Received: 14 August 2024 | Revised: 13 November 2024 | Accepted: 16 November 2024

DOI: 10.1002/ppp3.10626

Plants People Planet PPP Open Access

RESEARCH ARTICLE

From genes to governance: Engaging citizens in the new genomic techniques policy debate

Michelle G. J. L. Habets[1,2] | Phil Macnaghten[2]

[1]Rathenau Instituut, The Hague, The Netherlands

[2]Knowledge, Technology and Innovation Group, Wageningen University and Research, Wageningen, The Netherlands

Correspondence
Michelle G. J. L. Habets, Rathenau Instituut, The Hague, The Netherlands.
Email: m.habets@rathenau.nl

Funding information
This work was supported by the Rathenau Instituut.

Societal Impact Statement

The European Union is in the midst of changing the current regulatory framework for new genomic techniques (NGTs) to accelerate the production of plant varieties, in order to achieve the goals of the European Green Deal. These techniques are highly contested, with divergent views on how they should be governed. So far, there has been little effort to engage citizens in this legislative reform process. By engaging with Dutch citizens, we give the public a voice in shaping the future of agriculture and the food system. By facilitating the exchange of multiple views, we allow for more effective governance arrangements.

Summary

- The European Commission (EC) has proposed a new regulation for plants obtained by new genomic techniques (NGTs). Currently, food crops developed with NGTs are subject to the EU Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms (GMOs).
- The current proposal for a new regulation differentiates between two categories of NGT plants. Category 1 NGT plants will be subject to the new regulation, whereas Category 2 plants will remain subject to the GMO legislation, although the risk assessment may be adapted.
- In this paper, we analyze the views of Dutch citizens on NGT crops and their governance, prior to the publication of the new proposal. We find significant reservations arising from doubts about NGT crops delivering on their promises, the likelihood of unanticipated consequences, and unnaturalness.
- We extrapolate our findings to anticipate citizen's response to the new proposal and reflect on ways to move forward, both for policy making, and for the plant science community.

KEYWORDS
gene editing, genetically modified crops, governance, new genomic techniques, public engagement

1 | INTRODUCTION

The proposed introduction of genetically modified (GM) crops and foods in the late 1990s precipitated acute scientific and public controversy across Europe. Concerns centered on risks to human health and the environment, doubts about its value for society, objections to tampering with nature, and disquiet about the concentration of power in large, global agrochemical and plant breeding companies (Grove-White et al., 1997). In response, the European Union introduced regulatory measures designed to control the import and cultivation of genetically modified organisms (GMOs). From 2001, GM crops subjected to these regulations were required to be assessed for direct, indirect, and cumulative (immediate and long-term) effects on public health and the environment, while GM food and feed needed to be monitored, traceable and labelled, with the aim of informing consumers and other actors. A consequence of the European policy is that applying for a license to cultivate GM crops has become both time-consuming and expensive. Indeed, while worldwide there has been steady growth in the area covered by GM crops, there are only two European Union (EU) countries where GM crops are grown, GM maize in Spain and to a lesser extent in Portugal (European Commission, 2023a, 2023b, 2023c). In this context, various companies, scientists, and their respective associations have been active in advocating for a revision of the current regulation (Habets et al., 2019).

This pressure on the EU to change its legislation has intensified in recent years after the development of new genomic techniques (NGTs),[1] in particular, following the discovery of CRISPR-Cas9 in 2012. The Netherlands has been at the forefront of member states seeking to revise the current GMO Directive (Parliamentary documents of the Dutch House of Representatives, 2017/2018; Parliamentary documents of the Dutch House of Representatives, 2023/2024). Most arguments for a new, less strict regulation for NGT plants, and thus an exemption from the GMO Directive, rest on the claim that these techniques can make small, targeted changes to the genome of plants in the laboratory (also referred to as targeted mutagenesis). In principle, these mutations could have been achieved by conventional breeding or classical mutagenesis, and the changes in the plants' genome do not have to contain any foreign DNA. Many scientists and breeding companies therefore see these techniques as fundamentally different from the class of older genetic modification (GM) techniques that were designed to introduce foreign DNA into the genome of cells (Habets et al., 2019).

Because NGTs offer the capacity to change the genome in the lab in ways that are faster, more accurate, and less expensive, they offer the potential to accelerate developments in the GM of plants. Corporate and scientific actors express the fear that if Europe does not change its strict regulation, it will lag behind and lose its competitive edge in the plant breeding (research and development) field (Duroc et al., 2022; WePlanet, 2023). As the third largest sector behind the USA and China, the EU seed market is valued at around 7–10 billion Euros, about 20% of the global market (European Commission, 2023a). According to the impact assessment of the European Commission (EC), the EU seed market comprises about 7000 companies (mostly small- and medium-sized enterprises, SMEs) with about 52,000 employees.

Therefore, in July 2023, the EC published a proposal for a new regulation on plants obtained by certain new genomic techniques and their food and feed (European Commission, 2023b). According to the EC, adopting a specific legal framework for GMOs obtained by targeted mutagenesis (small, directed mutations in the DNA) and cisgenesis (the transfer of genes within one species) was necessary, as their earlier study demonstrated that the current regulation was "not fit for the purpose of regulating the deliberate release of plants obtained by certain NGTs and the placing on the market of related products including food and feed" (European Commission, 2021, 2023a; Paraskevopoulos and Feredici, 2021).

So far, there has been limited scope for public engagement in this legislative reform process, even though including the voice of citizens in the development of policy is viewed institutionally as important (European Commission, 2023c). Moreover, the historical unrest and social resistance to GM food in Europe has been partly attributed to the restricted scope for public involvement in the regulatory process (Grove-White et al., 1997; Jasanoff, 2000; Kearnes et al., 2006; Wynne, 2001). In this study, conducted before the EC presented their new proposal, we examined the views of Dutch citizens on the use and governance of NGTs in plant breeding.

1.1 | Proposal for a new regulation of new genomic techniques

The proposed regulation of the EC on NGTs distinguishes between two categories of NGT plants. Category 1 encompasses NGT plants that "could also occur naturally or be produced by conventional breeding techniques and their progeny obtained by conventional breeding techniques" (European Commission, 2023a). These plants would fall under the scope of the new regulation on NGTs. All other NGT plants would be classified as Category 2 NGT plants and would be subject to the GMO Directive, although a "proportional" risk assessment would be developed.

On February 7, 2024, the European Parliament (EP) adopted amendments to the proposal of the EC and supported the proposal with a narrow majority (European Parliament, 2024). Where the EC had proposed to treat Category 1 NGT plants in a similar manner as plants that *have* occurred naturally or that have been produced by conventional breeding techniques, making them exempt from risk assessment and labeling requirements, the EP voted to give consumers freedom of choice by enforcing labeling of all NGT products and not merely NGT seeds. The EP revised the proposal in additional ways, among others by a ban on patents on NGT products and by excluding NGT plants featuring herbicide-tolerant traits from the

[1]NGTs is "an umbrella term used to describe a variety of techniques that can alter the genetic material of an organism and that have emerged or have been developed since 2001, when the Union legislation on genetically modified organisms (GMOs) was adopted"; see (European Commission, 2023).

scope of Category 1 NGT plants. They also changed the criteria of equivalence of NGT plants to conventional plants. The EP voted again on April 25, 2024. The majority voted in favor. No amendments were possible in this second vote. This new amended draft of February 2024 is the final position of the EP and has served as the basis for negotiations among the Parliament, the Council, and the Commission.

Several agricultural organizations support the EU Parliament's amended proposal (Euroseeds, 2024; Plantum, 2024), although the European Plant Science Organization (EPSO) raised concerns about mandatory labeling and intellectual property provisions (EPSO, 2024). Meanwhile, civil society groups and some scientific bodies, which include the French Agency for Food, Environmental and Occupational Health, and Safety (2024) and the German Federal Agency for Nature Conservation (2024), argue that the proposal undermines biosafety (Biodynamic Federation Demeter, 2024; Friends of the Earth Europe, 2024; IFOAM Organics Europe, 2024), with some declaring that there is no evidence yet to support the argument that NGT and non-NGT crops are scientifically equivalent (German Federal Agency for Nature Conservation, 2024; The European Network of Scientists for Social and Environmental Responsibility, 2024). The European Parliament has requested an European Food Safety Authority (EFSA) review of recent studies (ARC, 2024).

Proponents and opponents for adopting the current proposal differ in their opinion on whether NGT crops are likely to help solve some of our current societal challenges such as climate change, biodiversity loss, and food security. Proponents believe that these NGTs can help develop new varieties more effectively and faster, and thus help the agricultural sector to increase our food security and assist the transition to a more sustainable agriculture, for example, by breeding new plant varieties that are resistant to pests, more adaptive to climate change, and that require less fertilizer. Opponents argue that NGTs will most likely be used to support the intensive, unsustainable, agricultural model (IUCN-NL, Natuur en milieufederatie Noord-Holland (MNH), Natuur, & Milieu, 2022). Currently, many GM crops are developed by large multinational agrochemical corporations, who focus primarily on traits like herbicide resistance, which aligns with the intensive agricultural model (Greenpeace, 2021). Furthermore, small-scale, nature-inclusive farming practices, such as organic agriculture, generally oppose the use of GM crops and, therefore, also NGT crops (Dequeker, 2022). Because the potential to enhance sustainability hinges on specific breeding objectives and the types of cultivation systems they target, opponents believe NGT crops will be developed for intensive agriculture, whereas it is the transition to nature-inclusive farming that in their view would make farming truly sustainable.

Because of concerns over patentability, labeling, and traceability, the European Council has not been able to reach an agreement among member states to adopt the new regulation before the European elections in 2024. As of July 1, Hungary has assumed the presidency of the European Council. The new European Parliament had its first plenary session of the new legislative term in July 2024. However, it will probably take until at least December 2024 before the new European Commission can restart negotiations with the new European Parliament and Council (Sanchez Manzanaro, 2024). There is therefore still time for politicians and policymakers to hear voices not heard yet in the societal and political debate. Notably, there has been only marginal attempt to involve citizens in the debate in a serious manner.

2 | RATIONALE FOR THE STUDY

Involving citizens is important for several reasons. First, citizens have the right to have a say in developments that affect them. Second, with citizen participation, political choices can be better legitimized and gain wider support. And third, with citizen participation, policy is better aligned with problems, practices, and needs in society (Broerse & de Cock Buning, 2012; European Commission, 2023c). While studies show the desire of citizens to be informed and to have a say in regulatory decisions on biotechnology, it is noticeable that there has been restricted scope across Europe (including in the Netherlands) for meaningful public involvement in the debate on NGTs. The EC held a consultation process in 2022 with the aim of informing citizens and stakeholders about the legislative initiative on plants produced by certain NGTs, and asking for feedback (European Commission, 2022). Overall, there was more support for the regulation of NGTs, albeit less strictly, than for exempting NGTs from the GMO Directive, which conforms to a higher percentage of respondents expressing a preference for a risk assessment and for the labeling of NGT crops. Although the EC provided citizens with the opportunity to comment on their plans, limitations are that the use of the survey method restricts the scope of questions to those seen as relevant by the Commission, and that the questionnaire is likely to have been completed mainly by stakeholders and citizens with prior knowledge about—and possibly a prior position on—the debate and the upcoming regulatory change. Indeed, one had to be aware of the existence of this public consultation to participate.

The aim of this research was to examine the views of Dutch citizens on the use of NGTs and older GM techniques in food crops, investigate what factors shape these views, and explore their views on the conditions they deem necessary to introduce NGT crops onto the European market, if introduced at all. This study was not designed to inform or influence the public, or to examine people's perceptions as consumers; rather, it is their role as citizens that shape this study with the goal of providing policymakers with knowledge on the shared commitments and concerns of citizens. We should also emphasize that this study was conducted in the summer of 2022, before the EC published their proposal, and before the organic sector in the Netherlands started their "my food, my choice" campaign (mijneten-mijnkeuze.nl). Citizens thus had not been exposed to the upcoming changes in the regulatory framework of GMOs yet, nor had there been much press coverage about NGT crops.

The research was set up to answer the following research questions.

- RQ1: Do Dutch citizens view crops modified by gene editing (GE) techniques (or NGTs)[2] as substantially different from those modified by the older GM techniques?
- RQ2: What are citizens' concerns and hopes for NGT crops and food, and what factors underpin these?
- RQ3: What governance does the public see fit for NGT crops?

In this paper, we provide an overview of our findings. Subsequently, we reflect on what our findings tell us about how Dutch citizens would view the current NGT proposal.

3 | METHODOLOGY

We employed the Anticipatory Public Engagement using Focus Groups (APEFG) method (Macnaghten, 2017, 2021), designed to examine how people develop views and perspectives on a new technology in structured social interaction. This small group deliberative method is particularly useful when technologies and their impacts are not yet visible in the public domain and when publics have yet to develop their own views and attitudes. With an anticipatory approach, societal responses to emerging technologies can be projected in terms of their likely unfolding in real-world circumstances. We conducted six focus group discussions (FGD), each lasting between 2,5 and 3 h, taking place in Amsterdam ($n = 5$) and Amersfoort ($n = 1$). The FGDs were structured using a topic guide (see Method S1). The APEFG method consists of five design criteria: context, framing, moderation, sampling, and analysis and interpretation.

3.1 | Context

A criticism commonly levelled at public engagement processes is that they tend to be framed from the point of view of a narrow set of incumbent interests, typically comprising expert scientific and policy-making communities, with the effect of "closing down" alternative ways of framing policy discussions (Stirling, 2007). To counter this possibility, the APEFG method develops an endogenous approach that attends to the contextual factors deemed as likely to be significant in the shaping of societal responses to the issue, and where the participants discuss these aspects prior to the participants deliberating upon, or even having knowledge of, the technoscientific topic under consideration (the participants are recruited topic blind). For our research, we projected that responses to gene edited foods and crops are likely to depend principally on people's views and relationships with food, their ideas on food production, and their views on the role of technology therein.

[2]In our focus group discussions, we used the concept of gene editing, instead of new genomic techniques (NGTs). In the remainder of the paper, we will use the terms interchangeably.

3.2 | Framing

The issue of how to "frame" information is a core concern for the APEFG method, cognizant that the representation of a technology is never neutral but always framed in particular ways and for particular purposes. For our research, we sought to offer the participants attributed information on the issue (as framed by expert actors) as well as an inclusive range of rhetorical resources and frames reflecting how different stakeholders (corporate, governmental, civil society, and NGOs) are framing and representing the issue in the public sphere. Using carefully designed concept boards (see Methods S2) to guide discussion (A0 in size), Concept Board 1 delineated different approaches to agriculture (intensive farming, agroecology, precision farming, and organic farming); Concept Board 2 set out three techniques to modify crops (traditional breeding, classical mutagenesis, and transgenesis); Concept Board 3 described arguments in the GMO controversy in the 1990s (for and against); Concept Board 4 set out the current regulatory landscape in Europe and information on GM crops; Concept Board 5 explained the CRISPR-Cas9 technique; and Concept Boards 6–8 articulated arguments that the GMO regulation should be revised, retained, or amended via a new level-based approach, respectively.

3.3 | Moderation

A deliberative discussion is more than a group interview or the aggregation of individual opinions and preferences. It is a space where a group identity and discourse can emerge, where the collective is empowered to articulate the issue at hand in its own terms (Ruiz, 2017). To facilitate this process, the moderator encourages the movement between argument and counterargument in a spirit of mutual understanding. The role of the moderator is to keep the group on topic (using a well-formulated topic guide, see Method S1), raise topics, listen empathetically, ensure a diversity of voices, probe difference and convergence between the participants, and move from one topic to the next only when the full range of arguments appears exhausted. Such a role requires training and expertise, and for our research, Macnaghten led the moderation for the English-speaking group (FGD1), and Habets for the Dutch-speaking groups (FGD2–FGD6). Even though the participants did express this to be a difficult topic, they proved able and competent to enter into the current and future worlds of GE in crops and foods, facilitated through abiding with general rules of good focus group moderation.

3.4 | Sampling

The focus groups were composed of a cross-section of invited citizens professionally recruited to represent prototypical segments of the Dutch population but with topic-specific characteristics to provide distinctive perspectives on technology and food. A financial incentive was offered for participation in the study. Informed consent was

TABLE 1 Overview of the composition and characteristics of the focus groups.

	Age range	Nr of participants	Gender	Educational background	Location	Language	Topic-specific variable
1	25–40	8	4 M/4F	Theoretical education	Amsterdam	English	Foodies and vegetarians
2	35–50	7	3 M/4F	Theoretical education	Amsterdam	Dutch	Technophiles
3	40–55	5	2 M/3F	Practical education	Amersfoort	Dutch	Outdoors and sustainable living
4	45–55	7	4 M/3F	Practical education	Amsterdam	Dutch	Outdoors and sustainable living
5	45–60	8	3 M/5F	Theoretical education	Amsterdam	Dutch	Public sector professionals
6	30–45	6	2 M/4F	Practical education	Amsterdam	Dutch	Mistrusting institutions

sought from the participants of the focus groups with assurances of anonymity on how the data would be used in practice. The topic groups included people who either enjoyed food and cooking or who were vegetarian (FGD1); people enthusiastic about technology (FGD2); people fond of the outdoors or who strived to live sustainably (FGD3 & FGD4);[3] a group of public sector professionals with a keen interest in global affairs (FGD5); and people who shared a certain distrust for institutions, politics, and government (FGD6) (see Table 1). The focus groups were "topic blind"; the participants were not informed on the specific topic prior to participation. We did not invite the participants with a priori stakes in the debate, such as scientists or farmers, who were deemed likely to already have a predisposed position.

3.5 | Analysis and interpretation

With consent, the focus groups were recorded and transcribed ad verbatim. Using Atlas.Ti9, we coded the full transcripts. Codes and themes were formed in the process of analyzing. Special attention was given to analyzing the values and assumptions that shaped the participants' responses to GE technologies. We looked for convergences and divergences between and across groups.

4 | RESULTS

In this section, we set out the results of the focus group discussions. Despite differences in group composition, as regards age, socio-economic background, educational level, and topic-specific characteristics of groups, similar concerns, hopes, and conditions were voiced, and fairly comparable attitudes to foods, GM and GE emerged, although there were expressed differences of opinion within groups. For example, we noticed a slight difference between groups in the specifics of issues that were emphasized when the participants talked about the (future of) food. Whereas the participants from a higher socio-economic background with a theoretical education were inclined to talk about the food and the food system in a global context (e.g., fairness and effect on the environment), the participants from a lower socio-economic background with a practical education tended to focus more on price and taste—although global issues were also discussed. Another difference was the underlying tone in which GM was talked about initially: some groups seemed more positive than others, but the more information the participants received and discussed, the more groups converged toward the view that we need to exercise caution when introducing this technology. For these reasons, our analysis below focuses on the commonalities across the focus groups, not least because responses were rarely linked to the specific characteristics of the group.

4.1 | Citizen views on food and agricultural systems

Here, we explore how people spoke of their connection with food, its meaning and role in everyday life, the issues associated with food and agriculture, and their views on food systems and the role of technology therein. Most people spoke of a deep connection with food, conveyed in terms of care and attention, and of the pleasure in cooking. They expressed a preference for tasty, healthy, and nutritious meals made with fresh, natural ingredients. Clearly, people enjoyed a seemingly expanding array of ingredients, tastes, and cultures, which were seen as helping to move Dutch society away from a traditional and somewhat dull diet of boiled vegetables, potatoes, and meat, to something more interesting. Although viewed as generally a good thing, this increased availability of diverse options (in combination with social media representations) had nevertheless for some generated the pressure not to be seen as boring. Moreover, they simultaneously denounced the unlimited, year-round availability of many products from all over the world. Eating locally grown and seasonal foods was viewed by many participants as more sustainable, and arguably as healthier and tastier as well. Other downsides in people's experiences of our changing relation to food included the increasing commercialization and marketing of foods, driven by finance and generating what many viewed as tasteless vegetables and bureaucratic oddities such as requirements for straight cucumbers. Groups discussed that the impact of cooking shows numerous fads and diets, and the role that food plays in social media.

When the participants discussed the future of food, they addressed several (systemic) challenges. Across almost all groups, people discussed systemic issues of food scarcity and high nitrogen

[3]Because focus group 3 only consisted of five people, and the agency we used was contractually obligated to procure a minimum of six participants, this focus group was repeated using different participants.

emissions, the latter, a problem particularly prevalent in Dutch agriculture. Some groups discussed the intensification of agriculture, its impacts on biodiversity (local and global), and the risks of epidemics because of livestock farming. For many, farmers were seen as trapped in an unsustainable system arising from a history of poorly considered government subsidies and dependencies. The focus groups discussions took place during the time of the farmers' protests in the Netherlands, and thus at a time when the media were reporting on drawbacks of the current food system. It is thus not surprising that these drawbacks were mentioned. Other worries discussed included the cost of food (a prescient issue especially for those in lower socioeconomic demographics), unfairness in the food system (a particular focus was the cost of foodstuffs going disproportionately to supermarkets and middlemen and not to farmers), a prevalent economic model that cultivates superficial needs (such as strawberries dipped in chocolate on Valentine's day), health inequalities (where healthy, nutritious, and organic foods were seen as becoming increasingly a preserve for the rich and elites), and growing vulnerabilities in the system, as expressed in the exchange below in FGD4 (the "outdoors and sustainable living" group).

Saskia[4]: Also, the climate is changing, so we should expect changes in how much things are going to cost, whether things can still grow or … . and [whether] everything will become more expensive….

Matt: Yes, I do worry… If you look at prices nowadays. If you want to eat healthily, well, healthy, what is healthy anyway? But if you just eat your portion of meat or vegetables or rice or potatoes or whatever, the healthier you want to eat, the more expensive it is compared with … So, it seems sometimes like, especially for people with a smaller budget, you are just being pushed in a certain direction; you do not have a lot to spend, so then you go in that direction and then you get fatter, or you get diabetes, or you get [other health] problems.

Tom: But it is like that. People with a lower income have no choice. They cannot choose organic. I see it very often in my work. People in mental health care with a minimum income; they want to live healthier but it's just not possible. It's just not possible. And I think the government can be blamed for that.

[4]Names of the participants are fictional.

Concept Board 1 depicted four different approaches to agriculture: intensive farming, agroecology, precision agriculture, and organic farming. Although individual people expressed a preference for organic and agroecological systems, people in general saw the need for an integration or balance among organic, agroecological, intensive, and precision farming. Technology was viewed as an essential ingredient, but distinctions were made between technologies such as artificial intelligence (AI) or robotics that were aimed at making the system more efficient, and those aimed at modifying the biological composition of the crop or the animal (e.g., through innovations in breeding and biotechnology), which were seen as potentially more problematic. Interestingly, even before the concept of genetic editing had been introduced to the focus group discussion, the company Monsanto had emerged in several groups as a symbol of a negative connotation of the use of technology in agriculture.

4.2 | Citizen views on the GM of plants

In this section, we examine Dutch people's views on the application of GM technology in food crops: how people viewed the technology in contrast to other techniques of plant breeding, how they responded to arguments either for or against the technology as manifested in the societal controversy that took place in the 1990s, and how they responded to the current political landscape of GM crops and foods in Europe, including their governance.

We first asked the participants about the concept of GMOs: whether they had heard of them and what associations they had. Most participants had heard about GMOs, particularly the older ones, who were also aware of the controversy surrounding GMOs. However, people generally had limited understanding of what the technique of GM actually entails. The participants expressed a mix of associations. On the positive side, people mentioned the capacity for GM crops to adapt to local conditions, to improve disease resistance and efficiency, to control mutations, and to increase yields. On the negative side, people associated GM with "Monsanto," "creepiness," "disconnecting from nature," "playing God," "not beneficial to consumers," "arrogance," "danger," "perfectly shiny (and tasteless) tomatoes," and as likely to upset the balance of nature and to produce a domino effect. This ambivalent reaction, between the sentiment of GM crops leading to greater efficiency and higher yields, and a more inchoate apprehension that they were somehow troubling in how they "disrespected nature," with associated harms, was voiced by the public sector professionals in FGD5 (public sector professionals) in the exchange below:

Mod: We want to talk about one particular technology, and that is genetic modification. What comes to mind when we talk about the genetic modification of plants and crops?

Bart: A square tomato … (laughter)

Carlijn: A triangular pepper.

Margo: A blue strawberry …

Carlijn: Everything is manipulated.

Cees: The first thing that comes to mind is: "more, with the same conditions." So, with the same amount of water, the same amount of light, the same amount of soil, that you have more yields.

Mod: So more efficient?

Cees: Yes, more efficient, that a crop can deliver more with the same amount of water.

Femke: To me, there is also a certain arrogance in it. That you have no respect for nature anymore … That everything can be made.

Ingrid: I find it less natural then.

Francine: Yes, I find it dangerous.

Following a discussion of GM crops and foods in general, we illustrated the use of the technique, with the example of the Bt-brinjal aubergine, modified by a gene from a soil bacterium to make the crop resistant to the eggplant moth in Bangladesh. Reflecting on the case, some participants expressed a positive view, as it offered to support the livelihood of farmers in the Global South and to help ensure that the population has enough food. Others expressed doubts about the long-term safety record for humans and on possible effects on the ecosystem. Overall, when the participants were asked to compare and contrast GM (transgenesis) techniques of plant breeding with traditional breeding and classic mutagenesis (see Concept Board 2), people expressed most sympathy towards traditional breeding techniques. Most people were unfamiliar with mutagenesis and with details of the technique of GM, and, following deliberation, did not meet either of these technologies with enthusiasm.

When asked to respond to arguments prevalent in the debate on the GMO controversy of the 1990s, depicted in Concept Board 3, most participants tended to respond as follows: that they accepted/believed that GM technology could help in our quest to solve systemic challenges such as global food security, but that in practice, the technology had been and would continue to be used by corporations for commercial reasons to gain control over the food system, with problems likely to manifest only later. This is reflected in the comment below in a discussion in FGD4 (outdoors and sustainable living):

Derek: Yeah, well, commerce wins, so. Look, what I just wanted to say is, if you are going to use this kind of thing to indeed alleviate food shortages in the world, that you can indeed ensure that certain crops are harvested in countries where they are really needed, where people are dying of hunger, then I think you are pursuing a good goal. The moment you actually start modifying seedless cherries and things like that, then I think: yes guys, what are we actually [doing?] … How incredibly selfish we are being with regards to evolution. And we are going to shoot ourselves in the foot with this. We can already see that with the whole climate problem, with diversity, the insects that are dying. And that's just what you create. And we have only really been at these things for twenty or thirty years, but we are already seeing the misery that's coming to the surface.

When asked to reflect on the current state of regulation in Europe, depicted on Concept Board 4, people tended to approve that Europe had adopted a cautious approach compared to other regions. For some, GM crops offered some potential, for others, it offered little meaningful help towards the systemic problems faced in global agriculture (such as the contribution of livestock farming to climate change), and that while GM agriculture may prove necessary for the Global South, it was not necessary for the Netherlands, as discussed by the participants in FGD2 (technophiles):

Willem: Yes, it is a circle in that sense. It is necessary, because of the way we do it now, agriculture, livestock breeding, that leads to climate problems. […] Because [it is] largescale agriculture, and monoculture agriculture, [that] leads to big problems. And, if you still want to be able to grow crops and ensure that the world's population can eat, you will have to further develop food, partly. Unless you can somehow apply the brakes, not completely, but sufficiently, then it would not be necessary. But yes, better to be safe than sorry, and really do continue to develop.

Mod: And does everyone agree with that, that we need it?

Merel: No, not at all. I think, they have also done research [and shown] that all the crops that are now being grown for livestock, for cattle feed, that's super inefficient. And, also, all that water that those animals have to drink. So, an awful lot of water and grain and soya goes to those animals. Those animals also need land, they

need to grow. They need to eat, and they need to drink. We then slaughter them and transport them all over the world. The pieces of meat are stored. And so… And [it is] through these animals we humans mainly get [our] protein. Whereas, if you take that whole step out of the equation, or at least reduce it, then you can give food directly to people. And then we would not have a food shortage.
[…]

Roel: We [The Netherlands] are not going to make the difference [if we would change our diet]. But we can be the trendsetter, which is often the case in the Netherlands.

Bart: Yes, but that's why it's important to always find a kind of middle ground, [so] as to inspire others, like: oh yes, it can be done this way.

Lieke: But I do not think genetic modification is necessary in the Netherlands. I think that if you look at the more developing countries in Africa, or places where it is indeed difficult to grow crops at the moment, and where people are hungry …. But yes, that may be, what I just said, I do not think we need it in the Netherlands to produce more [food], but I think especially in places… where it is difficult to produce food.

4.3 | Citizen views on the GE of plants

So far, we have examined how Dutch citizens view food, agricultural systems, and the GM of food crops. We have performed so to comply with our research methodology that emphasizes the need to explore the context out of which attitudes and viewpoints emerge. How people develop attitudes to the GE of plants, our argument runs will depend on how they view the role of (bio)technology in foods, their perspective on the arguments surrounding the (earlier) technology of GM, and their sense of the comparison between GE and GM. Proponents of GE often declare a difference in kind between GM and GE. But was this the case for our Dutch participants? Our research painted a distinct set of responses. Following a discussion in which the GE CRISPR-Cas9 technique was introduced by one of the moderators to participants aided by Concept Board 5, we explored arguments as to whether GE should be regarded as similar to traditional breeding or to GM. The participants viewed GE plants as similar in kind to GM plants for two reasons: because at an ontological level, both processes involved the direct manipulation in laboratories of the genetic structure of plants (it mattered less whether a GE plant could theoretically have occurred in nature; what mattered was that it had not occurred in nature), and because at a political level, the impulses underpinning the technology were seen as convergent (i.e., namely, to restructure plants to comply with human and predominantly commercial purposes). The difference between GM and GE was seen by some groups to be merely semantic. As a participant in FGD6 stated: "*It's still genetic modification, of course. So, no matter how you do it*." Others suggested that marketing reasons could be behind the attempt by certain actors to distinguish between them. The participants from the technology-oriented FGD2 supported this viewpoint:

Willem: Well, I think, this feels like genetic modification. But that's why I find the discussion [on whether or not gene editing is a GMO] a bit weird.

Lieke: Yes. No, just that … that gene-editing is exactly the same as genetic modification, is not it?

Willem: Yes.

Lieke: I think… You have given it another name. But I do not yet see, within this record, I do not yet see what the difference is in terms of approach and technology.

Mod: And how does everyone else feel about that?

Merel: It's not clear to me either.

Mod: No? Not clear? Or do you yourself have an idea of: well, actually I do think it belongs somewhere. Or would you say: well, I just would not know where that …. (Merel shakes no)

Bart: I do not have that knowledge to say "this is really totally different" and "No, this is really genetic modification." No, I just do not have that knowledge.

Merel: Maybe it's just marketing and it's just genetic modification …. but it's called differently. Yeah, and sounds nicer: "Editing."

Willem: And you do not have to go through as many hoops to market it.

Merel: Yes, maybe.

The example cited of the first CRISPR-edited food to enter the market—the γ-aminobutyric acid (GABA)-enriched tomato introduced in Japan with (still largely unproven) claims of lowering blood pressure and of increasing relaxation (Waltz, 2022)—did little to allay fears. While many participants found the technology of CRISPR interesting and even beautiful, they found the application of the GABA-enriched

tomato less so, with one participant in FGD5 (public sector professionals) stating "*I want a normal tomato without tranquillizers*," and another from FGD6 (mistrusting institutions) who found the application "*super creepy*". The participants saw this example as responding to a largely superficial need driven by commerce as a potential and partial response to the stresses of Japanese working culture rather than as a genuine attempt to solve a problem in the global food system. Again, across all the focus groups was a general preoccupation with motive: why was the technology being developed and for whom? And, as discussed in FGD3 (outdoors and sustainable living), were these reasons necessary and commensurate with the act of modifying a plant and taking it away from its nature:

Renate: Yes. What does it [gene editing] do to the tomato itself? You know, the tomatoes, of course, no longer have the vitamins and what should be in them that they had so many years ago. What happens to them? You take out pieces of DNA, so then you take out a piece of tomato. So, what is that tomato? Yes, I do not know how to say it. What is that tomato? Is it just a tomato of, well, it's a red ball and you can put it in the salad, for example. Is that it or does it also have something of nutritional value, nutritional utility. That.

Mod: And that's important to you that, yes, it remains a tomato and that?

Renate: Yes, I do not know if you get that back at all, but. I think, do not you destroy it more and more with that [gene editing], with that?

Mod: Would you worry about that?

Renate: Well, certainly. Soon the tomato will come out of a 3D printer.

Antje: I think so too.

Mod: Do you worry about that too?

Antje: Well, if you look at things like that, yes. Because the more that is done with it, the more natural characteristics are lost, I think. And, yes, what is in it naturally is why it is so good. To eat.

4.4 | Citizen views on the regulation of GE of plants

Through the discussion of three concept boards, we explored how people responded to three scenarios for the future regulation of gene edited plants in Europe: Concept Board 6 articulating arguments why the GMO regulation should be revised (for reasons that included those of boosting innovation, developing capacities to respond to societal challenges, and of making the technology more accessible); Concept Board 7 articulating arguments why the GMO regulation should not be revised (for reasons that included those of safety, hype and false promises, corporate control, and consumer choice); and Concept Board 8 articulating arguments for a new level-based approach to GMO regulation (where the kind of regulation and risk assessment would depend on the level of genetic change introduced into the plant, as well as on broader considerations of societal benefit, sustainability, and ethics).

The participants expressed (pleasant) surprise that many of their concerns had also been articulated by other organizations. Across the focus group discussions, there was no appetite for relaxing the GMO regulations for GE. By contrast, the arguments for retaining the regulations, or for a level-based approach, commanded more support with the participants for multiple reasons: that safety as a value was more important than that of boosting innovation and competitiveness, that while the technology might have a role in helping respond to societal problems this could not be entrusted to corporations who would be governed by self-interest and short-term commercial gain, and that making the technology more accessible might increase the probabilities of unforeseen and harmful consequences and for the technology to get into the wrong hands. By contrast, most people saw the plausibility of arguments for why the regulation should not be amended, as can be seen in the extract of conversation in the succeeding texts by the participants in FGD6 (mistrusting institutions):

Valerie: […] somehow, I feel very strongly this is going to come anyway. It is going to happen.

Amalia: You have no choice.

Theo: If you notice how much lobbying is going on…

Valerie: No. So, we can say, no, we are against it, but it's going to happen anyway, so then it's much more of a question of, how are we going to do it? What do we want, how do we want to do it?

Mod: And how would you like that?

Valerie: Well, with all that they say [points to arguments on Concept Board 7], the false promises, the safety, the power of companies, the freedom of choice, they actually have to be guaranteed that we as citizens, as people on this planet or in Europe, that they are guaranteed for us. That it is safe for plants and animals, that we get good food, that there is no widening of the gap between rich and poor, and that we still know what kind of

products we buy. And if you can guarantee that, then you could do it.

Mod: But then you might also say, yes, in order to guarantee this, you might need regulation.

Valerie: Definitely.

This extract is revealing. Even though Valerie and Theo (and other members of FGD6) did not approve of GE in plants; nevertheless, they foresaw little opportunity for opposing the technology given the power of lobbying and the strength of commercial interests. In such a context, the only realistic means to govern the use of the technology was regulation and to seek criteria for regulation that spoke to their core concerns: that it would be safe, that corporations would be held to account for false promises, that it would not exacerbate inequalities, and that consumer choice would be retained. Indeed, for the participants in FGD6, it was precisely because of the potential of GE to contribute to solutions to societal problems that clear and robust regulation was necessary.

While the current approach and format of the GMO regulation in Europe tended somewhat to be trusted by the participants as having effectively modulated the introduction of genetically modified crops, there was more circumspection invoked in relation to the proposal for a new level-based approach, including the option for an accelerated risk assessment procedure. While, in principle, there was support for the proposition to develop regulation that would consider societal considerations, there was concern that this could generate greater potential for subjective judgement and for the process to be captured by powerful, external interests. The need for independent assessors was a theme articulated by participants in FGD2 (technophiles):

Willem: And who assesses at what level something falls under?

Mod: That is a good question.

Willem: Because of course it should not be "the butcher is judging his own meat."

[…]

Willem: Yes, if these are your criteria for saying "this and that we are going to do," then we must also be able to establish these objectively.

Lieke: Yes, but that's the same thing: who determines what is ethical? That really needs to be established. As well as what the social benefit is.

Willem: Yes, that should be further elaborated. But I'm sure they will, I suppose.

Lieke: But I really think that a genetic change, that level 1, 2, 3, I think you can… You just have to be able to demonstrate that, right? Because if it's all traceable, then you also have to be able to show how many changes you have tackled in that DNA. So, I think that's the easy step. I think it's more difficult to determine what is or is not ethically justified and socially useful. Because what I find socially useful, you might find something completely different.

5 | DISCUSSION

We finish the paper with a discussion of the findings and their wider implications in four parts: how they respond to the research questions articulated in the introduction, how they align with the amended NGT proposal, the significance and wider validity of these findings for the plant science community and for the governance of NGTs, and on ways forward.

First, a remark on the method: traditional on the matter of context, our decision to start the focus groups with a discussion on food, the food system, and the role of technology therein was a choice based on previous research on citizens views on GM foods (Grove-White et al., 1997) and on wider scholarship on risk perceptions (Hansen et al., 2003; Irwin, 2001). While other choices could have been made, it was the centrality of food and its place in contemporary identity construction that underpinned this decision (Warde, 2016). On choices made in the progression of topics in the focus group, the design was set up to answer the research questions, including that of whether NGTs were perceived as substantially different from those modified by the older GM techniques. Thus, while the presentation of the GM debate (the 1990s controversy) and the GM example (Bt binjal) prior to the discussion on NGTs unavoidably had a shaping effect, we were careful to moderate these effects through mindful moderation (see succeeding texts). On the matter of sampling, while other selection choices could have been made (e.g., people with community gardens, people skeptical of technology, favoring meat, being nationalist, with different religious beliefs, etc.), the criteria used reflected our choices on the importance of food and technology in the construction of social identity (see earlier discussion), and in line with issues seen as important in previous research on citizen perceptions, including those of trust and agency (Grove-White et al., 1997; Marris et al., 2001).

5.1 | Responding to the research questions

RQ1: Do Dutch citizens view crops modified by gene editing techniques (NGTs) as substantially different from those modified by the older GM techniques?

Similar to a previous study commissioned by the Dutch Commission on GM COGEM (2019), we found that Dutch citizens make a

clear distinction between plant varieties developed by traditional breeding on the one hand, and genetic techniques, including classic mutagenesis, GE, and GM, on the other hand. Citizens express a preference for traditional breeding. This finding stands in contrast to one of the key narratives used by proponents for the exemption of NGT crops from the GMO Directive. Proponents, as well as some scientific bodies, emphasize that plants modified by GE technologies can be biologically equivalent to plant varieties of traditional plant breeding methods and (traditional) mutagenesis (EASAC, 2017; EFSA, 2020; EFSA, 2022; EuropaBio, 2023; European Commission, 2017; European Commission, 2021; Euroseeds, 2023). The argument for equating gene edited crops with traditionally bred crops is that the *product (the crop)* could be genetically similar, even though the process is different. Citizens in our focus group discussions, however, argue rather that the fact that certain mutations could have also happened in traditional breeding, or in nature, is irrelevant, because they did not develop through traditional breeding or evolve in nature. Instead, scientists modified the genome in the laboratory according to their expressed goals to introduce new traits. The process (and intention) of GE is relevant for citizens in our study. We can conclude that citizens see GE as (a form of) GM. However, for regulatory purposes, differentiation in risk assessment among different forms of GM techniques may be permissible under conditions, according to many participants, although trusted experts would need to assess this.

RQ2: What are citizens' concerns and hopes for gene-edited crops and food, and what factors underpin these?

Our study shows that Dutch citizens have reservations about introducing NGTs in plant breeding practice in Europe for three reasons. First, they have doubts about gene-edited crops delivering on their promises. While citizens see the potential for these crops to provide solutions for specific problems in agriculture, like infections and plagues, they question the plausibility that societal interests would prevail over commercial interests so long as decisions are left primarily to the market. In addition, they see gene-edited plants as unlikely to contribute meaningfully to solving current challenges such as the nitrogen crisis, the climate crisis, or food security, because these challenges are caused by multidimensional, complex, social factors. For citizens, it is the unjust food system that needs repairing, rather than the introduction of a new technofix. However, they can imagine that problems in other countries may call for a solution using NTGs.

Second, citizens anticipate unforeseen and unintended consequences to arise from the introduction of NGTs. Indeed, for our participants, it was the technological intensification of agriculture that had exacerbated many of our current societal problems—such as nitrogen disposition, decreased biodiversity, impoverished soil, and climate change—making it unlikely that a new technological innovation would not similarly be accompanied with unforeseen adverse effects downstream, such as a further concentration of the power of large companies in the food system, risks (and uncertainties) to human health, and risks to the precarious balance in natural ecosystems (including agricultural ecosystems). However, some citizens believed that because society went down the road of technification, there may not be another choice than using NGTs to solve the current problems in agriculture.

Third, although some citizens were enthusiastic about the possibilities raised by NGTs, many citizens viewed NGTs as in tension with core underlying cultural values. Central to these is the value of naturalness, predicated in citizens desire for fresh, wholesome, and minimally processed foods, where gene-edited foods were seen as a move away from their nature or purpose. Research indicates that for citizens from the Global North (and very possibly beyond), the process by which a product is made holds more importance than its content when assessing its naturalness (Scott et al., 2018) and that there is a strong preference for natural and organic foods in high-income countries (Roman et al., 2017; Rozin et al., 2004, 2012). It is not a coincidence that proponents of NGTs advertise NGTs as similar to traditional breeding and emphasize that humans have been breeding plants for more than thousands of years.

"Tinkering" in the genetic material of plants is seen as a move towards the making of plants as instrumental objects, modified for human convenience and for commercial purposes. Moving away from nature was thus seen as bringing nature (plants) ever more into the sphere of human control for purposes of efficiency. Citizens expressed similar sentiments in focus groups in France, Germany, Italy, and Spain around the end of the last century (Marris et al., 2001). The value of justice also underpinned the formation of citizen attitudes: the unjust distribution of food globally, the unjust or unequal access to healthy food nationally, and the unjust distribution of economic benefits in the food system. Across a few of our focus group discussions, citizens came to the view that if market authorization of gene-edited crops was facilitated by changing the regulatory framework, this will lead to growing inequality in the food system.

Before moving to our next research question, we briefly address differences and similarities of current views and perspectives found in this study and the views of Dutch, and other European citizens, on the GM of crops in the late 1990s and early 2000s. Although our study is not comparative, we identified certain similarities between our findings and those of the broad public discussion in the Netherlands in 2001 (Temporary Committee on Biotechnology and Food, 2002). Both then and now, citizens were ambivalent about the technology and objections were rooted chiefly in concerns regarding the (known and unknown) impacts of GM crop use (safety, social, and political), while only a minority objected on intrinsic grounds, seeing GM, for example, as an infringement on species integrity. Citizens expressed concerns over the necessity, usefulness, and purpose of genetically modified (GM) and/or NGT crops; they inquired about alternative solutions to societal challenges; and they believed strict regulation is necessary because of questions of safety. Such worries were also observed in other studies in Europe around that time (European Commission, 2000, 2002, 2005, 2010; Grove-White et al., 1997; Marris, 2001). Concerning differences, arguably one could say that citizens now have greater concerns about the systemic

impacts of global agriculture on the environment, and that they demonstrate a more mature understanding of the entanglement of technologies with politics and the food system.

> RQ3: What governance does the public see fit for gene-edited crops?

The citizens in our focus groups differed to some extent in their views on GM and GE, but when it came to regulation, they all opposed an exemption of GE plants from the GMO regulation. Other studies find similar results (COGEM, 2019; Hanssen, 2022; Nair et al., 2023). Following deliberation, citizens arrived at the view that Europe broadly has got it right with strict regulations in place for agricultural GM technology, and that Europe should exercise similar precaution with NGTs. Regulation is necessary for citizens for three reasons. First, citizens are concerned about risks and want these to be assessed before GE crops come on the market. Second, they believe freedom of choice is an important democratic right and value which requires GE products to be labeled. Third, they advocate regulation because they do not want GE crops to be developed purely for commercial motives driven by the logic of the market. They do not trust that companies, in a deregulated environment, would be motivated to develop socially useful products. Regulation is necessary to shape conditions for public interest market authorization and to mitigate growing inequalities and power concentrations in the food system.

When presented with a concise version of the Norwegian level-based model of regulation (see Methods S2, Concept Board 8), citizens expressed positive views on the principle of adding broader socio-economic and ethical aspects in an assessment for market authorization for GE crops. Nevertheless, they still expressed doubts about the practicality and feasibility of such a proposal. Who would decide on what is sustainability? Who would judge what is ethical? And how would ratings be compared?

5.2 | Alignment with current NGT proposal of the European Commission

In light of our findings, to what extent does the current NGT proposal align with what Dutch citizens view as good governance for NGT crops? Citizens in our study were unanimous in their views that the risks of NGT crops needed to be assessed on a case-by-case basis, although they were open to a differentiated risk assessment regime. These results are supported by several other studies (COGEM, 2019; Hanssen, 2022; Nair et al., 2023). The current NGT proposal does not align with these views as no risk assessment will be required for Category 1 NGT crops.

The European Parliament adopted two amendments to the regulation which align with the perspective of Dutch citizens. First, patents on NGT products are to be banned; both citizens and MEPs foresee that allowing multinational seed companies to patent NGTs and their products would risk giving these companies even more power over farmers' access to seeds (European Parliament, 2024). Prohibiting patents is viewed as a mechanism that can help prevent increasing inequality in the food system. Second, all NGT crops are to require labeling to provide freedom of choice for citizens. Various studies in addition to ours show that Dutch citizens attach value to freedom of choice to (not) consume these products (COGEM, 2019; Hanssen, 2022; Nair et al., 2023).

In addition, our findings demonstrate that Dutch citizens view regulation as a device that can help ensure that companies develop socially beneficial crops based on genuine need rather than commercially beneficial crops often based on superficial consumer desire. The European Commission considered the option of sustainability requirements for market authorization of GE plants (European Commission, 2023a) and rejected this as it was seen as likely to create regulatory burdens and uncertainty which could subsequently disincentivize development and authorization of GE plants in the EU, including the development of plants that may contribute to a sustainable agri-food system.[5]

5.3 | What is the significance and wider validity of these findings for the plant science community and for governance of NGTs?

Plant scientists have difficulties imagining valid reasons to be against the introduction of NGT plants in agriculture (So et al., 2024),[6] grounding the expectation of benefits of NGT plants on the accelerated speed of inducing GMs in the lab to change plant traits.[7] In general, natural scientists firmly believe in the efficacy of technological solutions and in science and technology as the primary source of knowledge for the improvement of well-being. Those involved in developing NGTs also tend to be idealistic, viewing their work as providing solutions to societal challenges and contributing towards a better world (So et al., 2024), potentially leading to cognitive dissonance between the *potential* of NGTs to generate genuine societal benefit and the *likelihood* of applications shaped in the real world by the logics of global commerce. They imagine as real benefits (and scientific fact) the imaginable benefits (Welsh & Wynne, 2013). In contrast, citizens seem to assess the new technology not by its potential power to improve well-being but instead on the circumstances seen as likely to determine how the technology emerges, the interests shaping its use, and alternative approaches and opportunity costs . They consider justice and fairness in the food system to be important guiding criteria for moving forward with technologies as solutions and demonstrate an awareness of the entanglement of technologies with politics and

[5]Although the current proposal includes measures to incentivize plant products that could contribute to a sustainable agri-food system, the list of traits justifying these incentives is so inclusive as to ensure that most NGT crops currently in development would satisfy this criterion and enter the market.

[6]From personal experience from participating in many stakeholder workshops.

[7]When confronted with evidence from GM crops, demonstrating that conclusions about sustainability of GM crops are hard to make, because it depends on the specific crop, the plant trait, time, and place, and with the fact that so far, GM crops have failed to deliver on their great promises, scientists usually attribute this failing to external factors that impeded the development of such GM crops. Mostly, the strict European legislation is seen as a cause.

the food system. Arguably, citizens are more accomplished sociologists than plant scientists.[8]

Although scientists have explained the difference between their own views and those of citizens as a clash among objective, expert knowledge, and a subjective misrepresentation of scientific knowledge, our study confirms that this viewpoint is an inaccurate perception of public views (European Commission, 2007; Marris, 2001; Welsh & Wynne, 2013; Wynne, 2011). Public interactions with dominant scientific agendas have inevitably included responses to underlying, implicit normative commitments that are often dismissed by scientific and policy authorities (Peters, 2000; Welsh & Wynne, 2013). Food consumption is deeply intertwined with social, cultural, and organizational practices. How individuals negotiate concerns about risks, environmental issues, and nutrition are interconnected in everyday life, and based on experience and social networks (Grove-White et al., 1997; Halkier, 1999; Hansen et al., 2003; Holm & Kildevang, 1996). Our findings confirm that concerns about food are, in part, concerns about wider social and cultural trends seen as increasingly prominent and problematic in late modernity. These include concerns about our (over)optimization of models of efficiency and productivity (Hansen, 2003; Holm & Kildevang, 1996), of attempting to solve societal problems with science and technology, of striving to make life even-more perfect, and of making the world more and more plastic (and less natural). All these concerns are moreover fueled by cynicism towards multinational companies and their shareholders, and skepticism about governmental authorities' capacity or willingness to design and implement adequate regulation to prevent commercial goals from driving biotechnology's development.

Our research is part of a broader corpus that suggests there is little evidence of a knowledge deficit nor of a decline in citizen's trust in science (Rathenau Instituut, 2024) but points rather to an ongoing miscommunication and/or misunderstanding between the community of plant scientists and citizens (and also NGOs and social scientists). Such a misunderstanding is based on, among others, differences in what counts as legitimate knowledge (and values) to take into account when evaluating technological solutions to current predicaments and its governance (Chesters & Welsh, 2006; Latour, 2004; Wynne, 2006), different interpretations of concepts like sustainability, and diverging values feeding into perceptions of what constitutes a benefit. For example, not many citizens participating in our focus groups considered the value of efficiency and/or optimization of productivity as a core value that should drive technological innovation.

5.4 | A way forward

We conclude with suggestions aimed at aligning policy on NGTs in plants with public sentiment. Our proposal requires three constituent elements: structured public dialog aimed at generating public views in an endogenous bottom-up manner aided by social science-informed interpretation, collaboration between plant scientists and social scientists aimed at generating reflexive interdisciplinary communities, and collaboration between social scientists and policymakers aimed at developing policy responses that are responsive to the quality and nature of public attitudes. To be responsive to such an initiative would require two additional responsibilities to be put into practice: an openness to socio-economic considerations in driving forward agricultural systems towards the agriculture we collectively desire, and recognition of the contested and situated epistemic construction of concepts, such as those of benefit and sustainability, that are implicit in expert and citizen formulations.

Does this point to an entirely different avenue for governance? We believe it points to a desire for regulatory reform that includes assessment of broader societal considerations which depend both on the product and/or the process. Citizens, like policymakers, emphasize the difficulty of such regulation as they assume that socio-economic considerations are based on opinions and values, are therefore subjective and thus non-scientific, compared to "science-based" risk assessments, as well as being open to capture by powerful, external interests. This assumption has been challenged by pointing out that this traditional distinction is ideologically rooted in neoliberal thinking—which prescribes the conditions under which circumvention of the market is deemed legitimate (Beumer, 2019; Kinchy et al., 2008; Kleinman & Kinchy, 2007). Beumer views regulatory objectivity instead as a product of established methods and consensus developed over time—rather than an inherent trait of the regulated matter (Beumer, 2019). Longstanding scientific practices and methods, such as testing risks through precise experiments, have enabled objective forms of decision-making (Beumer, 2017; Boholm, 2015; De Vries et al., 2011). Because socio-economic considerations lack such established methods, this does not point to an inability for objective decision-making about these issues; it merely means they have not evolved yet. Beumer demonstrates this using Kenya and South Africa as examples of states where regulation of socio-economic issues in biotechnology have evolved towards a more objective, socially robust form of decision-making (Beumer, 2019). The practice in these countries could be an example for European policymakers.

AUTHOR CONTRIBUTIONS

Michelle Habets and Phil Macnaghten jointly planned the research, executed the data collection and analysis, and substantially revised the paper. Michelle Habets took the lead in writing the paper.

ACKNOWLEDGMENTS

This paper has benefitted from the assistance of Petra Verhoef and Isabelle Pirson as well as from advice of Noelle Aarts, Bert Lotz, and Tsjalling Swierstra. We are also grateful for the comments of two anonymous reviewers. This paper is based on a policy report of the Rathenau Instituut, conducted in collaboration with Wageningen University and Research (Habets, et al, 2023,).

CONFLICT OF INTEREST STATEMENT

The authors declare no competing interest.

[8]We are grateful to the reviewers for making this observation.

DATA AVAILABILITY STATEMENT

The textual data that support the findings of this study are available in anonymized form from the corresponding author upon specific request. Full transcript data are not publicly available because of privacy or ethical restriction.

ETHICS STATEMENT

The research took place following the Wageningen Code of Conduct for Research Integrity. Citizens were professionally recruited by Norstat. Seeking informed consent from the participants is part of their application process. The transcripts of the focus groups will be saved encrypted for 10 years. The work complies with the journal's policy on 'Authorship and AI-generated content.'

ORCID

Michelle G. J. L. Habets https://orcid.org/0009-0008-2595-8975
Phil Macnaghten https://orcid.org/0000-0002-6611-4583

REFERENCES

ARC. (2024). EU Food Safety Agency to Give New Opinion on New Genomic Techniques/New GMOs. Accessed: December 5, 2024. https://www.arc2020.eu/eu-food-safety-agency-to-give-new-opinion-on-new-genomic-techniques-new-gmos/

Beumer, K. (2017). Travelling risks. How did nanotechnology become a risk in India and South Africa? *Journal of Risk Research*, *21*(11), 1362–1383.

Beumer, K. (2019). How to include socio-economic considerations in decision-making on agricultural biotechnology? Two models from Kenya and South Africa. *Agriculture and Human Values*, *36*, 669–684. https://doi.org/10.1007/s10460-019-09934-1

Biodynamic Federation Demeter. (2024). *Parliament vote on NGT proposal: A step back on biosafety, a step forward on traceability and labelling*. https://demeter.net/parliament-vote-on-ngt-proposal/

Boholm, A. (2015). *Anthropology and risk*. Routledge. https://doi.org/10.4324/9781315797793

Broerse, J. E. W., & de Cock Buning, J. T. (2012). Public engagement in science and technology. In *Encyclopedia of applied ethics* (pp. 674–684). Elsevier. https://doi.org/10.1016/B978-0-12-373932-2.00017-X

Chesters, G., & Welsh, I. (2006). *Complexity and social movements: Multitudes on the edge of chaos*. Routledge. https://doi.org/10.4324/9780203487075

COGEM. (2019). Percepties van burgers over genetische modificatie Een kwalitatieve en kwantitatieve verkenning. Onderzoeksrapport CGM 2019–02. Bilthoven.

De Vries, G., Verhoeven, I., & Boeckhout, M. (2011). Taming uncertainty: The WRR approach to risk governance. *Journal of Risk Research*, *14*(4), 485–499. https://doi.org/10.1080/13669877.2011.553728

Dequeker, S. (2022). Wat gentech en agro-ecologie elkaar te bieden hebben Tijd voor verzoening? *De groene Amsterdammer*.

Duroc, C., Benini, C., Vermeulen, M., Ribera, M., Bandry,J., Lacoste, E., Axiotiades, I., Doré, D., Pesonen, P., de Matos, O., Entzminger, C., Granados Chapatte, A., Rusek, J., Vacondio, F., Skentekbery, C., Redondo Benito, B., Nanda, A., von Essen, G., Moreno, N., Baldoli, M., Lecocq, N., Döring, A., Seifert, J., Jacobs, D., Scheres, H., and Fortescue, J. (2022). Letter to Executive Vice-President Frans Timmermans Commissioner Stella Kyriakides. Accessed: December 5, 2024. https://www.europabio.org/wp-content/uploads/2022/11/22.0786-final-joint-Letter-NGTs-14-11-2022.pdf

EFSA Panel on Genetically Modified Organisms. (2020). Applicability of the EFSA opinion on SDNs type 3 for the safety assessment of plants developed using SDNs type 1 and 2 and oligonucleotide-directed mutagenesis. *EFSA Journal*, *18*(11), 6299. https://doi.org/10.2903/j.efsa.2020.6299

EFSA Panel on Genetically Modified Organisms. (2022). Updated scientific opinion on plants developed through cisgenesis and intragenesis. *EFSA Journal*, *20*(10), 7621. https://doi.org/10.2903/j.efsa.2022.7621

EPSO. (2024). *Comment on the European Parliament vote on the NGT legislation proposed by the European Commission – Addition to the EPSO statement on the EC's legal proposal*. Accessed: December 5, 2024. https://epsoweb.org/epso/comment-on-the-european-parliament-vote-on-the-ngt-legislation-proposed-by-the-european-commission-addition-to-the-epso-statement-on-the-ecs-legal-proposal/2024/02/14/

EuropaBio. (2023). *The NGT proposal is an important step towards Europe's bioeconomy-driven strategic autonomy, competitiveness and sustainability ambitions*. Accessed: December 5, 2024. https://www.europabio.org/the-ngt-proposal-is-an-important-step-towards-europes-bioeconomy-driven-strategic-autonomy-competitiveness-and-sustainability-ambitions/

European Academies Science Advisory Council (EASAC). (2017). *Genome editing: Scientific opportunities, public interests and policy options in the European Union*. German National Academy of Sciences.

European Commission. (2021). Staff working document. *Study on the status of new genomic techniques under Union law and in light of the Court of Justice ruling in Case C-528/16*, SWD(2021) 92 final.

European Commission. (2022). Legislation for plants produced by certain new genomic techniques public consultation factual summary report. Brussels https://ec.europa.eu/info/law/better-regulation/

European Commission. (2023a). Commission Staff Working Document. Impact Assessment Report. Accompanying the document Proposal for a regulation of the European Parliament and of the council on plants obtained by certain new genomic techniques and their food and feed, and amending regulation (EU) 2017/625. Brussels, 5.7.2023 SWD(2023) 412 final.

European Commission. (2023b). Proposal for a regulation of the European Parliament and of the council on plants obtained by certain new genomic techniques and their food and feed, and amending regulation (EU) 2017/625. Brussels, 5.7.2023 SWD(2023) 412 final.

European Commission. (2023c). Recommendation (EU) 2023/2836 of 12 December 2023 on promoting the engagement and effective participation of citizens and civil society organisations in public policy-making processes. Brussels.

European Commission, Directorate General for Research. (2002). Eurobarometer 58.0. Europeans and Biotechnology in 2002. Brussels.

European Commission, Directorate General for Research. (2005). *Special barometer. Europeans and Biotechnology in 2005: Patterns and Trends*. Brussels.

European Commission, Directorate-General Communication. (2010). Eurobarometer 73.1 biotechnology, Brussels.

European Commission, Directorate-General for Research and Innovation. (2017). New techniques in agricultural biotechnology. Brussels.

European Commission, Directorate-General for Research, Directorate-General for Communication and Culture. (200). Special Eurobarometer 52.1: The Europeans and biotechnology. Brussels.

European Commission, Directorate-General for Research, Expert Group on Science and Governance to the Science, Economy and Society Directorate. (2007). Taking European knowledge society seriously. Brussels.

European Parliament. (2024). Amendments adopted by the European Parliament on 7 February 2024 on the proposal for a regulation of the European Parliament and of the Council on plants obtained by certain new genomic techniques and their food and feed, and amending regulation (EU) 2017/625 (COM(2023)0411 – C9–0238/2023–2023/0226(COD)) P9_TA(2024)0067.

Euroseeds. (2023). Plant Breeding Innovation – NGTs FAQs. Accessed: December 5, 2024. https://euroseeds.eu/app/uploads/2023/11/23.0431-FAQs-NGTs.pdf

Euroseeds. (2024) *European Parliament confirms positive vote on New Genomic Techniques- now the EU Council needs to embrace plant breeding innovation*. Accessed: December 5, 2024. https://euroseeds.eu/app/uploads/2024/04/24.0346-European-Parliament-confirms-positive-vote-on-New-Genomic-Techniques-now-the-EU-Council-needs-to-embrace-plant-breeding-innovation-.pdf

French Agency for Food, Environmental and Occupational Health & Safety. (2024). *Opinion on methods for assessing the health and environmental risks and socioeconomic issues associated with plants obtained using certain new genomic techniques (NGTs)*. https://www.anses.fr/en/system/files/BIORISK2021SA0019EN.pdf

Friends of the Earth Europe. (2024). *EU Parliament vote on new GMOs: A blow to food & environmental safety*. https://friendsoftheearth.eu/press-release/eu-parliament-vote-on-new-gmos-a-blow-to-food-environmental-safety/

German Federal Agency for Nature Conservation. (2024). *For a science-based regulation of plants from new genetic techniques*. https://www.bfn.de/sites/default/files/2024-02/24_02_07_BfN_policy_brief_NGT-7.pdf

Greenpeace. (2021). Danger ahead. *Why gene editing is not the answer to the EU's environmental challenges*. https://www.greenpeace.org/static/planet4-eu-unit-stateless/2021/04/20210331-Greenpeace-gene-editing-position-paper-EN.pdf

Grove-White, R., Macnaghten, P., Mayer, S., & Wynne, B. (1997). *Uncertain world. Genetically modified organisms, food and public attitudes in Britain*. CSEC, Lancaster University.

Habets, M., Pirson, I., Macnaghten, P., & Verhoef, P. (2023). *Editing under provision—Dutch citizens' views on new genomic techniques in food crops*. Rathenau Instituut.

Habets, M., van Hove, L., & van Est, R. (2019). *Genome editing in plants and crops—Towards a modern biotechnology policy focused on differences in risks and broader considerations*. Rathenau Instituut.

Halkier, B. (1999). Consequences of the politicization of consumption: The example of environmentally friendly consumption practices. *Journal of Environmental Policy & Planning*, *1*, 25–41. https://doi.org/10.1080/714038522

Hansen, J., Holm, L., Frewer, L., Robinson, P., & Sandøe, P. (2003). Beyond the knowledge deficit: Recent research into lay and expert attitudes to food risks. *Appetite*, *41*(2), 111–121. https://doi.org/10.1016/S0195-6663(03)00079-5

Hanssen, L. (2022). *De Publieke Stem. Publiekspercepties van Nieuwe Biotechnologische Technieken in de Agro- en Industriesector en Mogelijkheden voor een Effectievere Publieksparticipatie bij de Ontwikkeling van Nieuw Biotechnologiebeleid*. DEINING Onderzoek & Advies.

Holm, L., & Kildevang, H. (1996). Consumers' views on food quality. A Qualitative Interview Study. *Appetite*, *27*(1), 1–14.

IFOAM Organics Europe. (2024). *NGT vote a step backward for biosafety that nonetheless safeguards the possibility for traceability and national "coexistence" measures*. Accessed: December 5, 2024. https://www.organicseurope.bio/news/ngt-vote-a-step-backward-for-biosafety-that-nonetheless-safeguards-the-possibility-for-traceability-and-national-coexistence-measures/

Irwin, A. (2001). Constructing the scientific citizen: Science and democracy in the biosciences. *Public Understanding of Science*, *10*, 1, 301–318. https://doi.org/10.1088/0963-6625/10/1/301

IUCN-NL, Natuur en milieufederatie Noord-Holland (MNH), Natuur & Milieu. (2022). Biotechnologie in breder perspectief. *Een inventarisatie van de posities van Nederlandse natuur- en milieuorganisaties ten aanzien van biotechnologie*. https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2022/11/30/biotechnologie-in-breder-perspectief/posities-genetische-modificatie.pdf

Jasanoff, S. (2000). Commentary: Between risk and precaution—Reassessing the future of GM crops. *Journal of Risk Research*, *3*(3), 277–282. https://doi.org/10.1080/13669870050043161

Kearnes, M. B., Grove-White, R., Macnaghten, P., Wilsdon, J., & Wynne, B. (2006). From Bio to Nano: Learning Lessons from the UK Agricultural Biotechnology Controversy. *Science as Culture*, *15*(4), 291–307. https://doi.org/10.1080/09505430601022619

Kinchy, A., Kleinman, D. L., & Autry, R. (2008). Against free markets, against science? Regulating the socio-economic effects of biotechnology. *Rural Sociology*, *73*(2), 147–179. https://doi.org/10.1526/003601108784514570

Kleinman, D. L., & Kinchy, A. J. (2007). Against the neoliberal steamroller? The biosafety protocol and the social regulation of agricultural biotechnologies. *Agriculture and Human Values*, *24*(2), 195–206. https://doi.org/10.1007/s10460-006-9049-6

Latour, B. (2004). Why has critique run out of steam? From matters of fact to matters of concern. *Critical Inquiry*, *30*(2 Winter), 225–248. https://doi.org/10.1086/421123

Macnaghten, P. (2017). Focus groups as anticipatory methodology: A contribution from science and technology studies towards socially resilient governance. In R. S. Barbour & D. L. Morgan (Eds.), *A new era in focus group research. Challenges, innovation and practice* (pp. 343–363). Palgrave Macmillan. https://doi.org/10.1057/978-1-137-58614-8_16

Macnaghten, P. (2021). Towards an anticipatory public engagement methodology: Deliberative experiments in the assembly of possible worlds using focus groups. *Qualitative Research*, *21*(1), 3–19. https://doi.org/10.1177/1468794120919096

Marris, C. (2001). Public views on GMOs: Deconstructing the myths. *EMBO Reports*, *2*(7), 545–548. https://doi.org/10.1093/embo-reports/kve142

Marris, C., Wynne, B., Simmons, P., & Weldon, S. (2001). *Public perceptions of agricultural biotechnologies in Europe*. CSEC, Lancaster University.

Nair, A., Fischer, A. R. H., Payen, F., Kleter, G., Kohl, C., Baekelandt, A., Nanda, A. K., Jorasch, P., Davies, J. A. C., & R. Wilhelm (2023). *Data on the Netherlands and United Kingdom's Citizens Juries on New Plant Breeding Techniques* (Version 1) Zenodo.

Paraskevopoulos, K., & Federici, S. (2021). Overview of EFSA and European national authorities' scientific opinions on the risk assessment of plants developed through new genomic techniques. *EFSA Journal*, *19*(4), 6314–6357.

Parliamentary documents of the Dutch House of Representatives. 2017/2018. 27 428, no. 346 https://zoek.officielebekendmakingen.nl/kst-27428-348.pdf

Parliamentary documents of the Dutch House of Representatives. 2023/2024. 22 112, no. 3773 https://www.eerstekamer.nl/eu/behandeling/20240328/brief_regering_reactie_op_de_motie

Peters, H. P. (2000). From information to attitudes? Thoughts on the relationship between knowledge about science and technology and attitudes toward technologies. In M. Dierkes & C. V. Grote (Eds.), *Between understanding and trust. The public, science and technology* (pp. 265–286). Harwood Academic Publishers.

Plantum. (2024). *Europees Parlement stemt vóór Nieuwe Genomische Technieken*. Accessed: December 5, 2024. https://www.plantum.nl/nieuws/europees-parlement-stemt-voor-nieuwe-genomische-technieken-2/

Rathenau Instituut. (2024). Public trust in science. Factsheet. Accessed: December 5, 2024. https://www.rathenau.nl/en/science-figures/impact/trust-science/public-trust-science

Roman, S., Sanchez-Siles, L. M., & Siegrist, M. (2017). The importance of food naturalness for consumers: Results of a systematic review. *Trends in Food Science and Technology*, *67*, 44–57. https://doi.org/10.1016/j.tifs.2017.06.010

Rozin, P., Fischler, C., & Shields-Argeles, C. (2012). European and American perspectives on the meaning of natural. *Appetite*, *59*(2), 448–455. https://doi.org/10.1016/j.appet.2012.06.001

Rozin, P., Spranca, M., Krieger, Z., Neuhaus, R., Surillo, D., Swerdlin, A., & Wood, K. (2004). Preference for natural: Instrumental and ideational/moral motivations, and the contrast between foods

and medicines. *Appetite*, *43*(2), 147–154. https://doi.org/10.1016/j.appet.2004.03.005

Ruiz, J. (2017). Collection production of discourse: An approach based on the qualitative school of Madrid. In R. Barbour & D. Morgan (Eds.), *A new era in focus group research. Challenges, Innovation and Practice*. Palgrave Macmillan. https://doi.org/10.1057/978-1-137-58614-8_13

Sanchez Manzanaro, S. (2024). EU unable to approve new gene-editing plans in current mandate. Accessed: December 5, 2024. https://www.euractiv.com/section/agriculture-food/news/eu-unable-to-approve-new-gene-editing-plans-in-current-mandate/

Scott, S. E., Nbar, Y., Wirz, C. D., Brossard, D., & Rozin, P. (2018). An overview of attitudes toward genetically engineered food. *Annual Review of Nutrition*, *38*, 459–479. https://doi.org/10.1146/annurev-nutr-071715-051223

So, A. M., Habets, M. G. J. L., Testerink, C., & Macnaghten, P. (2024). The societal roles and responsibilities of plant scientists in the context of genome-edited crops. *Plants, People, Planet*, *6*(3), 760–773. https://doi.org/10.1002/ppp3.10485

Stirling, A. (2007). "Opening up" and "closing down". *Science, Technology & Human Values*, *33*(2), 262–294. https://doi.org/10.1177/0162243907311265

Temporary Committee on Biotechnology and Food. (2002). *Food and genes: A public debate on biotechnology and food*. The Hague.

The European Network of Scientists for Social and Environmental Responsibility (ENSSER). (2024). *Press Release: EU Parliament disregards science by endorsing deregulation of new GM plants*. Accessed: December 5, 2024. https://ensser.org/press_release/press-release-eu-parliament-disregards-science-by-endorsing-deregulation-of-new-gm-plants/#more-3631

Waltz, E. (2022). GABA-enriched tomato is first CRISPR-edited food to enter market. *Nature Biotechnology*, *40*, 3–11. https://doi.org/10.1038/d41587-021-00026-2

Warde, A. (2016). *The practice of eating*. Polity.

Welsh, I., & Wynne, B. (2013). Science, scientism and imaginaries of publics in the UK: Passive objects, Incipient Threats. *Science as Culture*, *22*(4), 540–566. https://doi.org/10.1080/14636778.2013.764072

WePlanet. (2023). Open letter coordinated by Hidde Boersma to the Members of the European Parliament. Accessed: December 5, 2024. https://www.weplanet.org/ngtopenletter

Wynne, B. (2001). Creating public alienation: Expert cultures of risk and ethics on GMOs. *Science as Culture*, *2*(4), 321–337. https://doi.org/10.1080/09505430120093586

Wynne, B. (2006). Public engagement as means of restoring trust in science? Hitting the notes, but missing the music. *Community Genetics*, *9*(5), 211–220.

Wynne, B. (2011). Intolerance: Science should inform, not define. *Nature*, *471*, 305. https://doi.org/10.1038/471305b

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Habets, M. G. J. L., & Macnaghten, P. (2024). From genes to governance: Engaging citizens in the new genomic techniques policy debate. *Plants, People, Planet*, 1–16. https://doi.org/10.1002/ppp3.10626