used to deal with the uncertainty surrounding the costs (risks) and benefits associated with the application of GM technology to crops in the UK, and more specifically, Scotland.

## GM CONSULTATIONS

In an effort to move the GM debate forward recent consultation exercises carried out by the Prime Minister's Strategy Unit (Strategy Unit, 2002a) and the Scottish Parliament Health Committee (The Scottish Parliament, 2002) were designed to address concerns that have brought the technology close to being mothballed indefinitely.

The position in Scotland, as in the UK as a whole, is that the last scheduled planting trials took place in Autumn 2002 and despite Tony Blair's apparent pro-GM stance (Radford, 2002) the government has, it seems, finally heeded public protestations and initiated a "national dialogue" on GM issues<sup>2</sup>. This national dialogue has three strands, of which the Strategy Unit's investigation mentioned above is one. The other two, running concurrently with the Strategy Unit cost benefit study, are a programme of public debate conducted by an independent steering body and a science review<sup>3</sup>. The public debate programme included nine public workshops held at the end of 2002<sup>4</sup>. The remainder of the programme consists of a series of steering committee meetings to be held in London (one is a private meeting, the others are open for the public to observe) and the opportunity for interested parties to send their comments to the committee. The extent to which this is open, participative debate is in itself a matter for debate. The science review panel is also holding a series of meetings that may have limited spaces for members of the public to attend and observe. There appears to be little chance for the 'person-in-the-street' to contribute. The recent announcement that the public debate will not benefit from the information obtained by the farm scale evaluations has not inspired public confidence (Meek, 2002). More promisingly, the Food Standards Agency is independently carrying out additional public consultation through a school debating competition, a student video project, discussion groups with young people and those on low incomes in Scotland and a citizen's jury (Food Standards Agency, 2003).

The summary of responses produced by the Strategy Unit served to reconfirm the concerns of those opposed to GM, reiterating issues such as health concerns, the need for consumer choice, the implications for non-GM crops and the long-term impacts on biodiversity (Strategy Unit, 2002b)<sup>5</sup>. It also suggested that many of the alleged impacts of GM crops could not be quantified or monetised and implicitly that the role of CBA would be limited. While this is a frequently raised concern about the limits of environmental cost-benefit analysis, the Strategy Unit made no reference to the progress made by environmental economists to address non-market impacts. The preponderance of such impacts within the GM debate means that any regulatory appraisal is likely to be incomplete without some attempt at their quantification. There would appear to be a role for revealed or stated preference methods to discover the 'willingness to pay' to avoid risks relating to potential cross-contamination or disamenity of GM fields.

An additional issue that caused a delay to the progress of the government's three strand public debate was that the devolved administrations of Wales and Scotland were behind Westminster and needed more time for the debate (Brown, 2003). At the time of writing there had been no indication from the Scottish Executive that they were considering a separate CBA for Scotland. However, the completion of GM trials coincided with a Scottish Parliament Health Committee consultation into whether the trials should be halted on the grounds that their health effects are largely unknown. The report of this inquiry roundly condemned the risk assessment procedures, criticised the application of the precautionary principle for failing to comply with the Scottish Executive's own definition of the procedure<sup>6</sup> and stated concerns about the transparency of the decision-making process. It also called for pharmaceutical style 'product' testing on human volunteers and additional research into the toxicological effects of GMOs on human health and into allergenic effects of GM pollen (Health and Community Care Committee, 2003). Lacking again from all of this is any objective assessment of the potential costs and benefits.

## COST BENEFIT ANALYSIS

Cost benefit analysis has dominated central government project and policy appraisal for decades and its recent use in environmental appraisal is encouraging (see Pearce, 1998). The approach presents the attainment of economic efficiency as the goal of evaluation, with socially desirable policy options being those that offer benefits in excess of costs. The method necessarily stands on the feasibility of attaching quantitative weights to society's preferences, and money is taken as the best numeraire or measure of individual's willingness to pay for positive, or accept compensation for negative, change. Put simply a good policy procures an aggregate net benefit for society.

While CBA was the initial intention of the Strategy Unit, their summary of responses stated that a strict CBA was no longer their objective because of the difficulties in valuation of the non-market impacts.

*“The Strategy Unit recognises that a formal cost-benefit analysis would be inappropriate as the main analytical approach to addressing the costs and benefits of GM and non-GM scenarios for the UK” (Strategy Unit, 2002b)*

This is largely due to the responses received through their initial consultation from those opposed to GM. It is probable that those in favour of GM would support the use of CBA since it would likely demonstrate the potentially enormous opportunity costs of abandoning the technology. Proponents have a compelling case since the rates of return to technological change can be reasonably quantified and hence the benefits side of the CBA would show strongly in their favour while the more problematic environmental costs would likely remain more uncertain and open to debate.

The arguments in favour of GM range from the potential benefits for developed country agriculture, the attainment of international food security and improved nutrition, through to biodiversity and wider environmental benefits associated with lower agricultural inputs (see for example, Farmers Weekly staff, 2003). In contrast, the anti-GM lobby point to potentially enormous costs of future environmental degradation. These arguments are a complex mix of conjectures about genetic pollution, agricultural resistance and toxicological health impacts, based on as yet unproven theoretical possibilities. They are fears that are based heavily on the dread of uncertain outcomes, the fear of

technological development, property right infringement concerning the production of negative externalities and a belief that the ecological 'web of life' is already faced with irreversible change because of 'progress-driven' human activities. Added to all of this is an intuitive belief that tampering with the very 'stuff' of existence at the genetic level is ethically, spiritually and physically wrong and stems from a deeply misguided notion that humans have the right of stewardship over the rest of the environment.

How to account for these preferences is problematic. Neo-classical monetary valuation methods rely on respondent preferences that conform to certain axioms (rules) that predict the way choices are made. Forcing people to consider the monetary value of avoiding potential catastrophes may not conform to these rules. Specifically the combination of ethics and dread may well be manifest in choices that are apparently lexicographic<sup>7</sup>; legitimate economic choices that GM proponents sometimes interpret as irrational. But lexicographic behaviour does not obviate the trade-off implicit in foregoing the alleged technological advantages. In other words, direct valuation may be problematic but the policy scenario can be informed by an indirect approach that clarifies the opportunity cost of not advancing the technological development and then asks whether society values the avoidance of potential costs by this much. To remove speculation and move the debate forward there is merit in undertaking a quantitative investigation of as many cost and benefit categories as possible. If nothing else consideration of the opportunity costs is more likely to inform efficient regulation: an espoused government objective.

#### WHAT POLICY SCENARIO?

To put some bounds on the cost-benefit assessment we need to consider policy scenarios. Recent studies have presented different policy scenarios of the future of GM crops. For example, the European Commission Joint Research Centre report (Bock et al, 2002) considered the implications of contamination of non-GM crops from GM crops under two scenarios, where 10% and then 50% of crop share was GM. Another report took one crop (oil seed rape) and, within a multi-criteria mapping study, presented stakeholders with six policy options for the future production of OSR (Stirling & Mayer, 2001).

The 6 policy options defined by the project were:

- No GM, organic agriculture
- No GM, conventional agriculture
- No GM, integrated pest management
- GM with segregation and labelling
- GM crops with post-release monitoring
- GM crops with voluntary controls on areas of cultivation

Another GM scenario report took a global perspective and considered the implications of four different scenarios. These were that biotechnology may be formally banned or voluntarily rejected, fully accepted, marketed through strict labelling, or limited to non-food applications (Weatherspoon et al, 2001). Qaim (1999) discussed the future introduction of genetically modified virus resistant potato varieties in Mexico. His four scenarios involved a combination of two different GM developments (for resistance to different viruses) and three types of potato. In a comment in the Guardian, January 2003, Sue Mayer outlined a 'countdown' to GM commercialisation in the UK, predicting that herbicide-tolerant oilseed rape, sugarbeet and maize could be first planted in Spring 2004 (Mayer, 2003). The Strategy Unit (2003) proposed four scenarios based on degrees of consumer acceptance (or rejection) and the extent of international regulations.

These are some examples of how the future of European agriculture might (or might not) include GM crops. Table 1 outlines issues for consideration in formulating scenarios: variables such as the extent of GM coverage, the type of management, regulation and controls, different GM crops, GM crops with different traits and different timescales. Any scenario would need to consider a combination of these and other issues.

**Table 1 here**

There are evidently many uncertainties regarding the future of GM crops in this country related to when GM technologies might be applied commercially, to what extent GM crops might be grown,

which crops might be grown and which technologies might be applied to those crops. In addition, there remains uncertainty regarding EU Directive requirements, for example, on thresholds for labelling. All of these factors will have a major influence on the costs and benefits of GM crops. What may need to be done, therefore, is a range of CBAs under different policy scenarios in order to cover 'all eventualities'.

To reiterate, any policy scenario will need to consider the geographic extent to which GM crops might be planted commercially. It will need to set out the different management and regulation options to be implemented, the crop and technology choices and the timescale under which they will be introduced commercially. An appropriate Scottish scenario might assume 50% of a number of crops will be GM by 2005. The chosen crops could be oilseed rape, potatoes and wheat; crops currently grown in Scotland which are significant to Scottish agriculture and for which genetic modification has already been developed and trialled in Scotland (OSR and, to a lesser extent, potatoes) or is being developed (wheat). However, there is a need to consider issues such as changing agricultural support payments (for example for oil seed rape) and how these changes might influence the mix of crops in the future. In the absence of a detailed 'map' of what the agricultural landscape might be in 2005 or later the challenges of producing a realistic scenario are considerable<sup>8</sup>.

## THE COST BENEFIT FRAMEWORK

A CBA should aim to quantify the costs and benefits associated with the chosen scenario. In strict cost-benefit terms all impacts are economic in the sense that they ultimately affect human welfare. Here we consider how the current literature can provide guidance on the three sustainability categories of impacts, namely environmental, social and economic. Within these broad categories, costs and benefits can be considered in relation to affected parties, for example, GM farmers, non-GM farmers, local communities, biotechnology companies, research institutions, downstream industries, consumers and so on.

An initial categorisation of the costs and benefits of GM crops is shown in tables 2 and 3. The range of potential costs and benefits is largely similar to those identified in the Strategy Unit's Scoping Note.

An important point is that many of the potential costs and benefits are technology specific and this is why the choice of policy scenario is so significant. It is widely acknowledged, for example, that many of the expected consumer benefits will only occur if 'the next phase' of GM technologies, such as crops with extra vitamins, is applied. Under the suggested Scottish scenario the CBA should ideally concentrate on those costs and benefits that can reasonably be expected to occur through the commercial application of herbicide tolerant oil seed rape, wheat modified to be herbicide tolerant and potatoes modified to be virus resistant<sup>9</sup>.

**Table 2 here**

**Table 3 here**

There are clearly many instances where the costs or benefits presented in tables two and three are potentially enormous. On the benefits side, the returns for the biotechnology industry from research and development could be one of the major benefits. For example, Alston et al (2000) found that average returns to agricultural research and development can be as high as 80%. Also, if all of the promised environmental benefits come to fruition (reduced need for agri-chemicals, reduced need for agricultural land, reduced need for irrigation) these may be highly significant. The direct benefits (for example yield increases and reduced costs for farmers) are quantified through the use of economic surplus analysis and the transfer of costs and benefits data. For example, cost benefit studies into the commercial application of GM oil seed rape (OSR) have been completed in Canada using data from the experience of Canadian farmers.

Conversely, the costs of GM segregation, dependent on pending regulations and requirements for labelling are likely to be considerable. Also, the environmental costs of the widespread release of GM crops are predicted by many (who are opposed to GM) to be potentially enormous. However, specific information on these risks and the ultimate impacts to enable quantification is less concrete. Equally uncertain are costs relating to the unrest within communities and unease among consumers.

The Strategy Unit Scoping Note states that "ethical considerations around GM research ... seem likely to be raised in the context of the public debate" (Strategy Unit, 2002a). It is vital that these

ethical considerations be addressed in any regulatory impact assessment of GM scenarios. The question is whether this exceeds the limits of informative CBA. The valuation of these non-market concerns suggests an important role for non-market valuation of the costs and benefits associated with different modification technologies. Although existing valuation studies may not cover sufficiently the range of impacts such that transfer of WTP values could be considered comprehensive they do provide a starting point. It should be possible to transfer values from contingent valuation studies relating to other environmental goods and bads. For example, WTP studies have been carried out relating to consumer avoidance of food-related health risks. These results may enable values to be calibrated for categories under 'social costs to individuals' in table two. Additionally hedonic analyses have investigated how environmental bads such as unpopular land uses affect values of certain areas. These values will help to identify the potential risk value that communities attach to fields of GM crops.

The way forward is therefore to try to undertake a defensible valuation of as many impacts as possible. Following this any gap between benefits and costs can be interpreted as the WTP amount required (WTP *for* benefits or *to avoid* costs). In this way we can make a reasonable assessment of the magnitude of welfare transfer that could be used in public debate, which just now is bereft of hard figures for the costs and benefits.

## UNCERTAINTY AND COMMUNICATION

### The Precautionary Principle

The cost benefit story helps to clarify thinking about the intangible elements of GM technology but the multiple uncertainties make a compelling case for precaution.

The Precautionary Principle (PP) is an appealing rule for decision making in the face of a significant (potential) risk to human health or the environment. However, it can be an expensive basis for policy making when it is invoked without reference to the potential relative costs and benefits of inaction. This is because the PP implies a non-negotiable cost (in terms of foregone potential benefit) when it is invoked to halt a development proposal (or application of technology) with which risk is associated or

perceived. It could be argued that recourse to the PP in this way sets a precedent that could stifle potential avenues of economic growth offered by the ongoing developments in biotechnology. An alternative argument might state that GM policy should be made only after thorough attempts to develop a rational approach to weighing up costs and benefits and assessing the balance of risks and uncertainties. If the risks can be identified and quantified and it can be demonstrated that they can be managed, mitigated or avoided many of the concerns of those opposed to GM crops are negated. It is also necessary to consider how widely held these views are. PP is an expensive option if it is used to fulfil the agenda of a concerned minority rather than the majority. In economic welfare terms the majority may not be as risk averse as this concerned minority and it would be inefficient and possibly inequitable to base policy decisions on the minority perception of risk or valuation of uncertainty. This would leave the majority to bear the opportunity cost in terms of foregone benefits (occasioned by loss of GM development), without investigating the relative strength of preferences (which may be to accept some potential risk in order to attain the perceived benefits). As Pearce (1997) asks “when is the foregone cost so large that it justifies environmental damage?”. Nevertheless there is still a need for the foregone costs and the potential environmental damage to be valued. Apart from the use of a money metric (i.e. stated or revealed willingness to pay), or the ballot box, there is currently no (*a priori*) defensible theoretical or practical basis for weighting the relative preferences in this way.

## Risk Assessment

The PP poses a conundrum for policy making. On the one hand it can be argued that without evidence of likely damages it does not make sense to prevent commercial application of GM crops using the PP. It could equally be argued that going ahead with commercial application of GM crops without demonstrating the converse case of low expected damage, completely undermines the point of the PP. The issue of risk assessment is therefore crucial to differentiate these positions. Indeed, some estimates of the ranking of supposed risks relative to other more widely appreciated and quantified risks is a necessity to avoid potentially wasteful regulation.

By itself the cost benefit information cannot completely obviate the need for precaution in this case. Because of the complexities of the issues in the case of GM technologies prediction of expected damages and risks cannot be undertaken without better risk quantification. For example, although we can draw on the results from various experiments that have demonstrated adverse effects on biodiversity (see for example Losey et al, 1999) there has not yet been an adequate assessment of the likelihood and severity of those risks to enable thorough quantification of the costs.

There are therefore several factors to consider when addressing the question of whether the precautionary principle should be applied or not. Have all sources of uncertainty, ignorance and subjectivity been addressed by the trials and by the CBA? Has the scope of regulatory control of GM crop trials been broad enough to address cumulative, additive, complex and indirect effects as well as more direct causal processes? Has there been full engagement with all interested and affected parties (would those affected parties agree that there has)?<sup>10</sup>. Embedded within these four points for consideration is the need for thorough risk assessment specifically addressing the concerns of potential consumers. If the answer to any of the four points is 'no', then it could be argued that the precautionary principle should be applied until the outstanding uncertainties are investigated. There is a scientific imperative to translate the uncertainties into known probabilities thus substituting costly precaution with more transparent risk management. The fact that this has not yet occurred was pointed out in the Scottish Parliament Health Committee report (Health and Community Care Committee, 2003). This has to be done with a view to communicating the risks and probabilities to potential consumers and this is where risk assessment is weakest.

Whatever the economic rationality demonstrated by the CBA the issue of public acceptability remains to be tackled. Even if a compelling economic case can be made decisions about where GM crops are grown and concerns about involuntary consumption of GM produce are likely to sustain opposition. Consumers and communities remain sceptical about risk management strategies and participation in decision making. While labelling is possibly the only answer to allay consumer fears, the policy process needs to contend with a number of logistical concerns about where the technology is rolled out.

These policy options can be explored with non-monetary alternatives to CBA such as multi-criteria analysis<sup>11</sup>. This approach is more participatory and, as noted above, a form of MCA has already been used by Stirling & Mayer in a pilot study of stakeholders (Stirling & Mayer, 2001). MCA frameworks are flexible enough for various incommensurate elements to be traded off by those most affected by policy decisions. It is important that such exercises should include the fullest information about all costs and benefits and so the completion of a comprehensive CBA (including comprehensive risk assessment) is still warranted. MCA can add much to any national strategy to promote GM crops. On its own however, it cannot guarantee that an acceptable decision is always rational. As ever there is likely to be a policy trade off.

## CONCLUSIONS

The main aim of this paper has been to outline some of the pertinent issues that arise in a regulatory impact assessment of GM policy in Scotland. We posed the question 'to what extent could CBA move the GM debate forward?' and our answer is that some form of quantitative CBA is warranted.

Consistent with government guidelines (IRIS) a range of potential costs and benefits has been outlined alongside the methodological challenges related to non-market valuation and scientific uncertainty. We concur with Demont and Tollens (2001) who comment that "given this large set of uncertainties one may question whether estimating the welfare effects of agricultural biotechnology in the European Union is feasible at all" but conclude that estimation of the welfare effects can and should be attempted. Thus while the Prime Minister's Strategy Unit has recently decided that CBA is not an adequate tool for the task, we contend that a partial CBA is still informative. Nevertheless we acknowledge that due to the complexity of the issues involved in the GM debate and the need to ensure consumers believe participation in decision-making has

been possible tools such as multi-criteria analysis can add value to the impact analysis. We recommend that an area where further research is desirable is how a combination of analysis tools can be utilised in a case such as the GM debate. Overall, we believe that through careful consideration of policy scenario, appropriate use of value transfer and with the addition of primary contingent valuation surveys to address lingering consumer concerns, a CBA of GM crops in Scotland is attainable and will, when complete, make a valuable contribution to this contentious area of policy making.

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## NOTES

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<sup>1</sup> We note that Spain and the Netherlands forwarded favourable opinions on applications for commercial approval of GM crops to the European Commission (EU's GMO Approval Process Shows Signs of Life, *Environment Daily* 1371, 27/01/03)

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<sup>2</sup> <http://www.gmpublicdebate.org.uk/index.html>

<sup>3</sup> At the time of writing there was a discussion between the committee in charge of the debate program and Margaret Beckett regarding the level of funding required for this process. The original amount committed was £250,000, the committee estimate a need for nearer £1 million and a revised amount of £500,000 was being offered (Radio 4 news 22/1/03).

<sup>4</sup> See <http://www.gmpublicdebate.org.uk/minutes/corrwillbourn.ppt>

<sup>5</sup> At the time of writing the Strategy Unit had just produced five working papers for additional consultation. <http://www.strategy.gov.uk/2002/gm/summ.shtml>

<sup>6</sup> The Health Committee Report quotes the Scottish Executive's Chief Medical Officer who stated that "in this context, the precautionary principle is that if a preliminary scientific assessment shows there are reasonable grounds for concern that potentially dangerous effects will occur on human health then a release will not proceed". The Committee's concern is presumably that the scientific (risk) assessment has not been adequate to assess whether or not these dangerous effects will occur.

<sup>7</sup> Lexicographic preferences or rights-based beliefs are those opinions held by certain individuals in society which prevent them from agreeing to trade-offs such as cheaper food for potential biodiversity damages. Lexicographic preferences make the use of CBA problematic since it is founded on the principle that loss (damage / cost / risk) can be compensated for by those benefiting from a particular policy.

<sup>8</sup> We note that Cranfield University is working on a DEFRA funded research project 'IS0209 : Agricultural futures and their implications for the environment' for England and Wales

<sup>9</sup> We note that Scottish seed potatoes are valued for their quality and the fact that, due to favourable climatic conditions which suppress aphids, potato viruses are not currently a problem. Nevertheless the advent of virus-resistant GM potatoes will undoubtedly be of great interest to other countries including those currently supplied by Scotland.

<sup>10</sup> These points are drawn from a list of eight evaluative criteria for assessing the precautionary quality of risk appraisal (Mayer & Stirling, 2002)

<sup>11</sup> For government guidance on the use of MCA see <http://www.dtlr.gov.uk/about/multicriteria/index.htm>

**Table 1: Scenarios**

<i>VARIABLE (S)</i>	<i>SCENARIO OPTIONS</i>	<i>NOTES</i>
GM COVERAGE AND CROP SHARE	For example: <ul style="list-style-type: none"><li>• No GM</li><li>• 10% GM</li><li>• 50% GM</li><li>• 100% GM</li></ul>	Could be all current crops at current or predicted future crop share (Similar to JRC report)
MANAGEMENT AND REGULATIONS	For example: <ul style="list-style-type: none"><li>• GM with segregation and labelling<ul style="list-style-type: none"><li>• EU proposed levels</li><li>• Other levels of acceptable GM presence</li></ul></li><li>• GM with monitoring<ul style="list-style-type: none"><li>• Farm Scale Evaluation procedures</li><li>• Other monitoring procedures</li></ul></li><li>• GM with voluntary controls</li><li>• GM under land use zoning (see for example. Haslberger, 2001)</li><li>• GM under intra-farm management</li><li>• GM under inter-farm management co-ordination</li><li>• GM with no special monitoring or regulation</li></ul>	Could be one crop type (for example oil seed rape which is the main crop to have been trialled in the UK, similar to Stirling & Mayer approach) or a range of crops
CROP AND TECHNOLOGY TYPE	For example: <ul style="list-style-type: none"><li>• Only crops that have already been trialled in the UK<sup>a</sup></li><li>• Crops that are already commercially grown in other countries</li><li>• Biotechnology crops in development<sup>b</sup></li></ul>	<sup>a</sup> For example in Scotland trials have been of oil seed rape (lauric and herbicide tolerance; resistance to glufosinate ammonium; elevated lauric acids and resistance to kanamycin; resistance to glyphosate) and potatoes (altered starch and sugar metabolism; glycoalkaloid metabolism; plant growth regulation).  <sup>b</sup> Developments in biotechnology suggest that any current commercial crop could have a genetically modified version in the future
TIME	For example: <ul style="list-style-type: none"><li>• 2005</li><li>• 10 years from now</li><li>• 50 years from now</li></ul>	One biotech company has recently predicted no progress on GM crops in Europe until 2005 (Teather 2002)

**Table 2: Costs**

	AFFECTED PARTY	COST ITEM
<b>ECONOMIC</b>	<i>Biotech companies</i>	Research & Development Field trials
	<i>GM farmers</i>	Promotion / lobbying / PR
		Segregation costs
		Premium on GM seeds
		Lower yields
		Controls – for example, meeting compliance with Biosafety Protocol
		Farm management procedures – for example, extra cleaning of equipment to avoid contamination
		Lower prices for crop
		Wild mustard infestation
		Liability insurance
		Losses through crop vandalism
	<i>Non-GM farmers (conventional)</i>	Extra security measures
		Unable to sell contaminated crop – have to sell as GM crop
	<i>Non-GM farmers (organic)</i>	Insurance against contamination losses
		Loss of trade – competition from cheaper GM crops
		Management to avoid contamination
	<i>Government</i>	Loss of organic certification
Loss of organic subsidies		
Unable to sell contaminated crop – have to sell as GM crop		
Loss of use of Bt as pest control		
<i>Consumers</i>	Insurance against contamination losses	
	Regulatory procedures	
<i>Downstream industries</i>	Consultation procedures	
	Taxes for government regulations	
<i>Rural businesses</i>	Paying more for non-GM	
	Paying for labelling / segregation	
	Segregation procedures	
	Testing equipment	
	Loss of tourism	
<i>Research bodies (public and private)</i>	Opportunity cost of research	
	<i>Community</i>	Community relations (within farming communities)
<b>SOCIAL</b>	<i>Community</i>	Community action
	<i>Community</i>	Conflict
	<i>Individuals</i>	Ethical / moral concerns of individuals – worry / psychological
		Allergies
		Pollen related health worries
	<i>Industry</i>	Loss of consumer choice
		Increased control of food chain by biotech companies
	<i>Region</i>	People moving away from certain areas
		<i>Political</i>
	<b>ENVIRONMENTAL</b>	<i>Biodiversity</i>
GM spread to wild flora and gain competitive advantage (threat to biodiversity)		
Cross-pollination with wild mustard, wild radish, wild turnip rape		
<i>Protected areas</i>		HT volunteers
		Superweeds
		New plant diseases (old viruses able to attack new species of plants)
		Protected area status at risk
<i>Chemicals</i>	Increased herbicide use	

**Table 3: Benefits**

	<b>AFFECTED PARTY</b>	<b>BENEFIT</b>
<b>ECONOMIC</b>	<i>Farmers</i>	GM profits for farmers
		Increased yields
		Reduced herbicide costs
	<i>Local economy</i>	Reduced pesticide costs
		Reduced water management costs
		Reduced greenhouse heating costs
	<i>Biotech companies</i>	Growth for local economies
		GM profits for biotech companies
	<i>Consumers</i>	Returns from R&D
		Less money spent on extra vitamins
	<i>National economy</i>	Cheaper food for consumers
		Development of biotech industry
		Regulation jobs
Labelling industry jobs		
Prosperity for farmers		
Returns from R&D		
<b>SOCIAL</b>	<i>Research bodies</i>	Food with added vitamins
		Food with added nutrients
	<i>Consumers</i>	Food with altered fat content
		Food with built-in vaccines
		Better health
		Better diets
		Less crop spraying
		Less time spent on farm management
		Reduced pesticide use
		Reduced fungicide use
More efficient herbicide use		
<b>ENVIRONMENTAL</b>	<i>Local area</i>	Less irrigation required
	<i>GM farmers</i>	Less agricultural land required
	<i>Chemical</i>	Reduced wastage (less loss through perishing, pests, weed competition, fungal infection)
	<i>Water</i>	Reduced energy use through less fuel used in field activities
	<i>Land</i>	Reduction in CO <sub>2</sub> emissions
	<i>Wastage</i>	Less energy used in transportation facilities as perishability is controlled
	<i>Energy</i>	Less energy used to heat greenhouses as frost resistant species are introduced