Frontiers in Political Science

TYPE Perspective
PUBLISHED 08 March 2024
DOI 10.3389/fpos.2024.1363044

OPEN ACCESS

EDITED BY
A. K. M. Ahsan Ullah,
Universiti Brunei Darussalam, Brunei

REVIEWED BY
Henk Jochemsen,
Wageningen University and Research, Netherlands

*CORRESPONDENCE
Sarah Hackfort
sarah.hackfort@hu-berlin.de

RECEIVED 29 December 2023
ACCEPTED 20 February 2024
PUBLISHED 08 March 2024

CITATION
Hackfort S (2024) Democratization through precision technologies? Unveiling power, participation, and property rights in the agricultural bioeconomy.
Front. Polit. Sci. 6:1363044.
doi: 10.3389/fpos.2024.1363044

Democratization through precision technologies? Unveiling power, participation, and property rights in the agricultural bioeconomy

Sarah Hackfort*

Agricultural and Food Policy Group, Humboldt University of Berlin, Berlin, Germany

This piece addresses the political dimension of sustainability in the agricultural bioeconomy by focusing on power, participation, and property rights around key technologies. Bioeconomy policies aim to establish economic systems based on renewable resources such as plants and microorganisms to reduce dependence on fossil resources. To achieve this, they rely on economic growth and increased biomass production through high-tech innovations. This direction has sparked important critique of the environmental and social sustainability of such projects. However, little attention has been paid in the bioeconomy literature to the political dimension surrounding key precision technologies such as data-driven precision agriculture (PA) or precision breeding technologies using new genomic techniques (NGT). The political dimension includes questions of power, participation, and property rights regarding these technologies and the distribution of the benefits and burdens they generate. This lack of attention is particularly pertinent given the recurring and promising claims that precision technologies not only enhance environmental sustainability, but also contribute to the democratization of food and biomass production. This contribution addresses this claim in asking whether we can really speak of a democratization of the agricultural bioeconomy through these precision technologies. Drawing on (own) empirical research and historical evidence, it concludes that current patterns are neither driving nor indicative of a democratization. On the contrary, corporate control, unequal access, distribution, and property rights over data and patents point to few gains for small firms and breeders, but to a reproduction of farmers' dependencies, and less transparency for consumers.

KEYWORDS

technology, bioeconomy, power relations, participation, property rights, genome editing, precision agriculture

1 Introduction

This piece addresses the political dimension of sustainability in the agricultural bioeconomy by focusing on power, participation, and property rights around key technologies. Bioeconomy policies aim to establish economic systems based on renewable resources such as plants and microorganisms to reduce dependence on fossil resources. To achieve this, they rely on economic growth and increased biomass production through high-tech innovations. This direction has sparked important critique of the environmental and social sustainability of such projects (Boyer et al., 2022; Eversberg et al., 2023).

However, little attention has been paid in the bioeconomy literature to the political dimension surrounding key precision technologies—such as data-driven precision agriculture (PA) or precision breeding technologies using new genomic techniques (NGT). This includes questions pertaining power, participation, and property rights regarding these technologies and the distribution of the benefits and burdens they generate. Such a perspective draws on work on technological change and the "political properties" of technologies (Winner, 1980, p. 123) aiming to account for the "social process in which scientific knowledge, technological invention, and corporate profit reinforce each other in deeply entrenched patterns that bear the unmistakable stamps of political and economic power" (Winner, 1980, p. 6).

The lack of attention to these questions in the bioeconomy literature (with only a few exceptions, e.g., Bastos Lima, 2021; Braun, 2021) is particularly pertinent given the recurring and promising claims that precision technologies not only enhance environmental sustainability, but also contribute to the democratization of food and biomass production. This contribution addresses this claim and asks whether we can really speak of a democratization of the agricultural bioeconomy through these precision technologies. Exploring this question is crucial because sustainability—often limited to environmental sustainability—also includes the democratization of existing power relations including participation possibilities within the bioeconomy (Gottschlich and Hackfort, 2016).

1.1 Hopes for democratization through precision technologies

Precision technologies have been promoted in many agricultural and bioeconomy policies and forerunner countries like Canada or Germany since they are considered key to achieve higher biomass production for the bioeconomy (e.g., BMBF and BMEL, 2020; Bioindustrial Innovation Canada, 2022). In the agricultural sector, PA through GPS-enabled and automated machinery, robots, sensors, and drones, collecting and storing big data on platforms and clouds and the use of artificial intelligence has expanded. Digital agriculture is often presented by industry and political organizations as a key strategy against food insecurity, climate change and biodiversity loss through a more precise and efficient application of fertilizers and pesticides (Prause et al., 2021). Beyond the promise of environmental sustainability, there are claims that these technologies will "help democratize agriculture" (Chandra et al., 2022). Proponents argue these innovations have "the potential to democratize ownership, [and] broaden political-economic participation" (Chiles et al., 2021). Some view technological advancements in sensing systems and data platforms as drivers of "democratization", that promote more equitable access to and benefits from these technologies (GPS World, 2022).

Similar hopes for democratization are associated with NGTs such as CRISPR/Cas9, a new genome editing technique, expected to make crops resistant to stresses such as drought through more precise plant breeding (Bain et al., 2020; Montenegro de Wit, 2020). Expectations are high that NGTs will help to address global hunger, and promote food security, sustainable agriculture, and adaptation to climate change (Qaim, 2020). Again, beyond the promise of environmental sustainability, proponents of NGT emphasize its potential to "democratize" plant breeding. Some scientists go so far as to say that "CRISPR/Cas is a democratic method" (TAZ, 2016). With fewer regulations and cumbersome rules, it could level the playing field for smaller companies and potentially reduce the scope of intellectual property rights for non-commercial research. It is argued that, while classical genetic engineering, with its time-consuming and costly approval procedures, is only profitable for agricultural giants and large global crop and export markets, NGT could enable the development of crops with more regional significance. The hope is that deregulation of NGT techniques could make them affordable to small- and medium-sized breeding companies, lowering the knowledge barriers to their use and making them accessible even to those without extensive expertise and expensive approval procedures, thereby disrupting current market concentration (Bain et al., 2020; Pixley et al., 2022; EC, 2023b).

In the following it is reflected upon whether the claim of democratization holds in terms of power, control, and participation, access and distribution of risks and benefits, and intellectual property rights. To do so, this perspective piece draws on (own) empirical research and historical evidence from countries where precision technologies are quite well-established and largely deregulated such as Canada and the US as well as from Europe, where PA is quite advanced but NGTs are tightly regulated under European law. With respect to the latter, the fact that a current proposal by the European Commission (EC, 2023a) aims to relax NGT regulations in Europe, makes this reflection even more timely and relevant.

2 Corporate power in precision agriculture

2.1 Power, control, and participation

In many countries with industrialized agriculture such as the USA, Canada or Germany, PA is largely dominated by a handful of powerful corporations. Large firms engaged in agricultural seed production, biotechnology, pesticides, and fertilizers such as Syngenta/ChemChina, Bayer/Monsanto, and BASF alongside major farm equipment manufacturers like John Deere and CLAAS hold substantial market shares. Even if some smaller companies participate in developing technological machinery and devices, amongst which a few start-ups have gained a foothold in the market, Bayer, John Deere & Co. predominantly control the development of precision technologies (Birner et al., 2021). Their large and capital-intensive machines are tailored to the needs of agro-industrial production, essentially serving their own profitable established business model of selling seeds and agrochemical along with new data-based services and products Oligopolies allow companies to develop solutions with low levels of adaptability and interoperability, locking many farmers into specific technological ecosystems. This lack of compatibility prevents farmers from freely switching to technology systems from different service providers in line with their specific needs (Bronson, 2022; Hackfort, 2023).

All major companies offer farm management platforms that serve as data collection hubs, providing these companies with multiple opportunities to create value from agricultural big data. At the same time, prominent technology companies are entering the sector and forming partnerships with agrochemical and machinery corporations introducing another aspect to ongoing corporate concentration in the agri-food sector (Prause et al., 2021). The collaboration between Bayer and Microsoft via their Azure project, purportedly the world's largest agricultural data-base, is just one example of this increasing corporate control (Marston and Burwood-Taylor, 2023). Established input providers such as Syngenta or BASF are building on earlier practices of securing relationships and dependencies with farmers by integrating their traditional proprietary products, such as seeds and pesticides, with the farm management platform services they offer, e.g., selling data-based and AI-driven seed recommendations with company-own seed. This increases the corporate control over technologies, seeds, and the entire agri-food system. At the same time, it means the marginalization of farmers following alternative approaches, especially smallholders, in shaping technology development in PA (ETC Group, 2022; Hackfort et al., 2024).

2.2 Access and distribution of risks and benefits

Farmers' access to digital innovations is often limited by the high costs of the large sized tools; prices and maintenance costs of smart land machines are too high for many small and medium-sized farms. PA based on current patterns thus shows the large scale oriented, agro-industrial model programmed into material technologies, which helps explain why many tools and devices are developed to work for commodity crops, typically grown at large-scale for export and less for other types of farming (Hackfort, 2021). Moreover, precision agriculture relies on the collection and analysis of large amounts of agricultural big data. Often, this data is collected and stored using infrastructure owned and controlled by the same large companies that provide services and products to farmers. Both access to this data and control over its use predominantly reside in the hands of these technology providers. When farmers accept the terms of service for using a digital platform, they effectively relinquish control of their data to the provider company (Hackfort et al., 2024). The companies are legally allowed to set the rules, and farmers can only accept or decline, a fact which highlights how unequally the factual control over technology and data is distributed. Corporations are in a privileged position, possessing unique insights into the activities of farmers on a continuous basis, highly detailed and over vast geographic areas of the world (Carbonell, 2016). While they develop strategies to generate economic value from this collected data, farmers sometimes do not even have access to their own data but instead must pay the providers to access their digital information, which is generated in part from their own farm data (Hackfort, 2023).

2.3 Intellectual property rights

This situation is sustained by the fragmented agricultural data policy regulation in most countries including US, Canada or even in the European Union (EU). The existing assortment of policy instruments in the EU including the protection of personal data within the General Data Protection Regulation (GDPR) does not cover the regulation of property rights and ownership of digital farm data. and there are no other legally binding mechanisms in place to strengthen farmers' data sovereignty (Atik and Martens, 2020; Hackfort, 2021; Atik, 2022). In fact, the aggregated data is often under the control of the technology and service provider companies that collect, process, and store the data. In addition, most license agreements for data platforms and services state that the aggregated data is legally controlled by the company that collects it. The end-user license agreements drawn up by the companies give rise to a form of dispossession which has been described as a "data grab" (Fraser, 2019). As a result, many providers and platforms do not disclose their back-end processes to customers, withholding information about how data is used and for what purposes and farmers typically have no control over the data they generate (Sykuta, 2016; Hackfort, 2023; Ruder, 2023).

3 Regulation of precision breeding

3.1 Power, control, and participation

NGT regulation in Europe is highly contested. In 2018 the EU Court of Justice classified NGTs as akin to conventional GMO technology, thus falling under existing strict regulation. Since then, proponents have been advocating for the deregulation of products created with NGT from the regulation (Leopoldina Nationale Akademie der Wissenschaften, 2019). While opponents raise concerns about deregulation due to uncertainties about environmental, social and economic risks (ENSSER/CSS, 2021).

In July 2023 the European Commission (EC) presented its legislative proposal to facilitate the entry of certain NGT categories into the EU-market by exempting them from current strict transparency and safety requirements (EC, 2023a). Civil society organizations criticize the EC's proposal as "biased" and undemocratic (newgmo.org, 2023) because, as the EC admits, in the preceding consultation processes only 4% of the stakeholders were NGOs, while 74% represented the agricultural industry, e.g., Syngenta, BASF and Bayer, and 10% came from agriculture and plant breeding (EU, 2023). The extent to which corporate interest groups ultimately influenced decision-makers is difficult to determine.

However, researchers and civil society organizations raise concerns that the EC, in violation of its own rules, has granted the biotech industry an inappropriately high level of influence in participatory consultations about current deregulation efforts regarding NGT (Hartung, 2020). They point out that many of the powerful agricultural industry stakeholders have a vested interest in exempting new GMOs from safety regulations, and that the EC failed to adhere to fundamental transparency protocols by not publishing responses to the consultation that had already been received (FOEE and Global 2000, 2021).

3.2 Access and distribution of risks and benefits

Critics argue that if the EC eventually decides that parts of NGT products on the European market would no longer need to be labeled, traced and risk assessed, it would end the freedom of choice for consumers to decide against NGT products. By removing the labeling requirement, NGT crops would be untraceable, leaving liability issues unresolved in the event of potential negative impacts of the technology. Deregulation would also create serious challenges for organic farmers if they could no longer guarantee their GMO/NGT free standards (Expert statement on risks of NGT plants, 2023). Opponents therefore argue that the EC's proposal is a violation of the precautionary principle as part of the relevant and applicable international agreements governing the handling of GMOs including NGTs (Buchholz, 2023).

Deregulation also raises concerns about the externalization of costs associated with GMOs since economic benefits enjoyed by GM crop producers are often accompanied by subsequent economic and social externalities placed upon nearby organic producers (Binimelis, 2008). This comes at a time when the EU has set goals to increase organic farming to 25% until 2030 in order to promote more sustainable agri-food systems with organic farming (EC, 2021).

In terms of access to and the distribution of the benefits of the technologies, we can also infer from the experiences of countries that have adopted GM crops on a large scale such as the US or Canada: Agrochemical firms profit enormously from the co-marketing of their patented herbicide-tolerant GM seeds and the "complementary" herbicides (Clapp, 2021a). Now, with NGT, the first commercially available genome-edited crop was an herbicide tolerant that fits perfectly into conventional industrial agriculture. Other products include a soybean with a better fatty acid profile and a tomato with improved blood pressure-lowering properties (Menz et al., 2020), suggesting that development is tending toward better marketable qualities rather than toward socio-environmental benefits. This leads some scholars to argue that such as with GMOs before, NGTs are likely to perpetuate unsustainable patterns of industrial agriculture that are profitable for agribusiness but detrimental to the environment and to many farmers (Ely et al., 2023). However, it is important to recognize that NGT differ from transgenic GM techniques: through increased precision, simplicity and affordability, they have democratic potential and allow for more sustainable production. However, how this potential is realized, not least depends on political regulation and property rights.

3.3 Intellectual property rights

In countries which have embraced GMO technologies we have seen how patents on transgenic crops drove the monopolization of the commercial seed sector over decades, causing smaller breeding companies to disappear (Bronson, 2015). This was a consequence of multinational pesticide firms in the US and Europe beginning to acquire biotech startups and investing heavily in biotechnology due to the profit potential of patentable GM seeds which led to a major consolidation in the global seed industry. Further, a recent series of mergers and acquisitions resulted in extreme concentration, with just four agrochemical giants—Bayer, Corteva, BASF, and ChemChina—today controlling over 50% of the global proprietary seed market (Hendrickson et al., 2019). Echoing this history of intellectual property rights, there is a new wave of concentration around NGTs. While only a few genome edited seeds and plants have been commercialized yet, agrochemical companies are racing to secure the patents on the new NGT techniques and NGT edited products (Gupta et al., 2020). Recent data shows that major seed industry players have already gained control over NGT; they have made early cooperation agreements with NGT inventors who hold basic foundational patents on the technology (Cameron, 2017). Today, Corteva and Bayer are leaders in plant breeding and NGT patents; Corteva, has secured CRISPR/Cas-9 patent agreements and a pool of 48 fundamental patents. Breeders must now pay fees and report to Corteva for CRISPR/Cas-9 use in plant breeding. Further, Corteva and Bayer filed the most patent applications with the World Intellectual Property Organization. Corteva had nearly 100 patents by the end 2022, and Bayer had more than 60 (Jefferson et al., 2021; Kock, 2021). However, ensuring small- and medium-sized breeding companies have access to essential technologies and their benefits is considered crucial for fostering a democratic agri-food system.

4 Discussion and conclusion

PA technologies theoretically allow for a more precise and efficient per-plant farming, for greater autonomy and economic benefits for producers through reduced farm input costs. However, as it was illustrated, this theoretical potential comes at the cost of reproduced power asymmetries and new forms of dependency. Corporate control in PA does not contribute to democratizing ownership and participation in technology design and use, nor does it indicate a level playing field for smaller companies and equitable access to and benefits from these technologies for famers. On the contrary, the dominance of powerful corporations over technologies and infrastructure reinforces farmers' dependencies on these corporate entities, ultimately solidifying their control over agricultural and food production which undermines democratization.

NGT might be more cost efficient, and its simplicity makes them theoretically more accessible and applicable for regional specific crops. However, it was illustrated that, even now, the NGTs including CRISPR, which have only been developed in the last 10 years, are no longer freely available. Democratic access to and control over the technology is thus limited and the distribution of its benefits unequal, a trend that points in opposite directions. Furthermore, democratization requires transparency and the participation of a variety of actors in policy processes. If this is not convincingly ensured in political spaces where vested corporate interests are known to be strongly represented (Canfield et al., 2021; Clapp, 2021b), democracy is undermined.

This perspective piece concludes that current patterns of unequal control, access, distribution, and property rights linked to technology, data and patents point to few gains for small firms and breeders, but to a reproduction of farmers' dependencies, and less transparency for consumers, thus is neither driving nor indicative of a democratization of the agricultural bioeconomy.

Achieving sustainability in the agricultural bioeconomy is certainly not just a question of technologies alone but without the democratization of existing and future technologies in terms of power, participation and property rights, sustainability will remain unattainable. To conclude, policies and regulation need to better account for historic trends; avenues through which a democratization in pursuit of a sustainable agricultural bioeconomy could include:

- effective antitrust policies to curb and prevent further corporate concentration and market monopolization in the agricultural sector;
- policies to strengthen technology and data sovereignty of farmers and breeders in the face of existing proprietary technology regimes and lock-ins;
- funding support for small-scale and alternative agricultural innovations, including digital but also low-tech, to promote technological diversity;
- regulation that upholds the precautionary principle, especially in regulating NGTs, allowing their use only under highly restricted and rigorously evaluated, labeled, and transparently documented conditions;
- patents on breeding methods or the use of genetic variation must be prohibited, as well as the extension of patents to genome-edited organisms, in order to promote equitable access to genetic resources and to conserve genetic diversity;
- and technology assessments in the bioeconomy should include issues of access and control with respect to the proposed precision technologies, thus promoting the study of the relationship between technologies, power and democracy as integral to the sustainability of the bioeconomy.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Humboldt University Ethics Committee of Thaer-Institute. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by the German Federal Ministry of Education and Research (BMBF) as part of the funding line Bioeconomy as Societal Change FKZ 031B0750.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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