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A UK-CGIAR Centre Dialogue Report

Opportunities for Alignment in Global Genome Editing Policies and Regulations

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Collaboration in Science and Innovation

Contents

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Executive summary

Twenty-first century agriculture faces multiple, intertwined and complex challenges. With the now-impossible "zero hunger" sustainable development goal receding into a rose-tinted past, agriculture must become more productive, more resilient to both biotic and abiotic stresses and do so with fewer chemical inputs and a smaller greenhouse gas footprint (Godfray et al., 2010; FAO et al., 2020). This complex challenge has been picked up by the UK-CGIAR Centre and many other research centres of excellence globally who share a vision of global food security, healthier populations and a sustainable agricultural system.

One new tool is gene editing (GE) – plant breeding in a more precise way to accelerate the genetic improvement of crop species. In parallel to the exciting developments in science and innovation, the enormous potential of GE is being recognised by lawmakers around the globe. At the time of writing, 34 countries have already adopted specific policies to enable the development and deployment of GE crops. But the speed and breadth of policy adoption do pose risks to achieving the ultimate impact. There are communication shortfalls between technical and regulatory stakeholders that impede the review and commercialisation of GE innovations. There is also an absence of global coordination for agreed GE regulatory standards, risking differences in how the same products are classified and managed across neighbouring and trading jurisdictions. Unless solutions are found, these issues could constrain the timely and widespread uptake of potentially transformative innovations to address global food and environmental challenges.

This dialogue report shares insights from a UK-CGIAR Centre mutual policy learning workshop to provide context and recommendations for GE regulatory alignment. Alignment here means where countries apply different policy approaches, but those that converge on similar intentions to enable widespread societal benefit from GE crop innovations. Doing so respects that countries might have shared objectives for regulation but different preferences for the systems and processes by which they achieve those aims. Such alignment would reduce duplication, support cross-border trade, strengthen trust between regulators and developers, and enable GE innovations to reach farmers, consumers and ecosystems more quickly. GE policy alignment efforts have already taken place at regional levels, particularly across Central and South American countries, resulting in coordinated, efficient frameworks for exchange of GE innovations. Learning from initiatives such as these we provide five recommendations for unlocking clearer, more enabling policy environments to realise societal impacts from GE crops:

1. Establish a cross-disciplinary GE community of practice. This should be a GE network, involving policy makers, researchers, regulators, businesses, communicators, environmentalists and farmers. The CoP will develop knowledge products essential for improving understanding and support of GE as an important tool for building resilient, nutritious and sustainable food systems.

2. Improve monitoring and visibility of GE policies, secondary legislation and the details of these. Some GE regulations are more visible and accessible than others, causing uncertainty and constraining collaboration with technology developers. We recommend the development of open web tools to further improve the accessibility of these regulatory documents and the national regulatory teams involved.

3. Improve learning and knowledge exchange around public engagement for GE. Public perception and acceptance of GE products continues to be an area of uncertainty in how best to measure and engage with. More is needed to understand public perceptions towards these products and successful communications strategies to improve dialogue. These tools must recognise that public concerns are not only based on biological understanding, and must speak to wider topics, such as patents, control and inequality of GE benefits. Social media must play a more central role in how GE developments are discussed and shared.

4. Investigate options for an international instrument or body to guide policy and regulatory alignment and standards. While international agreements and treaties inform practice around other genetic resources and technologies, no such instrument exists for GE products. Given the widespread changes around GE regulation and the novel nature of the technology, international guidelines or a body should be created to bring clarity, agreement and provide a foundation for policy alignment efforts.

5. Learn from regulatory alignment beyond the field of GM. GE regulatory conversations often centre around experiences from the GM regulatory conversations but lessons for regulatory alignment could also be learned from fields such as biocontrol, gene drives, fair trade and forest certification. These include, discussion of risk assessment, risk management and labelling of products to signal qualities that are otherwise invisible to consumers. Engaging with these wider regulatory practices and experts could draw on a greater knowledge bed to inform future policy.

Achieving these recommendations, and working with governments and partners such as the UK-CGIAR Centre, CGIAR system, AUDA-NEPAD, could help ensure that GE technologies are governed responsibly while enabling their contribution to food security, resilience and sustainable development.

Introduction

Gene editing (GE) offers a tool with enormous potential for transforming agriculture, health and sustainability but this technology is unlikely to achieve impact without enabling regulatory environments. Regulations are changing globally with regard to how GE products are recognised, categorised, released for market and traded. These changes began with the first GE regulations in Argentina in 2015, which went on to inform regulatory changes in surrounding South America countries, becoming a model for other regions and countries globally (Whelan and Lema, 2015). In the last eleven years, 34 countries now recognise GE as distinct from genetic modification (GM) and liberalising regulatory procedures, with another 39 in the process of changing to recognise GE distinctly from GM (Heaton et al., 2026; Heaton et al., 2026; Ricroch et al., 2026). This time of change offers great potential, but also raises challenges in two main areas which risk constraining the research, development, stewardship, commercialisation and impacts of GE-based innovations.

The first challenge is a communication shortfall between regulators, researchers, businesses, farmers and the public. This takes place at both national and international scales. GE technology is rapidly advancing, and more quickly than the policy designed to regulate the resulting advancements and scientific innovations. This rate of change around GE technology development and regulation risk uncertainties between actors of the latest developments on both the scientific and regulatory sides. This uncertainty presents an efficiency issue, where potentially useful GE technologies are not acted upon or delayed in regulatory decision making, commercialisation and scale-up at country, regional and global levels. The rate of change and nature of GE technology and policy changes could also influence public perception, acceptance and how best to communicate the value of new GE technologies to realise uptake and impact.

The second challenge is in coordination of regulatory action and technology diffusion. Many countries accepting GE follow similar patterns in regulation, with particular convergence in regulating transgene-free, or 'precision-bred', products in the same or similar ways as conventionally-bred crops. There are however nuances in the boundaries of how these GE crops are classified and most countries follow their own distinct national regulatory frameworks. In a context of globalised food systems, and a world with a shared polycrisis of issues, there is benefit in global alignment of regulatory systems which enable cascading or streamlined approval systems for accelerated deployment at scale (Lowe, 2021; Qiao et al., 2022).

In this report, we highlight opportunities and suggest approaches to support global coordination efforts to support GE development, regulation and

deployment for more nutritious, resilient, profitable and sustainable food systems. These opportunities arise by convening existing initiatives and institutions towards the shared aim of benefiting farmers, consumers, communities and ecosystems. For example, International Maize and Wheat Improvement Center (CIMMYT)'s partnership with the ag-biotech company Pairwise, using its Fulcrum platform to accelerate trait development across 20 countries, and the joint CGIAR/IITA and IRRI work on disease-resistant, high-yielding bananas, illustrate how existing CGIAR breeding pipelines are already integrating CRISPR-based editing at scale (CIMMYT, 2025).

This report is informed by conversations held as part of a mutual policy learning event in June 2026, London, UK undertaken as part of the UK-CGIAR Centre, involving representatives from America, Egypt, England, Kenya, Pakistan, the African Union and the CGIAR Gene Editing Initiative. The exercise was designed to facilitate the exchange of evidence, methodologies, experience, lessons learned and best practices between jurisdictions with an interest in benefitting from GE technology. The group was composed of policy makers, research communities and agricultural sectors. This resulting report shares conversations across the agricultural research space, and so are relevant to crop and livestock applications, but many of the findings and arguments bear relevance to wider GE innovation. In the following pages, we reflect on how jurisdictions are moving at different speeds and through different institutional routes, towards a shared regulatory logic for GE regulation. This logic is that transgene-free GE products should be assessed case by case and treated more like conventionally bred crops than like genetically modified organisms (GMOs), the legal instrument chosen to get there, and the institutional architecture built to sustain it. We close with suggested next steps that came out of the workshop.

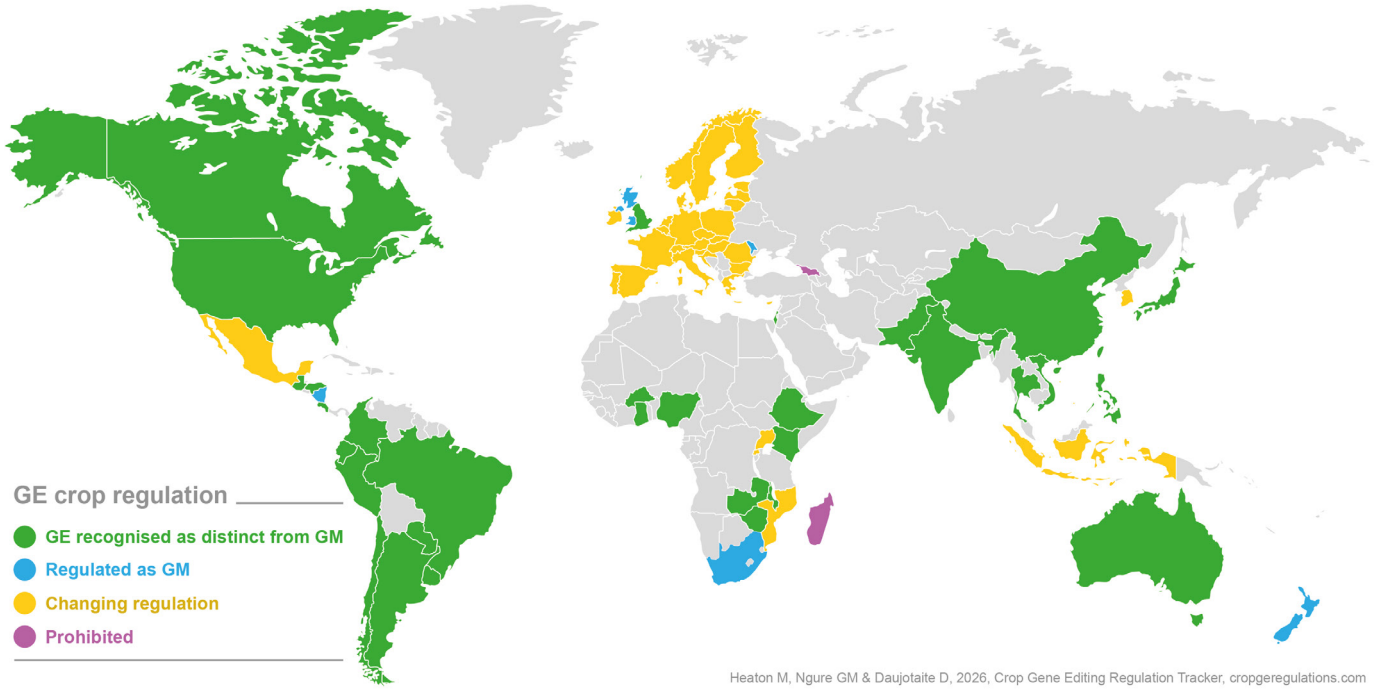


Figure 1: *Regulation of gene edited crops globally. Ongoing updated maps can be found at https://cropgeregulations.com/maps*

Regulatory context & developments

Gene editing, with the discovery of the CRISPR Cas9, created a much more precise and less costly way to edit the genetics of organisms than previously possible through conventional breeding and GM approaches (Kalaitzandonakes et al., 2023; Van Eck, 2020) . Such precision improvements open up greater potential for the improvement of crop, livestock and microbe products to benefit people and the planet. It is these kinds of GE innovations that provide tools to face the polycrisis of rising diet-related disease, climate change and ecosystem loss. But these kinds of GE products are also new in terms of regulatory categorisation.

The discovery of Genetic Modification (GM) brought with it not only the awareness of greater human control to move useful traits between species, but also the concept of 'transgenes' (foreign DNA

from outside the species' normal breeding pool) and how to regulate these appropriately for human and environmental health (Sundaram, Ajioka and Molloy, 2023). As such, regulation around the world largely organised into a binary grouping of a product being 'conventionally bred' (i.e. produced using a wide range of historically used approaches and transgene-free) or a 'Genetically Modified Organism' (i.e. created through GM approaches and containing a transgene). Such groupings were made on the precautionary principle of needing to evaluate and control any potential risks to humans and the environment arising from transgenic material. Consequently, GM products and their associated transgenes are subject to additional regulatory controls governing their movement within and across national borders. These controls are established internationally through the Cartagena Protocol on Biosafety and are further operationalised through national biosafety policies, laws, and regulatory frameworks. Where GE approaches have been particularly disruptive is that they use similarly lab-based procedures to GM, but can result in transgene-free products (Podevin et al., 2012). On these grounds, bioscientists and regulators have largely argued that the GM regulations that have been developed since the 90s are not sufficiently designed to govern the range of GE products. Instead, many countries are updating GM policies or are creating GE policies and regulatory frameworks to accurately describe and regulate the emerging GE products.

GE approaches are diverse but can largely be grouped into three kinds of process and output, categorised by the SDN system (Podevin et al., 2013; Mewett et al., 2026). SDN-1 which uses a template-free approach for simple changes to edit genes and can be made to result in a transgene-free products; SDN-2, which uses the cell's innate template repair mechanism to make specific edits, and can be made to result in a transgene-free product and; SDN-3, a method to incorporate genes for more complex changes, which can be used to make transgene-free products but often is used to make products containing transgenes. Where GE products are made to be transgene-free, it is difficult to distinguish by most methods them from those that have been conventionally bred[1.1][1.2]. The only way to confirm that the product was GE would be through record keeping, rather than any biological means of comparison.

A great deal of regulatory debate has focused on how to fairly review any potential risks GE products pose and regulatory processes that would be deliverable in practice. A common argument in the recent regulatory debate is that transgene-free products present no greater risk than the kinds of mutations present in conventional breeding, and therefore should be regulated the same way (Hartung and Schiemann, 2014; Sprink et al., 2016). Such a shift moves to a product focused, case-by-case basis for regulation, where the decision is made on the assessment of each GE product, rather than a process-based regulation where all GE products would be regulated the same way (Sprink et al., 2016; Brookes and Smyth, 2024).

Reducing the regulatory demands on GE products would influence the costs and time requirements to bring a new product to market, and the knock-on ramifications of which actors can engage and which traits are feasible to target. For instance, the research and development costs for proof of concept, demonstration and selection are around 80–85% lower for GE than GM products (Kalaitzandonakes et al., 2023). Similarly, the average GE product would require $24.5m and 14 years to make it through GM regulatory approval and market release, compared to $10.5m and 5 years if using conventional-bred crops (Lassoued et al 2019). Such costs are often prohibitively expensive for publicly funded or smaller private companies, and particularly so when targeting traits with less intrinsic market value, such as nutritional or sustainability traits. Consequently, this can result in developers choosing the most feasible regulatory pathway over the impactful technology. Another argument for reducing the timeline in regulatory approval is that it allows GE technologies to more readily supply innovations to face pressing challenges. For example, bringing in disease resistant varieties to areas where pathogens are already damaging harvests.

A general pattern across countries changing to recognise GE products has been to switch to regulatory categorisation through a case-by-case approach that places transgene-free products into the same regulatory systems as those of conventionally bred crops. GE products can also be made to contain a transgene and the general pattern globally is for these transgenic products to be subject to the same review and regulation as GM products. In some countries, both GM and conventionally-bred crops are managed by the same institute. In jurisdictions where different institutions oversee biosafety and varietal/seed regulation, such as Kenya through the National Biosafety Authority (NBA) and the Kenya Plant Health Inspectorate Service (KEPHIS), products developed using modern biotechnologies are first subjected to a regulatory pathway determination process. Egypt illustrates a country still building towards this model. As the world's largest wheat importer (requiring around 12.5 million tonnes annually), Egypt has strong food-security incentives to expand domestic GE

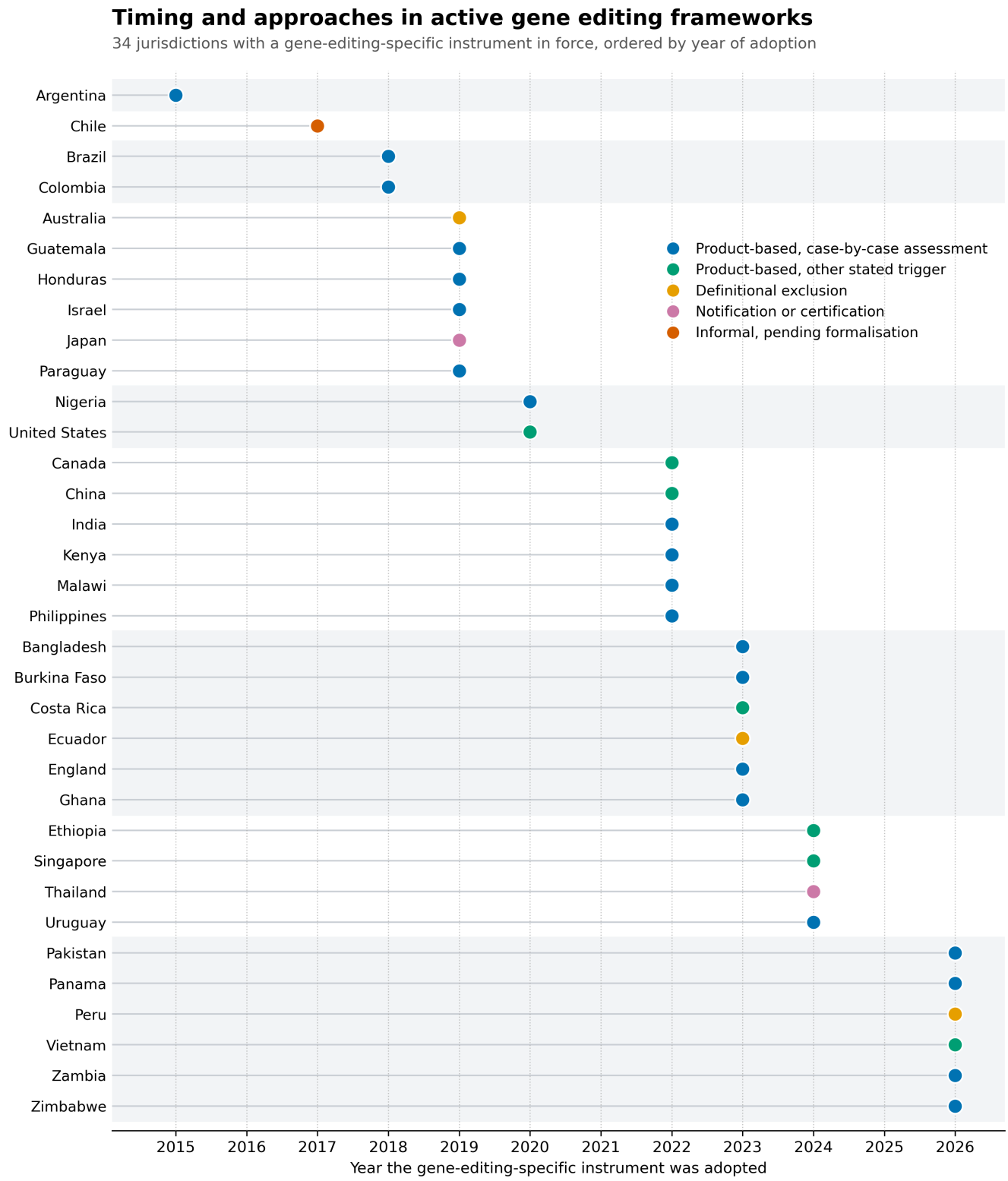


Figure 2: *Timing and approaches in active GE regulation. Categories: Product-based, case-by-case assessment: A developer submits a dossier or consultation request before release, and a named authority rules on whether the product falls inside GMO law. The decision is prospective, product-by-product, and the answer is a determination rather than an automatic exemption. Product-based, other stated trigger: Product-based, but the gate is something other than a case-by-case dossier. e.g., Canada tests for a novel trait. Definitional exclusion. No assessment gate at all, transgene-free products simply fall outside the statutory definition of a GMO. Notification or certification: Exempt from GMO rules but not from the state's attention:a mandatory pre-market step that is not a risk assessment. Informal, pending formalisation: A case-by-case procedure operating in practice without a formalised instrument.*

use, and its Agricultural Research Center is already exploring GE approaches to wheat, sorghum and potato. Egypt has not yet enacted a GE-specific regulatory framework, but its National Food Safety Authority's Decision No. 1/2025, marks a step in that direction, and Egypt is considering following a similar approach.

An area of ongoing discussion is whether and how GE products should be labelled throughout the production and commercialisation space. While a general pattern is that transgenic GE products should follow the national labelling practice, debate has focused on whether transgene-free GE products should be labelled. Where included in conventionally-bred regulatory systems, a general pattern has been for these products to be not labelled differently from conventionally-bred crops at the point of sale to consumers, although a GE history might be retained with the line for breeders to understand the legacy of the material. Some argue that labelling GE products would support consumer choice but challenges come in that such labelling signals a difference from conventionally-bred crops that scientifically cannot be detected (Murigai et al., 2020; Ortega et al., 2022; Yang et al., 2025). Further, this absence of a method to differentiate transgene-free GE products from conventionally-bred crops poses a challenge to how labelling identity could be maintained in the aggregation of crops for use (such as combining wheat grains for flour production regardless of variety) and across complex, international flows of commodities (Entine et al., 2021; Hundleby and Harwood, 2022). The question is therefore not only whether labelling makes sense for products we cannot tell apart beyond records of origin, but whether such labelling would be deliverable from a regulatory standpoint. In the recently accepted EU policy recognising GE products ("New Genomic Techniques") labelling has not been included for transgene-free GE products, but these products are intended to be kept separate from organic markets.

The present situation for GE product regulation described above has largely developed through national and regional discussions, often situated around a country that updates its policy, promoting neighbouring countries to evaluate their stance. This has been particularly evident across countries with less strict regulations on movement of products across borders and extensive local trade arrangements (such as the South American or African countries) where the commercialisation of GE crops in one country is likely to cause the movement of these products to surrounding contexts. Similarly, discussions have taken place with countries which are not connected by land but share extensive trade arrangements. For instance, trade partners with the EU have been reluctant to develop policies treating transgene-free GE products as conventionally bred out of concern that it could affect trade relations. Conversely, Health Canada and FSANZ Australia have been discussing how to align more closely on GE regulation as a pathway to improve trade.

What these international negotiations around GE policies highlight are potential points of divergence in different GE policies and regulations across countries. Many countries are yet to recognise GE, others have different stances on how these technologies should be regulated and nearly every context has a different system of review and permission for use of these products. While GM had a clear international agreement baseline in the form of The Cartagena Protocol on Biosafety (https://bch.cbd.int/protocol), no such agreement, policy or initiative exists around GE. A growing area of the GE policy discourse has shifted to topics of harmonisation and alignment of policies for trade and exchange of potentially useful technologies.

Overall, global GE regulations are at a time of change, with an increasing number of countries recognising GE products as distinct from GM, with the majority ruling to exempt transgene-free products from full GM regulatory requirements. Current trends provide an opportunity for GE innovations to be widely produced, traded and consumed but challenges and fragmentation remain that constrain the full potential of GE products. We focus on these uncertainties and challenges in the next section and offer suggestions for better international collaboration to unlock wide-reaching potential from GE innovation.

Dialogue reflections, challenges and solutions

Several challenges remain across the research, regulation and trade of GE products that continue to constrain the development, sharing and use of GE products. These include: uncertainty and communication shortfalls regarding GE regulatory status, criteria and protocols; fragmentation and a lack of momentum in GE regulatory alignment efforts; capacity shortfalls in GE research and regulatory practice; uncertainty of how best to engage with the public around GE and; challenges with mis- and disinformation on GE technical details, potential and risks (Scheufele & Krause, 2019). Despite these challenges, a promising development is the increasing global appetite amongst regulators, researchers and government departments for closer international working, mutual learning and coordination efforts. Such transdisciplinary connections are essential to develop enabling policy environments to yield impacts from GE technologies. We discuss these topics below.

Communication and advocacy shortfalls around GE innovation

Much of the challenges around GE stem from communications shortfalls. The technical nature of GE causes confusion for many stakeholders who do not hold a bioscience background. Fuelled by a generally held view that GM acceptance was hamstrung by poor communications between science and public, many in the GE field see better communication strategies as an essential to broker widespread support for GE innovations. Such communications shortfalls have driven public confusion about the technology, benefits and risks, partly feeding into disharmony in regulatory agreement and the deployment of GE technologies out of research. But critically, communications gaps also exist between those in bioscience and government fields in support of GE technologies, particularly internationally. Communication gaps between bioscientists and regulatory agents lead to confusion over policies and how to regulate GE technologies. Distance and rate of change between international actors underlies uncertainty over how different geographies are engaging and regulating GE technologies. Greater efforts are therefore needed to address communication shortfalls in how the GE community coordinates, as well as connects with wider society.

Public perception

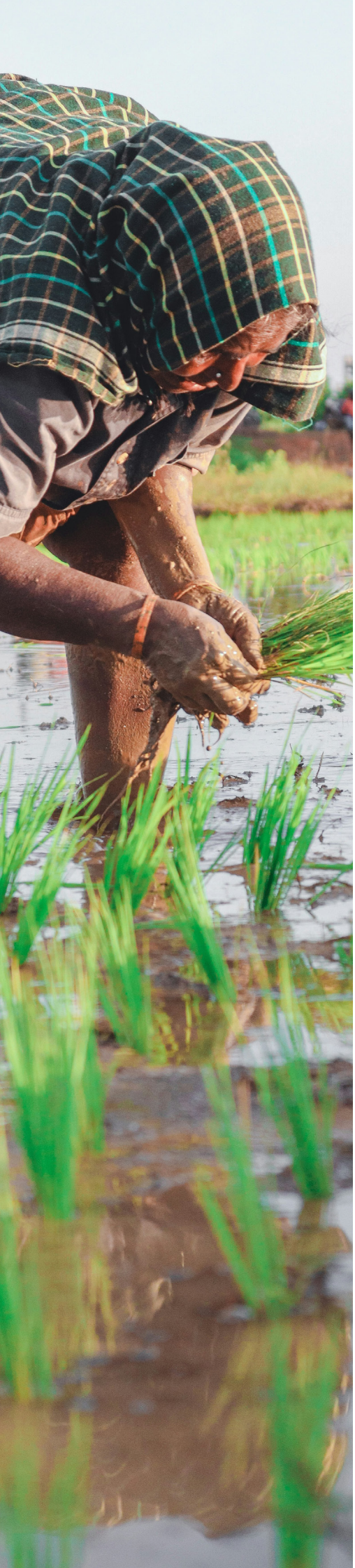
A great deal of attention has been given to how to communicate GE innovation, regulation and products to the public. Perceived risks around GM technologies continue to sway government and public opinion, which can be seen in the number of countries that block GM, labelling of products as 'GM-free' and advocacy groups lobbying to prevent the release and uptake of GE products. There is a concern today with GE developers that this 'GM stigma' will be inherited with GE products (Nawaz and Satterfield, 2022; Spök et al., 2022). This concern is supported by evidence from a Royal Society report on public trust, which found that GM-related fears centred on distrust of multinational companies as profit-driven actors, rather than on the underlying science itself, which was generally trusted. Defra's own 2021 public consultation on genetic technologies, which drew 6,440 responses, was likewise heavily shaped by advocacy groups

opposed to GE, underlining how this debate is driven by questions of motive and benefit rather than technical understanding alone.

The response of many in the bioscience space has been to attempt to close knowledge gaps in technical understanding in the belief that this will encourage the same support they hold for GE technologies and their potential. This approach rests on an assumption that a lack of support is due to a lack of understanding. This 'deficit model' to encourage advocacy became the dominant method of encouraging public support for GM technologies, but ultimately proved to be unsuccessful in achieving uniform support (Marris, 2021). Certainly, understanding of the technical details involved in GE technologies are part of the challenge in wider communication, and this is particularly for individuals without biology knowledge. For instance, there are public concerns about the potential for unforeseeable genetic mutations in GE crop technology, even though the widely accepted products of conventional breeding depend to a great degree upon the harnessing improvements from unforeseeable mutations, and in greater numbers than found in GE product selection (Hartung & Schiemann, 2014; Sprink et al. 2016). Once formed, such narratives are difficult to shift. The persistence of the 'Frankenfoods' framing, alongside public perceptions of biological control, illustrates how early negative framing can continue to shape debate long after the underlying concerns have been substantively addressed. Providing transparent and safe spaces to bridge technical knowledge gaps are certainly needed as part of a strategic communications plan to improve understanding and support for GE technologies, and this is particularly important to stem misinformation on the risks of GE technologies.

Lessons can be learned from how Kenya reduced technical knowledge gaps around GE technical details by providing training to government and media teams on the basic biology behind GE innovations (Ampadu-Ameyaw, Essegbey & Amaning 2021; Menary & Fuller 2024). The Plantwise/Plantwise+ extension services offer a comparable example beyond Kenya, having provided extensive media training for project workers, scientists and extension staff. The result was more equal understanding for policymakers across departments ahead of discussing the potential policy change, and greater scientific grounding in the stories media produced for the public surrounding the policy discussions. Strategic knowledge sharing actions such as this can help reduce understanding barriers around ongoing discussion of the underlying science and its outcomes (Macnaghten & Habets, 2020). The Kenyan example also reminds that information barriers, and the outcomes from reducing them, should be considered not just from a public perception perspective but also with overlapping sectors such as government, farmers, media and lawyers that influence how the technology is regulated, debated and used.

Still, the deficit model is not enough alone to achieve widespread support for GE innovations because not all public concerns are linked to bioscience understanding of the context and also are influenced by diverse actors beyond bioscientists (Weldon & Laycock 2009). This is partly because a common source of public concern around GE centres extends beyond bioscience, involving subjects such as benefit distribution, inequality, vested interests, accountability and how governance influences and is influenced by these factors (Kunyanga et al. 2023; Muringai et al. 2020; Oh & Lee 2025; Ortega et al. 2022; Shigi & Seo 2023; Spök et al. 2022). For instance, explanation of the bioscience does little to address concerns over how GE technologies might be used to promote intellectual property control of biological materials. Such arguments are often not unique to GE



innovation, and indeed are present in conventional breeding, but associate regulatory change discussions with actors and advocacy groups across a spectrum of public trust. The proliferation of social media brought further nuanced discussion to public attention, across platforms that bioscience has both struggled to achieve influence and compelling arguments in short form content (Brossard, 2013; Ji et al. 2022). The result has been a rise of both misinformation and disinformation which have contributed to a wider sense of uncertainty around GE technologies, their intentions and beneficiaries (Scheufele & Krause, 2019).

Inter GE developer and regulatory communications and networking

Overall, there is a need in many contexts to improve the visibility of GE policy and regulation, and doing so would help towards communications, accessibility and transparency of GE regulation. There is a wide spectrum in how countries display their GE policies. Some exist online with a combination of web pages and PDF files for greater information while other governments rely on personal interactions through which to share documents. Some government websites host GE policies but are inaccessible internationally. Shortfalls in the visibility of these GE policies and processes underlies uncertainty by technology developments of where their products might be viable, ultimately risking the omission of potentially useful GE innovations.

Conversations across bioscientists, regulators and private sector highlight often overlooked communication barriers within and between these groups around GE developments and regulatory change. These shortfalls constrain networking and coordination efforts to deliver benefits from GE technologies. The following sections describe these connections at sub-national, national, regional and global levels.

Researcher-researcher connections

On the researcher-researcher connections, a common pattern across countries is that GE leadership or champion products are limited to a narrow number of representatives. Despite the ubiquity of interest across bioscience product development in the potential of GE innovation, relatively few individuals or institutes tend to lead national GE projects, work internationally with other research partners on GE technologies and engage with regulatory actors - particularly when engaging internationally. Part of this should perhaps be expected given the novelty of GE products, the associated lag and competitive nature of public funding for GE developments and often notable resource demands for GE research. Time might therefore support some form of greater representation in this space but two challenges that emerge from situation is that (i) many less visible researchers are going unnoticed who have complementary interests for GE product development and (ii) there are a wealth of GE training materials, tools and resources that are not reaching the wider researchers who could benefit them.

Scientific conferences and literature have, to an extent, always tried to connect research groups around shared interest but greater efforts, particularly across disciplinary boundaries, could further support the wider diaspora of GE researchers. Groups such as the International Service for the Acquisition of Agri-biotech Applications (ISAAA) or even meetings organised by groups such as the British Embassy have worked

to bring actors together around GE, but more support is needed to support longer term network building and knowledge exchange.

Researcher-regulator connections

This smaller researcher pool also influences researcher-regulator connections, where greater connections between researchers with policymakers and regulators could inform GE regulatory change (Lassoued et al., 2020; Menary & Fuller, 2024). This is particularly in the case in contexts where GE regulatory change has been more politically sensitive and governments have been more cautious in pursuing wider interactions. Combined with the aforementioned researcher-research connection challenge, the result is that many GE researchers are disconnected from their national GE regulatory developments. To an extent, these researchers and regulators operate in different, and time-demanding, roles but the ramifications of this fracture are evident in the number of GE innovation developers who are unfamiliar with current regulations despite the immediate relevance of these regulations to the potential deployment and impact of their work. For some researchers, this separation is less of a concern as they view their research as further upstream and more distant from deployment but many researchers would welcome greater engagement. Similarly, GE policy leads and regulators often welcome input from diverse researchers but are unsure of the wider research contacts to engage with. While some countries are an exception to this, in general, greater efforts could be made to support dialogue between a wider array of GE developers, policymakers and regulatory actors.

Private actors

Private GE developers sit separately to the communication challenges between researchers and regulators. With a business viability drive to deploy products for financial remuneration, private actors are often closely connected with regulatory agents and responsive to GE policy changes (Selfa et al., 2021; Smith et al., 2021). The competitive nature of markets incentivises these actors to be ready to act on changing policies and to lobby for changes in potential markets that have yet to change. The factors that tend to slow down deployment by these actors are where countries are less public with their regulatory systems and processes, preventing developers from identifying potential new markets for their technologies.

Because private actors with GE products tend to be the first to bring innovations to markets and are often seen by donors as ideal partners as a mechanism to bring research discoveries to market and achieve impact. But while, on one hand, these private actors tend to have better communication with regulators, they also tend to deliberately prevent communication around the details of their own technology discoveries. The same competitive market pressures that encourage swift deployment may also prevent private actors from sharing innovation details, within regulatory transparency limits. This is often the opposite to many publicly-funded research institutes which release discoveries in full detail through publication and open access repositories. The challenge for private actors is that such discoveries are often not applicable for IP, such as with the discovery of potentially useful genes that already exist in global varieties or the release of open IP around a discovery to enable sharing (Kock, 2021; Lukasiewicz et al., 2024). The lack of control, through IP, therefore often serves to disincentivise private actors from taking up potentially useful discoveries out of concern that they will not have a unique product. While some actors argue that research should be more open to protected IP to enable marketing, others believe that public funding should not be used to make a private good which depends upon blocking access to knowledge.

It is, however, not only IP but also the 'marketability' of GE innovations that restrict the interest and ability of private actors to deploy potentially useful products. Increasingly, research is producing innovations with the potential to alleviate global challenges, such as biofortified crops to address malnutrition, but these same products struggle to deliver sufficient fiscal returns on the quantity focused markets that dominate much of the world. For instance, farmers and supply chain actors are commonly paid on harvest quantity, rather than the nutritional or sustainability qualities of the product, unless these traits bring an efficiency increase or input saving. This is particularly the case with larger commodity flows where harvests are aggregated, diluting nutritional benefits unless varieties are widely adopted or demanding separate funding streams. There is therefore a need to build understanding between researchers, private actors, donors and governments to consider how GE innovations targeting non-market focussed traits could be deployed through markets, such as through changing market incentives or taking public-backed approaches to reach beneficiaries.

A final point of note of a communication shortfall with private actors around GE innovation concerns the critical nature of in-country supplies for deployment. Many of the smaller biotech companies often operate by developing the GE innovation but working with seed producers in other countries who have the

means to partner, bulk and distribute the product in sufficient quantities. Details of these production agents in the country however tend to be even less visible than regulatory details. Improving visibility, capabilities and communications with these locally based production agents could therefore complement regulator networking to accelerate the deployment of GE products from private actors.

Regulator-regulator connections

Despite the global pattern of GE regulatory change and debate, regulators also appear to sometimes struggle to connect with others internationally. Sometimes this disconnect is deliberate, such as when one country worries that signalling their interest in GE regulatory change could influence trade relations with other bodies which either ban or have no experience with GE products. Other times, this disconnect happens despite the prevalence of governments and regulators openly studying and adapting the publicly posted regulations of other countries. The result is often the consideration and adaptation of regulatory triggers, systems and protocols without engagement with the teams who devised them. This can be seen in the 'copy and pasting' of GE policies from early adopters followed by adaptation of these approaches to fit with local departments and consensus. The challenge with this approach is that there are often questions or concerns around the wording, categorisation boundaries and delivery where open discussion would inform greater understanding and clarity in regulatory decisions and the grounds upon which these decisions are made. Regulators across some regions, such as South America and Africa, have been more interconnected in GE policy connections, but this has not happened globally and the result is a patchwork of differing GE policies for the same products (Entine et al. 2021; Heaton et al., 2026 Ricroch et al. 2026). GE technology and products will, however, continue to develop and so too will the policies and systems governing their development, trade and use (Hundleby and Harwood, 2022). Greater communication building between regulators could not only support national GE policies, it could improve alignment of these regulatory practices.

Harmonisation and alignment efforts

Food systems are globalised in both their integration and the challenges they face. GE innovations offer solutions towards some of these challenges but regulatory variation in the management of these technologies constrains use. The global change of GE regulations, and overlaps in how to regulate these technologies, has brought with it discourse about how well these policies work together internationally. This has been particularly relevant for neighbouring countries and trade partners to support the ongoing streamlined movement of goods. Such conversations generally either call for the 'harmonisation' or 'alignment' of GE policies. Harmonisation suggests a push for a more unified policy approach, similar to the adoption of the Cartagena Protocol on Biosafety and its shared protocol for how to respond to the movement of transgenic material. Alignment suggests different policy approaches, but those that converge on similar intentions and results. On this basis, we argue that 'alignment' offers a more inclusive global collaboration effort, respecting that countries might have shared objectives for regulation but different preferences for the systems and processes by which they achieve those aims. As such, we focus on the need for policy alignment in GE policy and regulation.

Policy alignment efforts have taken place at regional levels, particularly across Central and South American countries following the GE regulatory changes by Argentina and the regional alignment discussions that took place in 2018 with neighbouring countries (Whelan & Lema 2015). These discussions resulted in the publishing of shared guidelines for how GE technologies would be recognised and processed, for later considered by the respective governments and enacted into national policy. This approach, led by the global GE early adopter Argentina, demonstrated the value of connecting regulatory agents to create systems that ensure ongoing cross-boundary trade and shared access to potentially useful products. Africa is conducting a similar approach across the continent, led by the African Union Development Agency's (AUDA-NEPAD) program the African Biosafety Network of Expertise (ABNE) which has supported countries to domesticate the CPB through development of national legislation and now partners with them to develop guidelines for genome editing. To date, seven African countries, including Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Nigeria, and Zambia, have developed and published case-by-case GE guidelines. The CAADP Kampala Declaration can serve as a useful platform for elevating the role of biotechnology in building a resilient African agriculture and food systems sector. Individual alignment efforts are also taking place, such as between Health Canada and Food Standards Australia New Zealand (FSANZ). Regional precedents also exist beyond these examples, such as the ASEAN 'Seeds Without Borders' arrangement (IRRI, 2022). A World Health Organization-style set of universal guidelines was, however, generally seen as an unlikely model for GE, given the diversity of national contexts, priorities and capacity involved.

Harmonisation efforts outside of the previous examples have been more limited, despite growing calls for greater collaboration. Much of these discussions focus on differences in: (i) how GE products are categorised; (ii) the tests used to confirm this categorisation; (iii) confirmation protocols of categorisation and the transferability of these across states and; (iv) labelling of products and (v) Risk profiles (in the case of China). It is the nuance in how countries manage regulation across these areas that comprise the wealth of GE policy alignment debate, with the remainder devoted to public perception and acceptance.

Categorisation of GE products is largely shifting globally from a process-based model to a product-based, case-by-case assessment whereby transgene-free products are regulated as conventionally-bred products, often without labelling. This approach is often based on the argument that the absence of additional DNA raises no further risk concerns than the mutations involved in conventional breeding. Differences however exist in how countries consider the size and nature of edits to be considered within this category. For instance, England and the EU are currently also undergoing alignment discussions over whether England's Precision Breeding Act (PBA) should change to match the EU's New Genomic Techniques (NGT) regulation (Van Der Meer et al. 2023). The proposed change in question concerns the NGT's restriction on mutation size as a trigger for more conventional-like or GM-like regulation - a restriction not held in the PBA. In the NGT ruling, no more than 20 mutations and 20 base pair changes can be considered in the NGT-1 category (which grants regulation of the GE product in a conventional-like manner) (Schulman et al., 2025). The challenge for cross-border trade comes in that products with changes breaching this mutation number would be regulated as conventionally bred under the PBA, but NGT-2 (similarly to transgenic crops) in Europe. Such disagreements are pivotal as precision-bred products are already in field trials in England which would breach this mutation limit, meaning that these products would then lose their 'precision-bred' status should England align with the EU. The England-EU conversation has drawn much attention due to the closely embedded nature of these trade partners, but the same difference in opinion is likely to affect many global trade partners with the EU who have GE regulations that do not differentiate based on mutation number.

What these examples highlight is that differences in categorisation become apparent when criteria are public but not all countries share the detailed grounds upon how these decisions are made by review panels. This can be seen in the question of whether countries accept cisgenics as transgene-free products. Some countries, such as England and Kenya, have been explicit that cisgenic changes would not be considered as transgenic (Podevin et al., 2012). Pakistan offers a further, narrower variant of this shift. Its Agricultural Biotechnology Policy, released in May 2026, classifies SDN1 and SDN2 cisgenic crop products as conventionally bred, but does not extend this treatment to animals. This shows that even among jurisdictions converging on a shared regulatory logic, there is still variation in scope of what counts as 'transgene-free'.

A separate discussion lies not only in the nature of the GE change, but how it is measured. CRISPR-Cas derived transgene-free GE products involve a transgenic phase where the Cas9 backbone is incorporated into the genome to enable the edit. Once the edit is made, selection of the progeny can be made where any additional DNA has been lost. Bioscience methods can then be used to confirm the presence or absence of these foreign genetics.

The two main tests of this are Polymerase Chain Reaction (PCR) or full genome sequencing. The difference between these two are that PCRs are readily accessible to most bioscience labs and relatively cheap but are not as exhaustive in detection as a full genome sequence, but such sequencing is much more expensive and is less accessible to most labs globally. Some argue that a full genome sequence is the only way to be completely certain of the presence or absence of foreign DNA. Others argue that multiple PCR strategies are sufficiently accurate to detect an absence of foreign DNA and offer a much more deliverable regulatory criteria for the majority of the world's labs. A further complication, raised in relation to CGIAR's rice and research, is that sequencing-based confirmation can itself be undermined by somaclonal variation occurring naturally between lines across different agro-ecologies. Such changes mean that even full genome sequencing does not always offer clear confirmation. Greater interaction is needed between regulators and researchers to agree upon appropriate measures to determine product categorisation. Given the rapid pace for technology innovation likely that better, faster and less costly methods will be released for more precise gene editing as well as for measuring and monitoring the edit in the product

In addition to agreement in how GE products are measured for categorisation, consensus is needed in how best to document and share data and regulatory decisions. The current process for most GE regulation is that the genetic data should be obtained by the researchers and uploaded to online systems. In some cases, these tests are self assessed, with developers conducting the test and declaring the findings, rather than conducted by the government. For instance, England's R&D notification service is a working example of this self-assessment model. A precision breeding release notice must be submitted to the Department for Environment, Food and Rural Affairs (Defra) at least 20 calendar days before an intentional release, after which the Advisory Committee on Releases to the Environment (ACRE) has 90 days to review the application. Five release notices have been issued so far, with authorisation granted for barley.

In other cases, data is sent to a panel of experts to make a decision. Separate to these tests, some regulations ask for the data to be posted on online repositories for transparency. Some regulators work by awarding an exemption from full GM regulations, as is often the case with GE products that are regulated as conventionally-bred crops. Others provide an award of a particular status, such as NGT-1 in the new EU regulations. These systems to share data and recognise categorisation are particularly important to consider for transferability of GE products across like-minded contexts. Challenges arise when actors wish to move a product from one location where it has been accepted, to a new context. For instance, both England and Kenya regulate transgene-free GE products as conventionally bred, but rely upon different approvals systems to signal these confirmations of a transgene-gene. In this case where English partners were sending a transgene-free product to Kenya, the Kenyan National Biosafety Authority would need evidence from the English partner to confirm the status of the product. Some of this information might be readily transferable, such as PCR data hosted in an accessible database. Other parts might not exist, like a certificate of approval from the UK regulator, Defra, conferring a transgene-free status.

Such differences cause frictions which delay movement of potentially useful products. Alignment efforts could do more to establish a basic criteria of types of evidence and how they are presented to

enable efficient international exchange or national approval of new products. Along this line, the African Union is working with African countries to consider streamlined systems for the movement of GE products across countries with aligned regulatory approval. For instance, Kenya's National Biosafety Authority is willing to share product testing data to simplify processes for other like-minded governments (e.g. Ethiopia or Malawi). The African Agricultural Technology Foundation (AATF) was also suggested as a potentially interested organisation to help connect this kind of testing-data sharing across countries. To date, only three countries have approached Kenya directly to draw on its experience when developing their own guidelines but more could follow. Lessons can be learnt from these approaches by the African Union and South American countries in aligning GE regulation for the efficient sharing, trade and wider geographical spread of impacts from new GE technologies.

GE policy harmonisation is not only helpful in helping countries establish GE policies, but also in the ongoing improvement of these policies. At this time of genesis for new GE regulation policy, attention so far has largely focused on which countries have established GE regulations and their process of how GE products will be established. Less has focused on how effective these policies are in the management and release of GE products. Doing so could inform the improvement of GE regulations. An example of improvement of GE regulatory policy can be seen in Argentina's 'update' to their policy.

Capacity shortfalls and regulatory improvements

Despite the scale of change in global GE policy and regulation, relatively few GE products have made it to commercialisation. Many remain in research stages of testing and timelines for many breeding pipelines mean that many of these technologies could require years before being registered for commercialisation. Several challenges exist in GE regulatory development, coordination and implementation which restrict the sector and require attention to overcome.

An emerging challenge in GE regulatory discussions is around the need for sequencing data to confirm edits combined with institutions which do not have the financial, human or infrastructure capacity to obtain and interpret this data, particularly in large volumes. Regulatory departments rarely have this capacity, particularly in the developing world, and this risks undeliverable protocols or avoidance of such regulatory pathways if not viable. Sequencing costs are continuing to fall, and this could make them more accessible, but greater investment of resources and training is needed to support calls for genomic data in technology exchange.

GE regulations have developed much more quickly for plant and microbial use than animal use. Despite the potential for GE technology to provide solutions to current challenges in livestock farming, these regulatory discussions have stalled, largely due to concerns around ethics and the public perception. These perceptions and acceptance likely vary with the intended use of the final GE product, such as for food, feed or fuel. Another challenge is that GE regulations lack an instrumental instrument to guide action and alignment (Vengadesen et al., 2025). Such instruments exist for other areas related to the movement of biological materials, such as the Cartagena Protocol on Biosafety or the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA or Plant Treaty). The Plant Treaty in particular offers an example of a comprehensive international agreement, in harmony with other conventions, to bring about food security through conservation, exchange and sustainable use of plant genetic resources for food and agriculture while protecting local rights. This provides an example of how a body or agreement could be established to guide international management of GE technologies for benefits across food security and rights. Further efforts should look into the suitability and interest in such a treaty, and which institutions might lead its application.

Recommendations

The report has shared emerging developments across the GE regulatory space that influence the development and release of products. Some of these topics highlight areas where connections and capabilities could be improved. Based on these discussions, we close with recommendations for ways forward to unlock clear and enabling policy environments for the use of GE innovations.

Establishment of a cross-disciplinary community of practice. We recommend the creation of a cross-disciplinary GE network, involving policy makers, researchers,regulators,businesses,communicators, environmentalists and farmers. There is demand to connect these groups globally to build communities of practice (Macnaghten & Habets, 2020) (Donnelly et al., 2018). This CoP will be tasked with developing knowledge products essential for improving understanding and support of GE as an important tool for building resilient agriculture, food and environmental ecosystems. The value of this kind of connection is already evident as interactions ahead of the London meeting saw UK research directly inform the content of Pakistan's first GE policy. This concrete outcome demonstrates the practical impact a dedicated network could have if formalised and resourced. Activities should be bespoke for 'within group' needs (such as international meetings with regulators on harmonisation practice) as well as transdisciplinary working, by bringing these diverse stakeholders together for shared learning. Such activities should be designed to create a safe space for open dialogue, using approaches such as the Chatham House Rule, to share ideas, challenges and opportunities for improved practice. Many of the following recommendations we offer would be best acted upon through such a network.

1 Establish a cross-disciplinary community of practice

We recommend the creation of a cross-disciplinary GE network, involving policy makers, researchers, regulators, businesses, communicators, environmentalists and farmers. There is demand to connect these groups globally to build communities of practice (Donnelly et al., 2018; Macnaghten & Habets, 2020). This CoP will be tasked with developing knowledge products essential for improving understanding and support of GE as an important tool for building resilient agriculture, food and environmental ecosystems. The value of this kind of connection is already evident as interactions ahead of the London meeting saw UK research directly inform the content of Pakistan's first GE policy. This concrete outcome demonstrates the practical impact a dedicated network could have if formalised and resourced. Activities should be bespoke for 'within group' needs (such as international meetings with regulators on harmonisation practice) as well as transdisciplinary working, by bringing these diverse stakeholders together for shared learning. Such activities should be designed to create a safe space for open dialogue, using approaches such as the Chatham House Rule, to share ideas, challenges and opportunities for improved practice. Many of the following recommendations we offer would be best acted upon through such a network.

2 Improve monitoring and visibility of GE policies, secondary legislation and the details of these

Some GE regulations are more visible and accessible than others, leading to uncertainty and constraining collaboration with technology developers. Further, few countries share their protocols for secondary legislation to conduct GE research and release. For instance, sharing field trial protocols for the testing of GE material, such as has been done by the John Innes Centre (Simmonds et al. 2026). For both the policy and secondary regulations, these documents usually exist but have not been made accessible online. Even where they do, finding these resources requires moving between many different websites with different structures and languages. A more efficient approach would be to have a website which points to these different regulatory documents. The FAOLEX website does a great job of storing some of the global GE regulatory documents from a single online platform. Similarly, additional functionality is being added to cropgeregulations.com to provide a single source for global GE regulatory bodies and documents. Future work could further improve the accessibility of these regulatory documents and the national regulatory teams involved.

3 Improve learning and knowledge exchange around public engagement for GE

Public perception and acceptance of GE products continues to be an area of uncertainty in how best to measure, engage with and respond to. The challenge is compounded by the technicality of scientific language, inherited stigma from GM debates, the prevalence of misinformation and disinformation. Greater research is needed to understand public perception towards these products and evidence of successful communications strategies to improve dialogue for GE regulatory change. Another angle is to improve communication of the benefits of the traits, rather than solely focus on the technology that produced it, as is the case for the broad range of techniques within conventional breeding. Groups such as the Alliance for Science and ISAAA are doing a great job in providing training, narratives and communications tools to help support public learning and dialogue. These tools must recognise that public concerns are not only based on biological understanding, and must also speak to wider topics, such as patents, control and inequality of GE benefits. These conversations must also be made with the understanding that misinformation and disinformation are different topics, and require bespoke strategies to respond to as experts. Social media must play a more central role in how GE developments are discussed and shared, as these communications forums have been more liable to the spread of disinformation campaigns against GE products. The use of positive stories and addressing misinformation, rather than disinformation, is likely a more effective use of time in influencing public opinion. A simple, clear message can be highly effective here, such as preventing stunting in South-East Asia, which was cited as an easy, compelling case to make for the value of GE innovation, in contrast to more technical framings that require greater public background knowledge to appreciate. All of these communications objectives must be mindful that public engagement is a long-term project. A final note of caution in this section is that care should be used in how transgene-free products are argued as lower risk from a precautionary principle approach, as this argument risks denigrating GM products.

4 Create an international instrument or body to guide policy and regulatory alignment and standards

While international agreements and treaties inform practice around other genetic resources and technologies, no such instrument exists for GE products. Given the widespread changes around GE regulation and the novel nature of the technology, an international guideline or body would bring clarity, agreement and provide a foundation for policy harmonisation efforts. Potential models can also be found in The AUDA-NEPAD's Policy Framework and its High-Level Panel on Emerging Technologies (APET) which provide technical guidance that individual member states draw on when drafting national guidelines. This has also served to encourage international collaboration, as shown by the willingness of Kenya's Kenya National Biosafety Authority to share product testing data with other governments such as Ethiopia or Malawi. This pattern of an early adopting national regulator whose framework becomes an informal template, reinforced by a continental convening body offers a potential example for alignment efforts. Several multinational institutions exist that could support the development of such an instrument and standards. Such standards should be informed by review of global GE regulatory approaches and the transferability of these capacities for delivery. This could include development of a one-page impacts/report template for GE alignment that other countries could use as a decision-making resource.

5 Learn from regulatory alignment beyond the field of GM

GE regulatory conversations often centre around experiences and events from the GM regulatory conversations. These associations make sense given the similarity of the context and actors but lessons for regulatory developments can also be taken from fields such as biocontrol, gene drives, fair trade and forest certification. These topics also contain discussion of risk assessment, risk management and labelling of products to signal qualities that are otherwise invisible to consumers. For instance, similarity can be found in the method of risk management around the long practiced use of biocontrol and the mechanisms of how this is communicated to policymakers and public. Engaging with these wider regulatory practices and experts could draw on a greater knowledge bed to inform future policy improvement.

Conclusion

Gene edited crops are at a critical moment. Advances in biotechnology and crop breeding are already delivering innovations which can help unlock more nutritious, resilient and sustainable food systems. The question now is how changing GE regulations will influence the commercialisation and trade of these products, across jurisdictions.

Many countries are moving towards more proportionate, product-based approaches, particularly for transgene-free products, but uneven rules, limited transparency, communication gaps and capacity constraints continue to impede innovation, trade and public confidence. This report concludes that the priority is not necessarily full regulatory harmonisation, but practical policy alignment built on shared principles, clearer evidence requirements, stronger regulator-to-regulator cooperation and accessible information on national rules and approval pathways. Establishing a cross-disciplinary community of practice, improving the visibility of GE policies, strengthening public engagement, exploring an international instrument or convening body, and learning from related regulatory fields would provide workable systems for effective deployment.

This report and the meeting from which it derives are part of a new global coordinated effort to ensure the potential of GE is realised for innovation, food security, resilience, sustainability and public good.

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