

# Gene Editing in Agriculture: Social Concerns, Public Engagement, and Governance

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## Abstract

This special issue reflects a variety of methodological and critical perspectives on contemporary issues regarding social concerns, public engagement, and governance of gene editing in agriculture.

## Keywords

politics, power, governance, environmental practices, engagement, intervention

Promoters of gene-editing applications in agriculture have highlighted purported benefits of the technology, such as the potential for increased

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production of food security crops, enhanced nutritional benefits, and adaptations of agricultural crops to climate change. This overwhelmingly positive narrative overshadowed attention to social, environmental, and human health concerns expressed by publics. Gene editing in agriculture and food also poses new regulatory and governance challenges that have led to calls for invigorated engagement of diverse publics in governance by both academics and policy makers (Macnaghten and Habets 2020; Selfa, Lindberg, and Bain 2021; Middelveld et al. 2023; Cummings and Peters 2022; Helliwell, Harley, and Pearce 2019; Jasanoff and Hurlburt 2018; Gordon et al. 2021; Montenegro de Wit, 2020a, 2020b; Gould et al 2022). To explore key social concerns related to gene editing in agriculture and food, the guest editors of this special issue invited leading international social scientists to contribute their work to an interdisciplinary collection of articles. The constellation of scholars in this issue reflects a variety of methodological and critical perspectives on contemporary issues regarding social concerns, public engagement, and governance of gene editing in agriculture.

Polarization around the use and the governance of gene editing in agriculture and food reflects the lack of agreement among global regulatory approaches. In particular, there is disagreement about whether gene-editing regulations should be based on the *process* of applying gene-editing tools to plant agriculture, or alternatively, based on the final plant *products*. In 2018, the EU Court of Justice ruled that gene-edited plants were genetically modified organisms (GMOs) and fell within the purview of Directive 2001/18/EC or the GMO Directive. The issue was whether gene-editing techniques, which are sometimes considered forms of directed mutagenesis, should be included as forms of exempted mutagenesis. Passed in 2001, the GMO Directive's strict oversight of GMOs was strongly influenced by popular calls at the time for precautionary approaches for preventative decision-making in cases of complex risks to human health and the environment (Nuffield Council 2003). As Levidow (2001, 842) expounds, "Through the precautionary principle, governments acknowledge the limits of science as a basis for policy, while seeking to clarify scientific uncertainty." Only mutagenesis processes with a long history of safe use were exempted from the GMO Directive's oversight. The Court of Justice's 2018 decision explained that gene-editing techniques did not meet the "history of safe use" requirement.

Conversely, the preliminary 2018 ruling and final 2021 US agricultural biotechnology legislation, the SECURE (Sustainable, Ecological, Consistent, Uniform, Responsible, Efficient) rule, asserted that regulation will be determined based on the final *product*. Because most gene-edited

foods have no traces or signature of inserted genetic materials in final products, under the SECURE rule, they do not need to be regulated as GMO, and furthermore, developers can decide if regulation is needed. Critics claim the SECURE rule exempts many gene-edited products from oversight and essentially allows companies to self-regulate (Montenegro de Wit, 2020a). Scientists, NGOs, and even some biotech developers have argued that this approach will heighten public risk perceptions and likely undermine public trust in the technology and in gene-edited food products (Gordon et al. 2021; Jaffe and Kuzma 2021; Montenegro de Wit 2020a, 2020b).

Issues surrounding the regulation and governance of gene-edited agriculture and food continue to be contested, which provided the backdrop to a workshop on *Gene Edited Foods: Social Concerns, Public Engagement, and Governance* in October 2020, which led in time to this special issue of *Science, Technology, & Human Values*. Several of the papers deal with contrasting regulatory decisions related to gene editing for agriculture and food in the United States and EU, how these decisions play out in particular environments and cultures, and how citizens respond to the sociotechnical imaginaries of gene editing promoted by industry and governments. Social scientists from North America, Asia, and Europe present in this collection new research about social concerns and public engagement in gene editing in agriculture and food, exploring the interrelations of governance and engagement, identifying key considerations, responsibilities, and opportunities. Several of the papers take a historical and comparative approach, looking at past controversies and social mobilizations over GMO governance to inform the current debate on gene-editing governance (Schurman and Munro 2013). The papers in the special issues are framed theoretically by science and technology studies (STS), critical policy studies, and social movements literatures.

Jennifer Kuzma presents a historical country case study of the regulatory changes in oversight of the US biotechnology industry. Kuzma employs the Advocacy Coalition framework, coupled with Multiple Streams and Punctuated Equilibrium theories, from the social movements literatures, to unpack how advocacy coalitions use particular “focusing events” to bring attention to policy issues and attempt to make policy change around GMO regulation (Jenkins-Smith et al. 2014). The analysis of GMO oversight is organized into five historical phases from 1973 to the present (evolution, implementation, adaptation, revolution, and revision). Kuzma draws attention to the knowledge politics surrounding GMO oversight, which shifted from being initially dominated by molecular biologists who narrowly

defined the risk and policy issues to retain control of the policy agenda, to being broadened by other advocacy coalitions, composed of NGOs, environmental groups, and other academics, who highlighted other societal and ecological concerns. Over time, these advocacy coalitions continued to raise public awareness related to GMOs and increasingly used the media and the US court system to bring attention to the issues. Kuzma argues that the current SECURE rule that allows for exemptions for several types of gene-edited crops and for developers to self-determine whether a crop is exempt from regulation translates into much less transparency and less access to information. Importantly, it reduces the public's ability to participate in decision-making or to mobilize around societal or risk issues related to gene-edited foods. Kuzma ends with a recommendation for increased public access to information on gene-edited crops, such as through a public registry proposed by NGOs, which is essential for civil society groups attempting to catalyze policy change.

The paper by Adrian Ely and coauthors highlights the role of "regulatory cultures" (Jasanoff 1995) in shaping how agricultural biotechnology has been regulated in the United States, United Kingdom, and Germany between 1986 and 2021. The authors show how elements of the distinct regulatory cultures identified by Jasanoff in the 1990s—process-based (United Kingdom), product-based (United States), and program-based (Germany)—continue to shape the governance of gene editing in 2021. Drawing from social movements literature, they argue that changing "opportunity structures" (McAdam et al. 2001; Schurman 2004), including social, legal, and political frameworks, allow different stakeholders (scientists, activists, and others) in each country to mobilize and participate in debates and decision-making about agricultural biotechnologies. The authors also draw on Jasanoff's (2005) concept of "civic epistemologies," or the culturally specific, historically, and politically grounded ways in which societies produce and validate knowledge. In this context, the United Kingdom is characterized as communitarian, the United States as contentious, and Germany as consensus-seeking. Ely and colleagues show how elements of these civic epistemologies are maintained over time, and that recent regulatory decisions about gene editing illustrate dynamic trajectories as well as some new areas of convergence for the three countries' regulatory cultures.

Ruth Mampuy's paper focuses on the "wicked problem" of the deadlock in European decision-making on GMOs and new plant breeding techniques (such as gene editing). She concludes by proposing a reengagement with politics, documenting in the process how calls for increased stakeholder

engagement and the need for more scientific evidence have not resulted in decisions about the regulatory status of gene editing. Her in-depth critical policy analysis draws on a case study of a similarly wicked policy problem, the authorization of glyphosate in Europe, to illustrate that, despite scientific uncertainty and strongly divided positions among stakeholders, the process of re-politicization made it possible for a decision to be made in the glyphosate case. Mampuy argues that such re-politicization is likely only possible if there is a strong shared motivation or a sense of urgency to resolve the regulatory deadlock on gene editing.

Three additional papers employ distinctive research methods to investigate how new publics are engaging with gene editing in the current period: a cross-national consumer survey examining perceptions of risks and benefits of plant and animal gene editing in the United States, Germany, and Japan; a media analysis of how gene-edited foods are portrayed in the United States and Europe media; and an exploratory Q study to tease out the interpretive frames created to “make sense” of the different applications of gene editing.

Katto-Nitta and colleagues’ cross-national survey comparing public perceptions of risks and benefits of gene-edited agriculture and food in the United States, Germany, and Japan is one of few empirical studies on gene editing to include consumers from Asia. Conducted in March 2020, the survey investigated consumer perceptions related to gene editing in both plant and animal agriculture under the distinctly different regulatory contexts across the three countries, with the EU strictly regulating plants and animals as GMO; the United States essentially exempting gene editing for plant agriculture from regulatory review but regulating animals under the FDA; and Japan exempting gene editing from regulatory review for both plant and animal agricultures. The authors found that US consumers perceived the highest benefits and lowest risks of gene editing, while Japanese consumers perceived greater benefits than German consumers. Interestingly, German consumers had the overall highest levels of trust in government food regulation but also the least exposure to information about the use of gene editing. The authors also draw on the concept of civic epistemologies (Jasanoff 2005) to explain the contrasting perceptions among consumers across the three countries. While Germany and Japan have historically had strong anti-GMO movements, the authors suggest that changes in consumer attitudes and expectations in Japan may be due to the Japanese government’s successful promotion of sociotechnical imaginaries and future expectations (Jasanoff and Kim 2009; Yamaguchi 2021) of many consumer benefits from gene editing.

The analysis of how gene-edited foods are portrayed in public-facing media in the United States and Europe shows that the form and content of media messages were quite similar, despite different regulatory environments. Dahlstrom and coauthors found that the media in both regions predominantly focused on the benefits of gene-edited foods rather than associated risks, with discussions of gene editing related to governance and social progress frames in both regions. The media also clearly made a distinction between gene editing and GMOs, which the authors suggest follows from the predominant emphasis on social progress and positive benefits of gene editing as distinct from GMO. The most stark and provocative divergence between regional media reports of gene-edited foods was how the regions differently prioritized risks of over- and underregulation: the US media reported potential risks of not enough regulation while the risk of too much regulation was more widely reported in EU media.

The Q study by Nawaz and coauthors reveals how college students and staff in environmental studies and science fields “make sense” of gene editing and gene drive, and how their interpretations dramatically diverge from the sociotechnical imaginaries provided by proponents for the development and application of gene editing. Proponents have stressed the “precision” of gene editing (relative to traditional crop breeding) for delivering a wide range of crop modifications, but Nawaz and coauthors find that this benefit does not resonate with their study population, who are more concerned about the deepening of techno-industrial approaches to agricultural production. The participants created and applied frames to understand the implications of agricultural biotechnology that diverged from the sociotechnical imaginaries promoted by gene editing (GE) proponents. The authors highlight three frames—critical systems thinking, pragmatic techno-optimism, and ambivalent questioning—that characterize how participants interpret gene editing and gene drive. Participants emphasized that gene editing *could* be part of a suite of alternatives that also could include nonbiotech approaches to solve agricultural and environmental problems. Importantly, though, they questioned the underlying assumptions and problem framings which lead to gene editing being the solution, asking what other options may be viable. Nawaz and coauthors highlight that sociotechnical imaginaries of gene editing in agriculture promoted by governments and biotech companies are often not shared by publics—a finding advanced by several papers in the special issue.

All the papers in this special issue investigate how diverse publics interact and engage with gene editing in agriculture. Several papers highlight the role of civil society and social movements in contesting biotechnology in

agriculture in the context of particular regulatory cultures and histories with GMOs, focusing on the importance of “opportunity structures” and “focusing events” that bring attention to policy problems and efforts to make policy and regulatory changes. Several authors emphasize that publics will need transparent access to information to provide input into governance or advocate for any policy change related to biotechnology use in agriculture.

While values are always embedded in policy discourses and decisions, public engagement processes often make these values more visible and transparent. Acknowledging that publics should question and contest the underlying assumptions and problem framings surrounding the use of gene editing in agriculture represents the most expansive approach to public engagement in the special issue. These articles contribute to recent STS literature that interrogates how publics are defined, constructed, by whom, and for what purpose in the context of engagement on emerging technologies (Chilvers and Pallett 2018; Middelveld et al. 2023; Schwarz-Plaschg 2018; Macnaghten 2021; Macnaghten et al., 2019; Chilvers and Kearnes 2020; Lindberg et al. 2023). Mampuy's call for “re-politicization” or a reengagement with politics around biotechnology use in agriculture is a well-situated proposal to address such persistent wicked policy problems and to stimulate public engagement and more transparent governance. Echoing calls by academics and civil society organizations, the essay collection demonstrates the importance of history, culture, and knowledge politics in shaping engagement of diverse publics. Articles in the special issue highlight the importance of incorporating publics' myriad concerns, imaginaries, and counter-imaginaries into efforts to build more socially equitable governance frameworks for gene editing and other emerging technologies in agriculture.


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## References

- Chilvers, Jason, and Matthew Kearnes. 2020. "Remaking Participation in Science and Democracy." *Science, Technology, & Human Values* 45 (3): 347-80.
- Chilvers, Jason, and Helen Pallett. 2018. "Energy Democracies and Publics in the Making: A Relational Agenda for Research and Practice." *Frontiers in Communication* 3: 14.
- Cummings, Christopher L., and David Peters. 2022. "Gene-Edited Foods and the Public: The First Representative Survey Study of the United States." *Environmental Communication*: 1-10.
- Gordon, Doria R., Gregory Jaffe, Michael Doane, Aviva Glaser, Thomas M. Gremillion, and Melissa D. Ho. 2021. "Responsible Governance of Gene Editing in Agriculture and the Environment." *Nature Biotechnology* 39 (9): 1055-57.
- Gould, Fred, Richard M. Amasino, Dominique Brossard, C. Robin Buell, Richard A. Dixon, Jose B. Falck-Zepeda, Michael A. Gallo, et al. 2022. "Toward Product-based Regulation of Crops." *Science* 377 (6610): 1051-53.
- Helliwell, Richard, Sarah Hartley, and Warren Pearce. 2019. "NGO Perspectives on the Social and Ethical Dimensions of Plant Genome-editing." *Agriculture and Human Values* 36: 779-91. <https://doi.org/10.1007/s10460-019-09956-9>
- Jaffe, Gregory, and Jennifer Kuzma. 2021. "New Bioengineered (aka GM) Food Disclosure Law: Useful Information or Consumer Confusion." *Food Drug and Law Institute Magazine*, Summer.
- Jasanoff, Sheila. 1995. "Product, Process, or Programme: Three Cultures and the Regulation of Biotechnology." *Resistance to New Technology* 311: 31.
- Jasanoff, Sheila. 2005. *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton, NJ: Princeton University Press.
- Jasanoff, Sheila, and J. Benjamin Hurlbut. 2018. "A Global Observatory for Gene Editing." *Nature* 555 (7697): 435-37.
- Jasanoff, Sheila, and Sang-Hyun Kim. 2009. "Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea." *Minerva* 47: 119-46.
- Jenkins-Smith, Hank C., Daniel Nohrstedt, Christopher M. Weible, and Paul A. Sabatier. 2014. "The Advocacy Coalition Framework: Foundations, Evolution, and Ongoing Research." *Theories of the Policy Process* 3: 183-224.



- Levidow, Les. 2001. "Precautionary Uncertainty: Regulating GM Crops in Europe." *Social Studies of Science* 31 (6): 842-74.
- Lindberg, Sonja, Carmen Bain, and Theresa Selfa. 2023. "Regulating Gene Editing in Agriculture and Food in the European Union: Disentangling Expectations and Path Dependencies." *Sociologia Ruralis* 63 (2): 348-69.
- Macnaghten, Phil. 2021. "Towards an Anticipatory Public Engagement methodology: Deliberative Experiments in the Assembly of Possible Worlds Using Focus Groups." *Qualitative Research* 21 (1): 3-19.
- Macnaghten, Phil, and Michelle GJL Habets. 2020. "Breaking the Impasse: Towards a Forward-looking Governance Framework for Gene Editing with Plants." *Plants, People, Planet* 2 (4): 353-65.
- Macnaghten, Phil, Sarah R. Davies, and Matthew Kearnes. 2019. "Understanding Public Responses to Emerging Technologies: A Narrative Approach." *Journal of Environmental Policy & Planning* 21 (5): 504-518. <https://doi.org/10.1080/1523908X.2015.1053110>
- McAdam, Doug, Sidney Tarrow, and Charles Tilly. 2001. *Dynamics of Contention*. Cambridge, UK: Cambridge University.
- Middelveld, Senna, Phil Macnaghten, and Franck Meijboom. 2023. "Imagined Futures for Livestock Gene Editing: Public Engagement in the Netherlands." *Public Understanding of Science* 32 (2): 143-58.
- Montenegro de Wit, and Maywa. 2020a, June 1. "How a New Biotech Rule Will Foster Distrust with the Public and Impede Progress in Science." *The Conversation*. Accessed May 22, 2023. <https://theconversation.com/how-a-new-biotech-rule-will-foster-distrust-with-the-public-and-impede-progress-in-science-139547>
- Montenegro de Wit, Maywa. 2020b. "Democratizing CRISPR? Stories, Practices, and Politics of Science and Governance on the Agricultural Gene Editing Frontier." *Elementa: Science of the Anthropocene* 8 (2020): 9.
- Nuffield Council on Bioethics. 2003. "The Use of Genetically Modified Crops in Developing Countries: A Follow-up Discussion Paper." Accessed August 15, 2023. <https://www.nuffieldbioethics.org/assets/pdfs/GM-Crops-Discussion-Paper-2003.pdf>.
- Schurman, Rachel. 2004. "Fighting "Frankenfoods": Industry Opportunity Structures and the Efficacy of the Anti-biotech Movement in Western Europe." *Social Problems* 51 (2): 243-68.
- Schurman, Rachel, and William A. Munro. 2013. *Fighting for the Future of Food: Activists versus Agribusiness in the Struggle over Biotechnology*. Vol. 35. Minneapolis: University of Minnesota Press, 2013.

- Schwarz-Plaschg, Claudia. 2018. "Nanotechnology Is Like . . . The Rhetorical Roles of Analogies in Public Engagement." *Public Understanding of Science* 27 (2): 153-67.
- Selfa, Theresa, Sonja Lindberg, and Carmen Bain. 2021. "Governing Gene Editing in Agriculture and Food in the United States: Tensions, Contestations, and Realignments." *Elementa: Science of the Anthropocene* 9 (1): 00153.
- Yamaguchi, Tomiko. 2020. "Performativity of Expectations: The Emergence of Plant Gene Editing Technologies in Japan." *Elementa: Science of the Anthropocene* 8 (1).

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