

Beyond naturalness? Social dimensions of gene editing in agriculture

Novel gene-editing technologies are ushering in a new era of designing life forms; they are capable of modifying species genomes via ‘precise’ edits rather than the random mutations used with earlier generation genetic modification. A mushrooming of scientific research and synthesis reports have begun to explore and document the potential scope of what—proponents claim—are a range of applications of gene editing aimed to address food security, climate change, and other challenges facing agriculture. These applications, however, introduce social risks, ethical dilemmas and governance concerns. This thesis examines key and under-explored questions of governance and public perceptions of gene-editing technologies across six empirical chapters.

As it blurs the line between what is ‘natural’ vs. human-made, gene editing is also bringing questions of ‘naturalness’ to the fore. This thesis traces, across its chapters, the multiple interpretations, meanings and values relating to ‘naturalness’ that different actors and institutions bring to their engagement with gene editing. It finds that assumptions about what is ‘natural’ (such as about life forms, modifications to genomes or agricultural practices) are embedded in existing regulations and governance of gene editing and relevant genomic data. Yet, the thesis also finds evidence that—contrary to what is sometimes assumed—public groups may be less concerned with whether gene-edited organisms are ‘natural’ and more with the types of food systems that these applications support.

Chapter 2 (accepted for publication in *Environmental Science and Policy*¹) explores ways of defining and operationalizing ‘naturalness’ that might illuminate attitudes towards gene editing

¹ Nawaz, S., & Satterfield, T. (In press) On the nature of naturalness? Theorizing ‘nature’ for the study of public perceptions of novel genomic technologies in agriculture and conservation. *Environmental Science and Policy*.

in agriculture. It proposes an ethical framework of ‘logics of naturalness’, evaluates these logics given relevant empirical work, and applies the logics to gene-editing applications. To my knowledge, this is the only paper to empirically review definitions of naturalness as they relate to biotechnology across a range of social science fields. I conclude that ideas of naturalness may reflect different values and worldviews, particularly those rooted in valuing specific human and ecological relationships. I propose that future public engagement work would benefit from utilizing multiple such definitions of naturalness to identify the spectrum of values underpinning responses to novel technologies.

Chapter 3 (published in *Science and Public Policy*²) reviews the basis by which key jurisdictions ‘trigger’ regulation of gene-edited crops. Using a framework from responsible research and innovation (RRI), I evaluate updates to biosafety regulation underway in response to development of gene editing. To my knowledge, this is the first effort to compare regulatory triggers across jurisdictions globally. I find that most jurisdictions regulate along dichotomous ‘regulated or not’ or ‘natural or not’ distinctions that are, I argue, increasingly incompatible with the multiplicity of technical approaches to gene editing now possible. I suggest two ways to align regulations of gene-edited crops with principles of RRI: (1) a multi-tiered approach to regulations that allows for differentiation across techniques, and (2) a shift in the narrow focus on technical specifics of edits to broader consideration of social and ecological outcomes.

Chapter 4 (published in *Elementa: Science of the Anthropocene*³) explores responses to gene editing in the organic sector of Canada and the United States. Drawing upon 19 interviews and

² Nawaz, S., & Kandlikar, M. (2021). Drawing Lines in the Sand? Paths Forward for Triggering Regulation of Gene-Edited Crops. *Science and Public Policy*. <https://doi.org/10.1093/scipol/scab014>

³ Nawaz, S., Klassen, S., & Lyon, A. (2020). Tensions at the boundary: Rearticulating ‘organic’ plant breeding in the age of gene editing. *Elementa: Science of the Anthropocene*, 8. <https://doi.org/10.1525/elementa.429>

other primary and secondary sources, this chapter applies the concept of ‘boundary work’ in science and technology studies (STS) to trace regulatory dilemmas introduced by gene editing. This is the first work to empirically (as opposed to theoretically) explore the compatibility of gene editing and organics. I find that gene editing has spurred an expansion and revision of regulatory decisions regarding allowable technologies under organic standards. Similar to Chapter 3, I find a focus on technical specifics has obscured more value-based conversations and also narrowed which actors can participate in decision-making processes. I also find that both organic regulations and interviewees cited a diversity of understandings of what ‘natural’ might mean and how valuable ‘natural’ approaches should be for the sector—signaling the need for greater discussion and clarity on the role of technologically based breeding methods in organic agriculture.

Chapter 5 (published in *Global Environmental Change*⁴) explores the governance of genomic data and information, which are key inputs to the application of gene editing techniques. Utilizing analysis of 139 documents from formal proceedings of two international fora, I follow contentious debates on whether access and benefit sharing (ABS) agreements should apply not just to physical resources, but also to related genomic data and information. I draw upon theories of ‘valuation’ and ‘assetization’ from STS to highlight differences in conceptualizations of genetic resources in the debate. While these debates have received substantial scholarly and policy engagement, this is the only work that examines the underpinning conceptualizations of genetic resources. I find that questions of value—when it is added, how it gets added and where exactly it lies—differentiated views. Those actors that viewed the value of genetic resources as

⁴ Nawaz, S., Satterfield, T., & Hagerman, S. (2021). From seed to sequence: Dematerialization and the battle to (re)define genetic resources. *Global Environmental Change*, 68, 102260. <https://doi.org/10.1016/j.gloenvcha.2021.102260>

produced via historical stewardship tended to view data or information as part of the genetic resource, whereas those who viewed their value as added by scientists and lab equipment tended to view data or information as a separate entity. This chapter suggests that what counts as a resource—including what counts as ‘natural’—is relevant to justice issues of compensation for genomic data and information from, largely, biodiverse countries in the Global South.

Chapter 6 (accepted for publication in *Science, Technology and Human Values*⁵) offers an exploratory Q method study with 20 young urban professionals, aimed at uncovering central patterns of thinking around specific applications of gene editing and gene drives in agriculture. This is the only study I am aware of that focuses on the views of this demographic, and one of few existing studies that studies public attitudes on the subject. I find three ‘frames’ of thinking: ‘critical system thinking’, ‘pragmatic techno-optimism’ and ‘ambivalent questioning’. Notably, I do not find participants’ evaluations centered on technical specifics such as genetic similarities or the precision of edits, despite what many proponents have asserted. Second, I find that a key aspect of the ‘critical system thinking’ frame was the perceived necessity of a technology and the possibility of achieving the same result via other means. This finding suggests an important, and underrecognized, dimension of opposition or rejection amongst this group may relate to concerns about the political economic system and context in which gene-edited organisms are emerging and which they may be seen to support.

Chapter 7 (published in *PLoS ONE*⁶) draws upon an online survey on attitudes towards gene editing amongst US and Canadian publics (n=1478). The survey explored the relationship

⁵ Nawaz, S., Satterfield, T. & Phurisamban, R. (In press) Does ‘precision’ matter? A Q study of public interpretations of gene editing in agriculture. *Science, Technology and Human Values*.

⁶ Nawaz, S., & Satterfield, T. (2022). Climate solution or corporate co-optation? US and Canadian publics’ views on agricultural gene editing. *PLoS ONE*, 17(3 March), e0265635. <https://doi.org/10.1371/journal.pone.0265635>

between attitudes towards gene editing, and attitudes towards food systems more generally, via a novel attitudinal scale on views on the Green Revolution. I find that attitudes critical of industrialized food systems, measured through this scale, predict overall comfort with gene editing. As well, I explore views in the context of specific tradeoffs involving biodiversity and pesticides, finding that such ‘system-critical’ attitudes predict who might opt out of these difficult choices. I argue that, while refusal to participate in ‘taboo tradeoffs’ involving biotechnology is often assumed to be an irrational response, these results suggest the possibility that such reactions are instead based in articulable critiques of food systems. This is the first effort I am aware of that operationalizes system-critical attitudes like these via a generalizable, quantitative approach.

The findings presented in this dissertation suggest that the concept of naturalness appears frequently—in both explicit and implicit ways—across a range of conversations and debates. Gene editing seems to throw into question what it means for something to be natural, and this thesis has shown that, in the wake of this destabilization, assumptions of ‘natural’ begin to reveal themselves as constructed, contingent and political, rather than objective or singular facts. I demonstrate that biosafety and organic regulations rely upon assumptions of ‘naturalness’ that are beginning to unravel, destabilizing governance of these and related technologies. I suggest that regulatory approaches would benefit from articulating these definitions and acknowledging their assumptions, and perhaps, shifting towards their social and environmental consequences. Finally, this thesis highlights that some public objections to gene editing may indeed be rooted in critiques of political-economic systems and specific values regarding social and ecological relationships—perhaps not, as is often assumed, in irrational and unfounded objections.