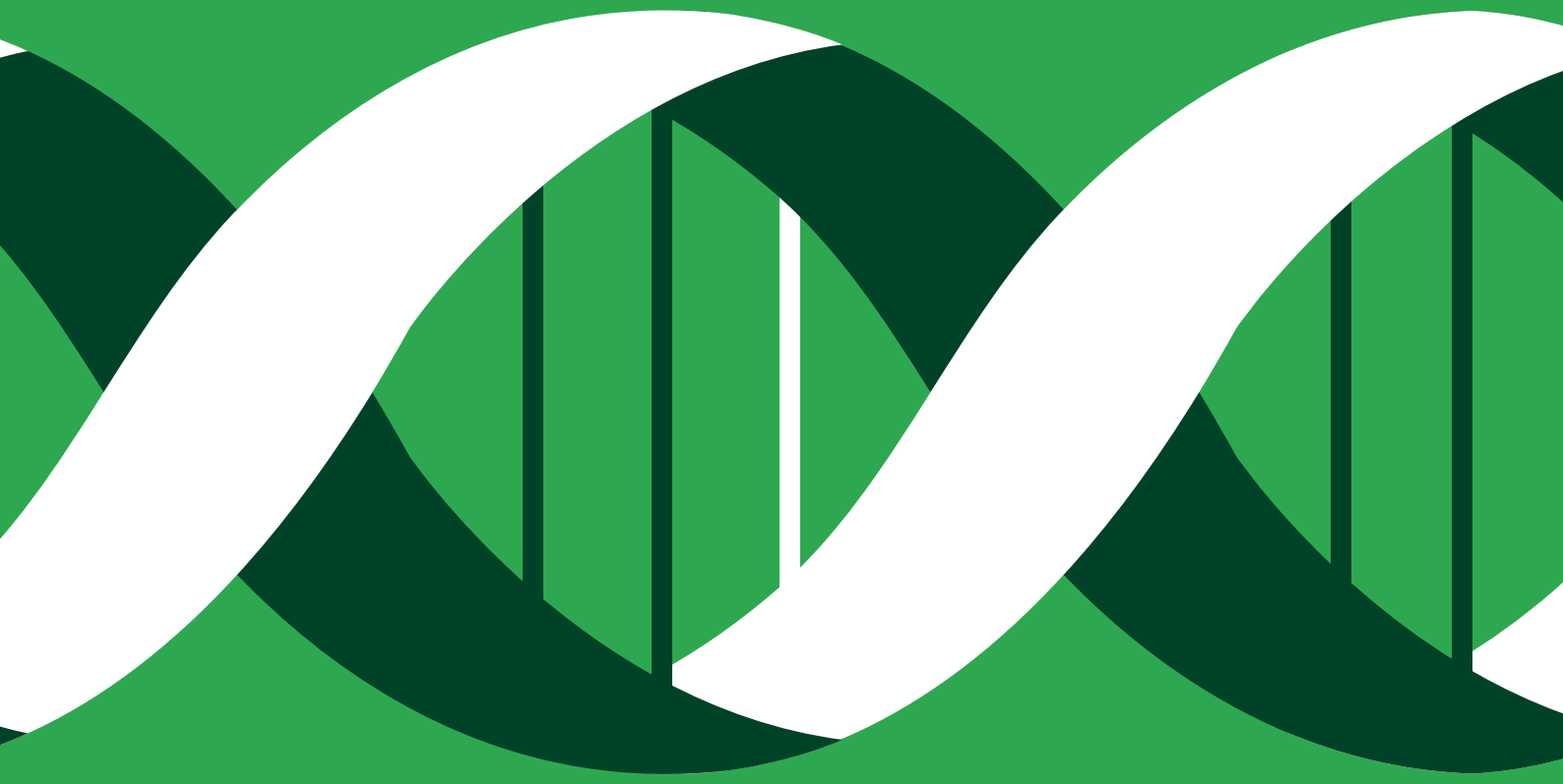
Genome Editing and Agriculture:
Policy, Practices and Public Perceptions (GEAP3)
Policy Briefing 4

FUTURE PATHWAYS FOR GENOME EDITING IN AGRICULTURE: PUBLIC POLICIES, PUBLIC DEBATES, PUBLIC GOODS



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Introduction

Genome editing belongs to a category of cutting-edge modern technologies that have assumed a totemic importance for some politicians and policy advisors as, urged on by futurologists and business executives, they contemplate the emerging disruptions of the 'Fourth Industrial Revolution' (4IR). Other technologies that have been associated with 4IR include nanotechnology, big data and machine-learning, self-driving vehicles, stem-cell therapies and laboratory-cultured artificial meat.

Genome editing is a technique of genetic engineering that involves the alteration of an organism's genetic structure by adding, deleting, changing or replacing individual nucleotides or sequences of DNA.[1] Also known as gene editing, it comprises several different methods and tools, which can be used to alter the traits of crop plants and livestock animals (see GEAP3 Briefing 1).[2]

The truth is that nobody really knows how technologies like these might change industries, economies and societies in the coming decades, but everyone seems to agree that emerging technologies will have – or are already having – a transformational impact. So how should societies be preparing themselves to engage with genome editing and its products in the domains of food and agriculture, including all the possible opportunities, risks, advantages and costs which they present?

This briefing collates key insights arising from desk-based research and an expert dialogue which was convened during October 2020 by the policy hub of the GEAP3 network,[3] to discuss the governance of genome editing applications in agriculture, especially in crop breeding. The dialogue events focused on policy and regulatory questions for the European Union (EU) and the United Kingdom (UK) in the context of their trade relationships with each other and with third countries, especially in North America and sub-Saharan Africa.

This briefing identifies the major themes arising from the dialogue and documentary sources, and sets out a number of outstanding questions for policy.

[1] DNA stands for deoxyribonucleic acid, a type of molecule often referred to as the genetic 'building blocks' of life.

[2] GEAP3 Briefing 1: 'Genome Editing in Agriculture: Issues for Policy and Regulation' (available via geap3.com/policy-hub)

[3] See geap3.com and the details at the end of this briefing.

Making way for genome editing

Some scientific advisory bodies and lobby groups have urged European governments to facilitate the early and rapid deployment of genome editing in agricultural as well as medical applications (see Box). A genome-editing technique known as CRISPR (see GEAP3 Briefing 1) has been heralded by scientists and business leaders as an opportunity to develop improved crop varieties more quickly and reliably. This is often described as a chance to meet pressing challenges such as climate change, global food security and a more sustainable agriculture.

Scientific bodies and lobby groups call for regulatory changes to enable rapid deployment of genome editing in agriculture

"leading scientists representing European plant and life sciences research centres and institutes endorsed a position paper to urge European policy makers to take action in order to facilitate the potential of genome editing for agriculture, in Europe."

ALLEA – All European Academies, 2020[4]

"the science academies and the DFG see an urgent need to reassess the products of the much more precise and efficient methods of genome editing and to amend European genetic engineering law."

Leopoldina National Science Academy, German Research Foundation and the Union of German Academies of Science, 2019[5]

"Subjecting crops obtained through modern genome editing to GMO regulations will deny European consumers, producers, researchers and entrepreneurs important opportunities in sustainable agriculture. Therefore, an urgent review and amendment of the European legislation on new breeding technologies is needed."

EUSAGE – European Sustainable Agriculture through Genome Editing, no date[6]

[4] ALLEA – All European Academies, 2020. Genome Editing for Crop Improvement. Symposium Report. Berlin, DE: ALLEA – All European Academies. https://allea.org/wp-content/uploads/2020/10/ALLEA_Gen_Editing_Crop_2020.pdf

[5] Leopoldina National Science Academy, German Research Foundation and the Union of German Academies of Science, 2019. Stellungnahme: Wege zu einer wissenschaftlich begründeten,differenzierten Regulierung genomeditierter Pflanzen in der EU | Towards a scientifically justified, differentiated regulation of genome edited plants in the EU. Berlin, DE: Nationale Akademie der Wissenschaften Leopoldina, Deutsche Forschungsgemeinschaft and Union der deutschen Akademien der Wissenschaften. https://www.leopoldina.org/uploads/tx_leopublication/2019_Stellungnahme_Genomeditierte_Pflanzen_web_02.pdf (Quotation taken from the English-language short version of the statement.)

[6] EUSAGE, no date. Regulating genome-edited organisms as GMOs has negative consequences for agriculture, society and economy. Position paper. European Sustainable Agriculture through Genome Editing (EUSAGE). https://www.eu-sage.eu/sites/default/files/2020-02/Position%20paper%20on%20the%20ECJ%20ruling.pdf

Other stakeholders are concerned that novel technologies that can be applied to positive ends can also be used in ways that do not produce broad benefits for society or the environment. They highlight problems in modern agriculture that stem from previous rounds of technological innovation. Even if modern farming technologies and methods have led to positive outcomes, such as increased global production of some major food crops, they have also generated various undesirable consequences, such as air and water pollution, soil erosion, greenhouse gases, and declining biodiversity.

Participants in debates about genome editing also look back at experiences with transgenic crops (a previous generation of genetic engineering applied to plant breeding, often known as genetically modified or GM crops). These were intended to make crops resistant to pests and diseases, increase crop yields, provide farmers with more convenient and financially efficient crop management options, and improve the nutritional composition of food crops.

However, some of these promised crops have not yet seen the light of day, and among those that have been commercialised are GM crops that have been associated with accumulating problems. Crops that were designed to withstand herbicides, which were supposed to assist farmers with weed control, have been associated with a very large increase in the use of the chemicals, leading to the development of an increasing number of herbicide-resistant types of weeds that are more difficult and expensive for farmers to control. In some cases, GM crops that were given built-in defences against insect pests have stimulated the evolution of insect populations that can withstand the pesticidal toxins that the plants have been engineered to produce.

The genetic engineers' solutions to these new problems often involve more genetic engineering, to develop new types of GM crops that incorporate resistance to several different kinds of herbicides, and express multiple toxic proteins that kill insect pests in different ways. Critics contend that this amounts to an arms race – a technology treadmill, which draws farmers into ever higher costs and deepening dependence on the agri-business companies that supply the new technologies. If genome editing ends up entrenching and intensifying this dynamic, they say, then it will not do much to help address the urgent challenge of achieving a more ecologically and economically sustainable agriculture, especially over the longer term.

Proponents of genome editing, including some who participated in our dialogue events, say that the new techniques are more sophisticated, which will enable molecular plant breeders to generate new crops with complex and valuable traits, such as drought tolerance, that have proved difficult to develop using GM technology. They argue that CRISPR is an essential tool for achieving sustainable and resilient agriculture and tackling climate change within the next few years.

Other participants in our dialogue events questioned this contention. Just because genome editing offers a new way to snip and splice genetic material, they said, does not mean that scientists have yet mastered understanding, or controlling, the expression of complex genetic traits in living organisms and real environments.

The critics worry that genetic engineers, when talking to policy makers and the public, advertise speculative future benefits of CRISPR while downplaying uncertainties that are discussed in the scientific literature, and focus only on narrowly defined risks and safety issues without attending to larger concerns about the social, economic and environmental purposes and impacts of genome editing in agriculture.

Precision means control?

CRISPR is often described as a very precise technique, but the attribute of precision can convey different meanings to different audiences.

Technically, precision in CRISPR refers to the way the tool can be targeted to cut an intended location in the genome, where it can make small changes which affect a small number of base-pairs of DNA. In their precision, CRISPR and other genome-editing tools have been compared favourably to the previous generation of transgenic techniques, which incorporated genetic material randomly into an unpredictable site within the host genome (see GEAP3 Briefing 1).

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The exactness of genome editing at a molecular scale has been taken to imply that CRISPR also provides certainty and control at larger scales. According to this view, CRISPR is as safe as, or even safer than, previous techniques of transgenic and conventional breeding, because it involves genetic alterations that are more deliberate, more predictable, and easier to verify and monitor. Policy makers, politicians and media pundits have picked up on this message that CRISPR is safer, and this seems to be influencing debates about the appropriate regulations to govern genome editing and its products.

However, critics dispute the inference that molecular precision also means safety on the levels of the organism, ecology and society. These critics make their case in a number of ways. They point to scientific reports in which CRISPR was found to have created unintended changes in genomes, both at the target location and in non-target areas. They remind stakeholders about the degrees of uncertainty that still remain in genetic engineering, in spite of advances in scientific knowledge. They urge scientists and regulators to take explicit account of epigenetics, which can change the expression of genetic traits, in ways that are heritable, without corresponding changes in the underlying DNA; and pleiotropy, which is the ability of genes to influence the expression of more than one trait. They argue that ongoing uncertainty about the operations and effects of these biological mechanisms implies a continuing need for careful and cautious regulation of genome-edited organisms on a case-by-case basis.

Should we worry?

Some molecular biologists argue that the existence of unintended effects is not a cause for alarm or a justification for strict regulations. They point out that multiple random mutations are apt to occur in living organisms without any direct human intervention, and are common in conventional crop breeding. They also point to the decades-long safe use of mutation breeding, which works by exposing genetic material to radiation or chemicals, and can also produce multiple random mutations at one time. Compared to these changes, say these scientists, the deliberate alteration of one or a handful of genes represents a very small risk. They explain that crop developers typically carry out genetic screening and other checks to ensure that the changes created through genome editing are as intended, and have not produced negative side-effects (see GEAP3 Briefing 1). Overall, supporters of genome editing assess the risks posed by genome editing to be small in proportion to the advantages, which are quantifiable in terms of time saved and financial resources conserved.

Other stakeholders doubt whether the genetic mutations generated by genome editing, mutation breeding and traditional cross-breeding techniques are really as well understood as supporters claim. They wonder whether it is safe to assume that genetic changes that are generated by quite different processes of genetic modification are essentially similar, or if that hypothesis should be tested scientifically (and if so, how that testing would be done).

> [Some experts find that] consumers and citizens seem to weigh the risks and safety of novel genetic technologies against the purposes for which they are applied, as well as the size and distribution of the social and environmental benefits they could generate. Answering these societal questions could be the most important challenge for the promoters of genome-edited crops.

After a genetic alteration has been generated using genome-editing tools, the processes that occur afterwards still depend on some basic principles of genetics and rely upon some traditional breeding techniques. The molecular breeder must still contend with uncertainty over how genetic changes at the molecular level will affect the expression of plant traits. The uncertainty arises from epigenetics and pleiotropy, and from the potential for changes in DNA to lead to unpredictable changes in RNA, or at the levels of protein expression (proteomics) or metabolism (metabolomics). These effects need to be analysed and fine-tuned before a viable cultivar is ready for release to farmers, and regulations may also

require this to be done. These steps still take time, even if the process of genetic alteration at molecular level, using genome editing tools, is relatively quick.

Genetic marker-assisted breeding techniques have already helped to accelerate conventional plant breeding methods, enabling breeders to quickly develop useful and commercially valuable new traits without the help of genetic engineering. This leads some observers to doubt whether the speed advantages of the CRISPR tool for plant breeding are as decisive and compelling, in practical and economic terms, as some genetic engineers believe.

With these thoughts in mind, is CRISPR technology as revolutionary, in its practical utility, as some scientists assert? In the words of one participant in our expert dialogue, "Where are the 'killer apps'?"

The doubters want to see evidence that new genome-edited crop varieties will really enable farmers to achieve a step-change in sustainable productivity, resource-use efficiency, or other desirable objectives, or do so any quicker than other methods of crop improvement.

Participants in our expert dialogue noted that this kind of circumspection is often echoed by members of the public when they participate in public dialogues, consultations and focus groups: consumers and citizens seem to weigh the risks and safety of novel genetic technologies against the purposes for which they are applied, as well as the size and distribution of the social and environmental benefits they could generate. Answering these societal questions could be the most important challenge for the promoters of genome-edited crops.

Co-existence and freedom to operate

Another topic of discussion, which genome editing has inherited from earlier debates about GM crops, is the potential for genetically engineered and 'conventional' crops to co-exist. If farmers or consumers wish to exercise an individual choice to accept or reject genetic engineering technologies, is it feasible for different production systems to operate, comfortably, side-by-side in the same landscapes and markets? If the two systems cannot exist in close proximity without creating friction, are governance measures available that could allow stakeholders to pursue their private interests without coming into conflict?

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It has been argued that systems of liability and insurance could incentivise users of genome-edited crops to keep their operations from harming neighbours who are non-users, and resolve disputes fairly and equitably. But for what kinds of 'harm' would liability arise, and what forms of compensation would be appropriate and effective?

Some participants in our expert dialogue were concerned that calls from industry and scientists to deregulate genome-edited crops are ignoring the problems of co-existence. They worry that complete deregulation would mean that farmers and consumers who want to avoid genetically engineered crops would be denied the freedom to do so, or would be burdened with all the costs of keeping genome edited and non-genome edited crops separate. On the other hand, supporters of genome-editing object to systems of regulation that place burdens of liability on farmers who want to grow the new crops, and require genome-edited foods to be segregated and labelled. They believe that such measures are not justified by an objective risk of harm, yet they discourage the use of a technology that could generate broad benefits for society and the environment.

Better regulation

Stakeholders who support a liberalisation of rules governing genome editing in agriculture argue that the costs of excessive regulation should be weighed alongside the costs that arise from insufficient regulation. A commonly heard criticism of the way GMOs have been governed is that regulations have made the cost of commercialising a new GM crop so high that it has only been accessible to large companies with deep pockets, and only attractive for large-scale, industrial farming applications in the world's most commercially important crops.

This argument is not confined exclusively to scientists who support the rapid liberalisation of genetic engineering applications, including new genome-edited crops. Various other stakeholders, including some civil society groups, environmental campaigners and small-farm organisations, agree that new regulations are needed which could support the development of modern biotechnologies by smaller firms and public-sector breeders, to create solutions for neglected 'orphan crops', small-scale farms, narrow agro-ecological niches, and for more diverse kinds of agriculture.

Another area of regulation is intellectual property. Some stakeholders are concerned that transgenic organisms and enabling technologies can be patented, which often has the effect of limiting access to technologies and germplasm by public and non-profit breeders. Also, university science has become more dependent on corporate research funding. Some contributors to our dialogue held the opinion that patent protection is inappropriate for technologies that are in principle cheap and easy to use, so that they can be used to develop new commercial products quickly.

According to this argument, in such cases, there is no need for patent protection to incentivise the large and long-term investments needed to support slow and costly research and development. The argument implies that, since CRISPR is widely hailed as a simple and affordable technology, it would not be appropriate to protect genome-editing tools with intellectual property rights.[7] This argument also carries the implication that it would be regrettable if stringent safety regulations were then to impede the rapid commercialisation of useful new technologies.

[7] Another consideration is whether it will be possible to detect genome-edited organisms and distinguish them from organisms that have been developed using other mutation-breeding techniques; if not, patents might prove to be hard to enforce anyway (see GEAP3 Briefing 1).

Societal benefits and public goods

Some contributors to our dialogue expressed scepticism about the idea that simply deregulating genome-edited crops and foods would automatically lead to the development of socially and environmentally valuable products. Profit-driven commercial actors typically prioritise private benefits and short-term rewards over public goods and long-term benefits. A different mechanism is needed to promote innovation in the public interest. Some of our dialogue participants are involved in promoting policy frameworks for 'responsible research and innovation' (RRI), which aim to ensure that societal goals are more likely to be achieved.

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A legal expert who participated in our dialogue raised an objection to the notion that regulators should require product developers to demonstrate a broad social benefit before their genome-edited crops and foods could be permitted. The principled argument behind this objection was that, in a liberal society, individuals and companies were, or should be, free to pursue private interests, regardless of whether their activities benefit wider society. Underlying liberal-democratic constitutions is a presumption that private actors may apply technologies to secure private benefits, provided they are not doing immediate harm to others.

The policy challenge that arises here is whether such a laissez-faire principle provides a sound basis for the responsible governance of novel technologies' wider impacts and long-term effects, especially insidious negative impacts that are not perceived until later, or which externalise costs inequitably onto society or certain communities.

Precaution, post-caution?

The Precautionary Principle (PP) is a principle of technology governance which aims to guide policy makers towards responsible decision-making in contexts of scientific uncertainty. Critics of the PP say that it is an 'anti-innovation' or even an 'anti-science' principle. However, when properly applied, it is better understood as a principle that should help to steer innovation towards socially useful and beneficial purposes. The point is that the PP encourages innovation in the light of careful reflection about the purposes and benefits to be realised. Taking risks under uncertainty can be justified, transparently, if the purposes and benefits are substantial enough to merit the risk, and if precautions are taken to avoid, monitor and mitigate harm.

While some scientists have called for the PP to be rejected, more moderate scientific voices accept that a precautionary approach is appropriate where there is genuine scientific uncertainty. However, they point out that a proper application of the PP requires mechanisms to review and revise precautionary measures as scientific uncertainty diminishes. One participant in our expert dialogue captured this spirit when they called for the PP to be complemented with "post-cautionary" reviews. These reviews would create an 'exit strategy' from precautionary regulations when scientific understanding improves, and evidence accumulates which indicates that risks and hazards are small. According to this approach, governments should systematically revisit precautionary laws after an appropriate period, assess the performance and impacts of previous regulatory choices, and revise them appropriately.

Proceeding responsibly with novel technologies

How should societies and governments proceed with genome editing? Opting for light-touch regulation of genome editing applications across the board would imply that accelerating the adoption of these technologies is an intrinsically desirable thing to do. From this optimistic viewpoint, new technologies like genome editing can be assumed a priori to lead, on balance or in aggregate or eventually, to outcomes that are socially, economically and ecologically positive and sustainable. However, technologies of many kinds can be and have been applied for deplorable as well as benign purposes; they may be used to advance private agendas that are not necessarily in the public interest; and they can be deployed in pursuit of short-term and local advantages while producing serious, enduring and highly consequential problems at larger spatial and temporal scales. Assuming that rapid innovation and technological change are intrinsically good and desirable things is naïve, ahistorical and potentially reckless.

Innovation optimists often argue that, without the technological innovations of the past, human society would be a lot worse off today. People who ask sceptical questions about genome editing and other cutting-edge innovations are sometimes portrayed as luddites with a poor grasp of history, who underestimate the benefits of the numerous modern technologies that underpin human wellbeing today.

Since the industrial revolution and the dawn of scientific breeding, technological change in agricultural methods and practices has indeed driven a huge transformation of farming and food systems. However, it is also undeniable that modern, intensive farming methods have been associated with serious environmental and social problems, including erosion and salination of soils, chemical pollution of air and water bodies, the destruction of biodiversity, draining of water reserves, unsustainable consumption of fossil fuels, large contributions to greenhouse gas emissions, homogenisation of global diets and the persistence of hunger and under-nutrition alongside diseases associated with obesity and overweight.

> The challenge, for governments and society, as they consider what to do about genome editing in agriculture, is to balance competing priorities, steer innovation, take responsible decisions in the light of uncertainty, consider ramifications and alternative scenarios, and take care over the distribution of costs, benefits and risks.

Neglecting to consider problems like these, including their links to historical innovations in agricultural technologies and methods, reflects

a common flaw in reasoning. It displays a kind of survivorship bias, whereby it is assumed that whatever happened in the past must have been beneficial, on balance, since those of us who are alive today are evidence that the good choices and decisions of our ancestors allowed our technologically sophisticated modern society to survive and prosper.

This seductive and plausible argument contains a logical flaw. It systematically ignores and devalues all the things that were lost along the way. It downplays the new problems which our technological trajectories have generated, albeit unintentionally or through ignorance. It overlooks the possibilities that existed at times in the past to do things differently; to choose alternative technological paths, and to achieve different outcomes, which might even have been better than those we enjoy today.

We know that agriculture faces many challenges in the current century and that new and existing technologies will need to be employed in new ways to meet them. The challenge, for governments and society, as they consider what to do about genome editing in agriculture, is to balance competing priorities, steer innovation, take responsible decisions in the light of uncertainty, consider ramifications and alternative scenarios, and take care over the distribution of costs, benefits and risks.

Some participants in our expert dialogue shared the view that it would be essential to bring a wide cross-section of society into the conversation, in order to deliberate over the distribution of costs, benefits and risks for different people, groups and interests. The scope should embrace socio-economic as well as biophysical risks, and the interests of future generations as well as those currently alive. It should consider how to generate public goods (as well as how these should be defined and assessed), not just private benefits. It should weigh the costs of inaction as well as of action. A frank appreciation of uncertainty should be at the centre when considering both risks and benefits.

Questions for policy and decision making

Here are some questions for European and other policy makers and decision makers to consider, relating to the future governance of genome editing in agriculture and food.

- If the regulations applied to (some) genome edited organisms differ from the rules applied to transgenic organisms (GMOs) in agriculture and food, what principled grounds will explain and justify the difference in treatment? Will the rules distinguish between different types of genome-edited organisms according to whether the final product contains transgenes, and/or the magnitude of genetic changes made (see GEAP Briefing 1)? How will the grounds used to draw such distinctions be clearly defined, articulated and defended to stakeholders and publics?

- Will policies and regulatory frameworks governing genome editing in crop improvement take account of the proposed social purposes and plausible public benefits that could be attained using general or specific applications of the technology? If such intended purposes and future benefits are to influence regulatory decisions, how could they be assessed and weighed against potential risks and harms? Could crop breeders be required to articulate or demonstrate a societal benefit in order to win regulatory clearance for their genome edited organisms? Would it be reasonable to require applicants to show that the proposed objectives could not be achieved economically or efficiently in other ways, without using genome editing?

- What accountability exists for making promises about the benefits of genome editing and its products? If the projected benefits do not materialise, or are unevenly distributed, or come with serious side-effects, who is accountable for that? If there is no effective accountability for such promissory statements, what value should policy makers give to them?

- Can we rely on the developers of genome-edited organisms, nationally and internationally, always to be responsible and conscientious in checking for unintended on- and off-target effects, and to identify risks and manage hazards that might arise from them? If we cannot rely solely on responsible behaviour by product developers, what regulatory measures could provide assurance that developers are not taking unreasonable or disproportionate risks or exposing others to unacceptable harm? Could a regime of liability and redress, underpinned by insurance, play a role here?

- To what extent, if at all, should considerations of international trade influence policy and decision making on genome editing in agriculture? What would be the implications of regulatory non-alignment, in relation to genome edited organisms, for trade and other international relationships (such as international development aid and technical cooperation)? How can or should policy makers and regulators in Europe work with international partners to co-ordinate regulatory processes, decision making and outcomes for genome editing that will promote sustainable and resilient agriculture, food security, and other desirable objectives across borders and at a global scale?

- Will public and consumer values and attitudes be taken explicitly into account in the design of regulatory frameworks, or in the approval process for specific applications of genome editing in agriculture and food? How could public concerns be included transparently and effectively in deliberations that lead to decisions?

- How will the Precautionary Principle and the principles of Responsible Research and Innovation inform the governance and regulation of genome editing in agriculture and food?

- Does the proper interpretation of the PP entail that the implementation of precautionary rules should be followed by regular 'post-cautionary' reviews, which would allow regulations to be revised when scientific uncertainty diminishes? Is it possible for regulatory protocols to define a point when research, having sought but failed to identify or discover negative effects, provides sufficient evidence to provide confidence that risks and hazards are absent, or small enough, to justify full or partial deregulation?

- Will the governance framework for genome editing in food and agriculture allow both 'genetically engineered' organisms and 'conventional' crop production systems to co-exist, both on farms and in markets? How could this be accomplished in practice?

The GEAP3 Project Policy Hub

The Genome Editing and Agriculture: Policy, Practices and Public Perceptions (GEAP3) network is an international research consortium that brings together social scientists, policy experts and bio-scientists to explore the domestic and international ramifications of the EU's policy and regulatory approach to genome editing in agriculture. The network is exploring and analysing key developments in genome editing and their implications for agriculture through three hubs: policy, practice, and public perceptions.

The GEAP3 Policy hub has explored systematically the implications of the EU's regulatory approach to genome editing. The hub examined how competing visions for the governance of genome editing conflict or may be reconciled.

The work of the GEAP3 network is continuing in the Practices and Public Perceptions hubs.
For further information on the GEAP3 network and its three hubs, please visit the project website at https://www.geap3.com

Other GEAP3 briefings in this series

Briefing 1: Genome Editing in Agriculture: Issues for Policy and Regulation

Briefing 2: Genome Editing in Agriculture: The Politics of Regulation in the European Union

Briefing 3: Genome Editing in Agriculture: Regulation in the United Kingdom after Brexit

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Further reading

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Research Topic: Plant Genome Editing – Policies and Governance. *Frontiers*. https://www.frontiersin.org/research-topics/7596

Van Der Meer, P., G. Angenon, et al. (2021). 'The Status under EU Law of Organisms Developed through Novel Genomic Techniques.' *European Journal of Risk Regulation*: 1-20. https://www.cambridge.org/core/journals/european-journal-of-risk-regulation/article/status-under-eu-law-of-organisms-developed-through-novel-genomic-techniques/4812A77647B94B3BB789D3532379C081

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