Applying the principles of data feminism in agricultural research leads to more transformative outcomes (15 words)

# Abstract (70 words, at 78)

Agricultural research reflects complex institutional and interpersonal relationships that have historically been, and continue to be, subject to power imbalances. Recently, the Data Feminism framework was developed to aid scientists in understanding and addressing power imbalances inherent in their work. We present evidence that its application in agricultural research concomitantly fosters creativity and leads to more transformative outcomes. Many researchers already practice data feminism; formalizing those efforts will make the work more intentional, visible, and in time, ubiquitous.

THE WORD RELATABLE?

# Introduction (486 words)

At its most fundamental level, agriculture involves the cultivation of land to produce food. This arrangement renders the former a prerequisite for the latter, immediately invoking potential power dynamics. Indeed, over thousands of years and across civilizations, agriculture has fomented, leveraged, and reflected power hierarchies (CITE). It follows that the interpersonal and institutional relationships upon which agricultural research is built mirrors those artifacts, with potentially profound ethical and social consequences. This is not unique to agricultural research. Globally, recognition that these issues require intentional examination has spurred the creation of new academic fields (CITE), and while social scientists have long recognized these implications (Allen and Sachs), technical scientists are increasingly being asked to consider the context of their work. Calls for, as well as attempts to codify, this reflexivity have been made in the fields of food studies and agroecology (CITE agroecology things, de Wit, Nick and Liebman’s paper), but it remains a formidable task.

We believe the recently developed Data Feminism framework (CITE), which targets technical scientists, is particularly well-suited to support agricultural researchers in this pursuit. The framework is rooted in empirical studies of power and emphasizes intersectionality, or the inability to study dimensions of power in isolation (XX). It is action-oriented and domain-agnostic, and D’Ignazio and Klein’s (2020) work has been highly cited in numerous disciplinary contexts. To our knowledge, it has had limited interpretation in the context of agriculture, though a recent study evaluated the National Agricultural Statistics Service (NASS) agency of the United States Department of Agriculture (USDA) on their data reporting practices through the lens of Data Feminism (CITERISSING).

Our thesis is that explicit application of the data feminism framework positively contributes to research creativity, stakeholder participation, and agricultural sustainability writ large. Here we discuss the application of data feminism themes (power, reciprocity, and framing) in various research phases, with suggested activities relevant for agricultural research and relatable, positive experiences resulting from said activities (Table 1).

### Table 1. Summary of paper structure

|  |  |  |
| --- | --- | --- |
| **Research phase(s)** | **Applied data feminism theme** | **Agricultural research results** |
| Hypothesis generation and study design | Research for the public good should seek to equalize power | Technical audits, listening to and serving the margins, incorporating other ways of knowing |
| Conducting and implementing research | Farmer-researcher relations should be reciprocal | Compensation, metrics for success |
| Analysis and dissemination | All research is values-informed | Diverse framing as a strength, co-existance of multiple truths |

The goal of this paper is not to simply reiterate the principles laid out by D’Ignazio and Klein (2020), nor to suggest one set of guiding principles is superior to another. Rather, as agricultural scientists, we found the principles helpful in guiding our own work, and we aim to highlight and demonstrate their utility. Our perspectives are strongly framed by our collective experiences in the agricultural systems of the United States (US), and specifically of those in the maize-producing areas of the Midwest. However, while the specifics of a given system will vary, the topics are universal.

# Research for the public good should seek to equalize power

Power has been defined as a relationship through which one can obtain one’s will even in the face of resistance from others (CITE). The fact that power is unevenly distributed and experienced in this world is central to data feminism (CITE).This fact is particularly acute in agriculture; labor exploitation(both historicalCITE and modernCITE) and Native land dispossession(CITE) are examples of overarching features of agricultural systems that render power inequities deeply embedded and ubiquitous. Research seeking to support public good requires an understanding of how that research legitimizes or challenges historical and present power artifacts. However, these are complex topics, and it is not reasonable to expect agricultural scientists to be experts in navigating them.

To aid non-experts in contextualizing their work, Data Feminism applies Collins’ (1990) matrix of domination to elucidate where and how power inequities may manifest, and therefore clarify how they may be challenged. To demonstrate the relevance of this tool for agricultural scientists, Table 2 presents an adaptation of the matrix with select examples from modern US agricultural systems. The examples are not meant to be an exhaustive accounting of power in US agriculture - they were chosen to help agricultural scientists understand that power differentials are real and quantifiable.

This is not meant to be a comprehensive review of power issues in agriculture, nor a thorough documentation of efforts to address those issues. Rather, our hope is that this effort supports technically trained agricultural scientists in connecting their work to its broader societal implications and in sculpting that work to contribute to a more equitable society.

### Table 2. Domains through which power may be expressed and experienced (adapted from Collins 1990)

|  |  |  |
| --- | --- | --- |
| **Domain** | **Description** | **Select examples of uneven distribution or experience of power from modern US agriculture** |
| **Structural domain** | Laws and policies that distribute power | Racially tiered implementation and funding of US land-grant university system (Croft 2019; Sharp 2004, Martin 2018)  Discriminatory design of US land heirship laws (Deaton 2007; Baily and Thomson 2022)  Discretionary implementation of eminent domain laws (Fraley) |
| **Disciplinary domain** | Entities that implement and enforce (or fail to implement and enforce) laws and policies distributing power | USDA credit granting discrimination based on race and gender (Carpenter 2012)  Systematic exclusion of groups via USDA NASS2 census collection formats (Pilgeram et al. 2020; Dentzman et al. 2020)  Barriers to participation of American Indian lands in NRCS3 programs (Johnson 2019) |
| **Hegemonic domain** | Entities that circulate ideas related to who has power | Cultural things about how should own land…  Public extension and conservation programs focused on top-down, technical solutions (Belshaw 1979; Johnson et al. 2021)  Focus on Western science in agricultural curriculums (Snively and X 2001) |
| **Interpersonal domain** | Individual experiences, expression, and awareness of who has power | In- and out-group mentalities in agricultural practitioners (Kniss XXXX), gendered experiences of fieldwork and farmer interactions (Chiswell and Wheeler 2016, the trans one?); gender biases in agricultural students (Basche and Carter 2020) |
| 1United States Department of Agriculture  2National Agricultural Statistics Service, an agency responsible for collecting and reporting information related to agricultural production within the USDA  3Natural Resource Conservation Service, an agency that provides technical and financial assistance to land owners | | |

To help agricultural researchers envision how their work may integrate into a larger effort to rebalance power in one or more domains, we present three thematic opportunities with positive experiences of their application.

## Technical audits

By leveraging their scientific training, agricultural scientists have great potential to contribute to documentation of issues in the four power domains (Table 2). In an example of rebalancing power in the structural domain, a series of studies documented significant soil degradation and crop yield losses following the remediation efforts accompanying underground pipeline installation (Brehm and Culman 2022a; Brehm and Culman 2022b; Ebrahimi et al. 2022a; Ebrahimi et al. 2022b). This research documented the previously unquantified long-term impacts pipeline installations have on productive agricultural land (a globally limited resource) and challenges the laws that allow pipeline installation companies to impact landowners, farmers, and the public without fair compensation. In the hegemonic domain, university nutrient application recommendations have traditionally been generated using top-down, siloed experiments with little transparency or opportunity for the public, farmers, or even other scientists to provide input. A recent study challenged the appropriateness of this arrangement, exposing flaws in traditional experimental designs that render them unable to deliver meaningful recommendations (Miguez and Poffenbarger 2022). This occurred against the backdrop of stakeholders demanding more accountability with regards to agricultural nutrient management (CITE?). In response, in 2022 the state of Iowa launched an ambitious effort to democratize and support horizontal knowledge exchange in generating nitrogen recommendations (IowaNitrogenInitiative). As part of the initiative, farmers volunteer (see Reciprocity section) to perform nitrogen rate trials in their own production contexts, and the data is collectively pooled to drive transparently calculated recommendations and to support public model development. Similarly, in 2022 a grassroots farmer organization, Practical Farmers of Iowa, launched a regional program paying farmers (see Reciprocity section) to test nitrogen rates of their choice using replicated trials and sharing their individual and pooled results with the public (CITE). These efforts represent an exciting shift in the hegemonic power universities traditionally exercise in generating nutrient recommendations.

## Listening to and serving the margins

Conducting research that is inspired by and supportive of those who have been institutionally excluded is another effective means for agricultural scientists to challenge hegemonic and interpersonal power structures. Institutional exclusion can manifest through multiple avenues, including individual characteristics (e.g., gender, race, ethnicity, age, language, sexuality, formal education level, technology use, socioeconomic status) (Leslie et al. 2019; Carter 2019; Pilgerum et al. 2022; Pfammatter and Jorgenden 2023; Shih and Fan 2009) and farm-level features (e.g., production system, degree of farm mechanization, farm location, farm size, utilized markets, long-term ambitions for the farm)(Wheeler 2008; Belshaw 1979;). This systemic and cultural exclusion often translates to exclusion from agricultural research activities. This is a serious issue that can not only hinder more equitable agriulcutral systems, but also deprive the greater public from benefiting from needed knowledge. There are significant opportunities for improving agricultural conservation outcomes by supporting peer-to-peer learning amongst institutionally excluded groups (Mahajan 2019; Diiro et al. 2018; Wells and Eells 2011; Carter and chrisoffel 2022). For example, a group of farmers formed Practical Farmers of Iowa in 1988 partially in response to feeling neglected by the Land Grant institutions (CITE). One of those farmers’ low-input system inspired one of the most scientifically productive crop diversification experiments in the US (PFI something; Davis et al 2012; Hunt XX). Similarly, Latino farmers have had little institutional support, and in response Practical Farmers of Iowa recently launched a Latino Engagement program (<https://practicalfarmers.org/programs/agricultores-latinos/>). Serving the margins is a way for agricultural researchers to leverage their privilege to help build legitimacy within the margins (de Wit and Alastair I think), reducing the hegemonic and interpersonal powers of exclusion.

## Legitimizing other ways of knowing

The idea that there are ’multiple ways of knowing’ originates in Indigenous epistemologies but has migrated into common vernacular. At its most basic level, it recognizes the diverse means through which individuals and groups understand the world around them, including empirical observation and logical reasoning, but also intuition, personal experience, cultural traditions, and spiritual insights, among others. In dismissing knowledge originating outside of traditional scientific methods, scientists wield power by reinforcing the dominance of a single scientific paradigm and limit the potential contribution such knowledge can have in enriching scientific understanding (Peltier 2018). It follows that utilizing non-traditional measurements is one way agricultural scientists can honor multiple ways of knowing within a scientific framework. An apposite example is USDA NASS reporting of a ‘workable field day’, defined as day where weather and field conditions allow producers to work in fields a major portion of the day (NASS <https://www.nass.usda.gov/Publications/National_Crop_Progress/Terms_and_Definitions/index.php#days>). While it is based on scientific principles relating to soil moisture (Earl 1997), it represents a deeply personal interaction between the farmer and the land that has evaded modelling attempts (Huber et al. 2023). Perhaps because of the connection to personal experience, survey data on workable field days is often used in extension settings, but to our knowledge has not been extensively used within scientific frameworks. In an example of challenging the hegemonic power concerning knowledge generation, Practical Farmers of Iowa has launched a study wherein farmers will quantify their experiences with cover cropping through the metric of workable field days (<https://practicalfarmers.org/2024/04/putting-soil-to-the-test/>CITE). This effort does not detract from nor undermine the numerous scientific publications relating cover cropping to changes in soil-water dynamics – rather, it will enrich it by producing results that are based on other, meaningful ways of knowing (Robertson et al. 2001). Similar efforts to incorporate alternative knowledge bases are being explored in relation to complex topics such as soil and agricultural system health (Gage2015 book; Maeder; Freidrichson2021).

# Farmer-researcher relations should be reciprocal

In addition to what research is done, the way it is done presents opportunities to redistribute power more equitably. For over a century, experimental plots managed by researchers have been the workhorse of agricultural research. As agricultural research evolves, the importance of farm-scale trials is becoming more pronounced (Lacoste2021, Kravchenko2017; Koehler-Cole2023; Laurent2022), with advances in the ability to organize and streamline data collection from farm environments opening the door for blending research plots with farm fields to gain more statistically powerful and relevant public research in collaboration with farmers (igancio’s paper, laila’s, mother daughter stuff, participatory breeding thing; Stone 2016). However, these arrangements require careful consideration to support equitable and fair power relations.While guides for farmers in conducting on-farm research are readily available (Chaney 2017, Stefan’s list), to our knowledge there are fewer resources suggesting best practices for the scientists, researchers, and organizations the farmers may be collaborating with. The Agroecology Research-Action Collective’s Principles and Protocols provide useful guidance on working with communities and organizations in general (de Wit et al. 2022). However, we feel the researcher-farmer collaboration merits explicit attention for agricultural scientists.

## Compensation

The context for farmer involvement in research can vary widely (Toffolini and Jeuffroy 2022; Jackson-Smith and Veisi 2023). While much work has been done to describe collaboration contexts, the topic of compensation is seemingly taboo - to our knowledge there are few studies on mechanisms for farmer compensation, and even fewer exploring how those mechanisms influence collaboration dynamics. This omission is problematic; research participants should always be compensated, and the form this compensation takes is particularly germane to the topic of power.

It is common for farmers to be compensated by *the experience and knowledge gained from the activities*, *access to research findings*, *better productivity*, or a similarly non-tangible exchange. In its most egregious forms, this arrangement is elitist, extractive, and disrespectful. We acknowledge individual researchers may be constrained in their access to unrestricted grant money to pay participants, but they are often coming from institutions with well-funded endowments. Research participants may view the researcher as representative of said institution, and therefore without an offer of monetary compensation, may reasonably intuit a devaluation (hegemonic domain). Moreover, failing to provide compensation further exacerbates historical biases, favoring well-resourced farmers in access to on-farm research activities (disciplinary domain).

Granting agencies clearly have a role to play in supporting fair compensation for farmer participation in research. While some grant funders allow for farmer-participant support including stipends and travel reimbursements, to our knowledge none require it. To assist researchers in compensating farmers in ways that equalize opportunities and power distributions, public funding sources (and private sources committed to fair and equitable research activities) should explicitly require explanations of how farmers will be remunerated for their participation in research projects and provide associated funding categories to support it. This is in the best interests of everyone involved; fair remuneration for farmers supports formation of equitable partnerships that are more likely to be sustained in the long-term. For example, the grassroots organization Practical Farmers of Iowa has a farmer cooperator program that is still in operation after more than 30 years with continued growth, facts attributed in part to their policy of monetarily compensating farmers for their participation in on-farm research (but see Metrics for Success section). The Iowa Nitrogen Initiative, for comparison, was not allocated money for farmer-participant compensation, and they have capacity for more participants than they can secure. While research on farmer compensation and project outcomes is scarce, blending of monetary compensation with other forms that support learning, sharing, development, and growth are likely to be most effective (Thornely 1990, Liebig 1999, Laila’s paper, Thompson and Thompson 1990, de Wit thing), and could be used to specifically support institutionally-excluded groups’ needs (e.g., childcare). Other forms such as conference attendance, formal training opportunities, technical assistance, provision of inputs, or in-kind support are possible, but exact dollar values on the compensation should be calculated and communicated. Blended compensation packages that coincided with high participant satisfaction are included in supplemental files as a resource to support .

## Metrics for success

In addition to compensation, both researchers and farmers should aim for relationships defined beyond simple transactions. We believe many researchers strive to build rich relationships with their farmer collaborators, however they often lack metrics that help them articulate and measure that success. Building on recommendations from the data feminism framework (D’Ignazio and Klein XX) and other sources (Carter Roesch-McNally XX; agroecologypaper), we suggest the following four broad metrics be incorporated into project evaluations:

1. Was trust was built?
2. Were power and resources shared?
3. Did learning occur in both directions?
4. Were both entities transformed as a result of the collaboration?

Incorporating these metrics *a priori* can help guide activity planning, and help ensure anticipated outcomes are aligned within a relationship of reciprocity.

The success of this type of model can again be demonstrated by the longevity of the Practical Farmers of Iowa (hereafter shortened to Practical Farmers) on-farm research program, which has been in place since 1987. Practical Farmers has continually refined their post-program participation surveys, and through deep, critical reflection and constant iteration, their current survey successfully quantifies outcomes in the four metrics described above. As these questions have become metrics for success, Practical Farmers has designed their program to support these metrics, resulting in highly satisfied participants (Can I cite something? A PFI report?) which translates to more consistent funding. Other researchers and entities likely utilize some form of these metrics, but to our knowledge they are not widely employed by granting agencies or at an individual researcher level. To support reciprocity in farmer collaborations, we provide the post-participant survey questions used by Practical Farmers in supplementary material as a resource (supplementary file).

In this section on reciprocity, we have concentrated on designing equitable farmer-researcher relationships. However, many of the ideas presented are not exclusive to these actors. All relationships contain the potential for power inequities, and intentional examination can lead to better collaborations, regardless of the form. While not specific to agriculture, researcher-researcher, researcher-student, researcher-employee relationships all have potential for power inequities based on seniority, discipline, perceived prestige, etc. Is this worth mentioning?

# All research is values-informed

The feasibility (or even desirability) of objectivity in science has been debated since its inception, and recent discussions highlight how its implementation has been entangled with colonialism, racism, and other forms of oppression (X). Topics such as the importance of the role of interpretation, plurality of methods, critical reflexivity, and fallibilism are embraced as inherent in the pursuit of knowledge, while still valuing the foundations of empirical evidence and systematic investigation. While these ideas have been embraced and codified in social sciences (Ryan 2006; others), it has failed to deeply permeate other fields, including agriculture (Clark 2002 (nursing); Norton 2008 (ecology); Nicklay et al. XX; Pretty 1994; Ebel et al. 2020). Here, we collectively group these ideas into the acknowledgement that all research is framed, and that multiple truths can coexist. We stress that we are not claiming that all perspectives are equally valid, or that there are no objective truths. Instead, we emphasize how this mentality opens us up to diverse perspectives and leads to productive conservations in the field of agriculture. We argue that it is only by adding diverse sets of perspectives can we create a more complete, and just, picture of the ‘truth’.

## Diverse framings are a strength

As an agricultural scientist, your background and values frame your work. By seeking to eliminate the influence of that framing we insinuate it is possible, and are concomitantly quelling what our own experiences can proffer. A book written to illustrate how underlying value systems shape individuals’ perspectives on solutions to complex global challenges unwittingly uses agricultural research as its backdrop. ‘The Wizard and the Prophet’ (CITE) explores the worldviews of Norman Borlaug and William Vogt, two white, Western men working on agricultural topics during the 20th century but coming from divergent backgrounds. Borlaug was raised on a Midwestern US farm, and his life was greatly impacted by the introduction of tractors. This experience likely influenced how he thought of solutions, and he is portrayed as a ‘wizard’, embodying a technocentric worldview the prioritizes technological innovation and human ingenuity as the means to address global issues. Vogt began his life in a rural area surrounded by unbuilt environments, but moved to the city and witnessed the urban development of his place of birth. Vogt is portrayed as a ‘prophet’, emphasizing the need to live within ecological limits. Borlaug researched ways to leverage technology to intensify agricultural practices and increase food production, an effort that contributed to a larger collection of innovations collectively referred to as ‘the Green Revolution’ and for which Borlaug won a Nobel Peace Prize (CITE). Vogt used science to formally develop the idea of carrying-capacity (CITE). He advocated for limiting population growth rather than increasing food production, and developed a model for environmental activism that is still used today. Both Borlaug and Vogt had valid results and conclusions based on using the scientific method to investigate questions that were motivated by their personal values and experiences. The differing motivations do not invalidate their truths, but rather demonstrate how multiple truths can co-exist at once.

## Coexistance of multiple truths

In the context of policy making, the acknowledgement of contradictory realities, such as the coexistence of abundance and starvation, is understood as an inherent complexity in addressing multi-faceted issues (Stone 2022). In this context, the broader the set of realities that are available, the more complete the overall picture becomes, and concomitantly the possibility for more equitable solutions. For topics as fundamental to human survival as food production, incorporating the scientific contributions produced using diverse framings will undoubtedly lay the foundation for more equitable outcomes. Ironically, although the worldviews of the two example figures are divergent, they represent those of two American males of European descent as written by an American male of European descent. This demonstrates how even classical delineations such as race and gender portend very little in regard to value systems, and lends us to imagine the insight that would be gained from adding more framings. Today, an increasing availability of diversely framed reflections concerning the Green Revolution have led to significantly more nuanced understandings of the motivations, impacts, and XX of the Green Revolution (PBS series, https://www.pbs.org/wgbh/americanexperience/films/man-who-tried-to-feed-the-world/

others). As calls for a ‘second Green Revolution’ proliferate (XX), the ability of society to leverage diverse voices contributing to the discussion will be a great asset. Scientists who are able to acknowledge and navigate the existence of multiple truths are better equipped to provide solutions that do not preferentially disadvantage vulnerable groups (Jordan about world views paper).

While the set of framings represented in agricultural science is becoming more diverse. Examining how a particular set of values can influence scientific outcomes has produced productive conversations, as well as creative new lines of inquiry. For example, recent research has explicitly analyzed how various framings dictate weed management goals, exposing novel research questions that emerge only when new framings are taken seriously (MacLaren et al 2020; Weisberger et al. 2024). Comparative analyses, article responses, and commentaries are also avenues for productively exploring what analytical decisions are made, what may have motivated those decisions, and how they impact conclusions. Complex agricultural topics such as herbicide use (Kniss), climate impacts of ethanol production (Hill 2022), organic agriculture (Wilbois 2019; Swedish organic reviewer paper), tillage and soil carbon (Miguez/Schulte), and bioenergy (XX) are examples where conversations have benefited from dissecting how different framings may lead to different data analysis choices.

Is this worth getting into?

On the flip side, researchers should respect that framings create data. There are numerous initiatives that advocate for free and open sharing of data generated by governments, industries, and research institutions ((CITE). The open science movement champions the ethos of transparency, collaboration, and accessibility in scientific research; as a corollary the movement promotes the unrestricted sharing of data (CITE). Indeed, the sharing of data has facilitated more efficient use of resources for research through data re-use (Piwowar), and in some countries freely available governmental data XXX both public and private entities leverage governmental data that is freely available (Piwowar). However, the open sharing of data also introduces risks regarding data misinterpretation or misuse. Data shared openly may be used out of context. By embracing our own framings, we concomitantly recognize the need to understand the framings of others. Failure to do so can result in gross misunderstandings (Cropscape data article, NASS data increasing women producers). Data should be treated within the gift culture of scholarship, in which goods are bartered between trusted colleagues rather than treated as commodities (Wallis).

# Conclusions

In this paper, using the principles of data feminism as our guide, we demonstrate how (1) agricultural scientists can uniquely contribute to examining and challenging power through technical audits, serving and listening to the needs of the minoritized, and embracing multiple ways of knowing, (2) building farmer collaborations with reciprocity metrics codified in the project leads to better outcomes for the farmers and researchers, and (3) embracing framing as an inevitable and positive attribute leads to more transparent, creative, and effective research. SOMETHING MORE.

Agricultural systems functions of complex institutional structures that have historically had, and continue to have, power imbalances embedded within them. The seven principles of data feminism were developed to aid data scientists in identifying, examining, and addressing power inequities related to data generation, interpretation, and distribution. We believe these principles provide an accessible but under-utilized framework for helping agricultural researchers understand and actively work towards mitigating power inequities prevalent in our discipline. Here we interpret the tenets of data feminism in the context of agricultural research within three overarching discourses: power, reciprocity, and framing. Many researchers already apply these principles in their work, but we hope that providing this explicit framework in an agricultural context will make the work more intentional, visible, and in time, ubiquitous. We present evidence that working within these three frameworks concomitantly fosters creativity and leads to more transformative outcomes for agriculture and sustainability as a whole.

*The explosion in capacity for societies to generate, store, and utilize data has prompted a global discourse on the intersection of data and power. Power interacts with every stage of the data lifecycle, from provenance to utilization, in complex ways that has demanded creation of new academic fields such as critical data studies, data justice, and techno-politics (e.g., data ethics (CITE), algorithmic accountability (CITE), critical data studies (CITE), techno-politics (CITE)), and have been focal points of numerous popular culture artifacts (CTE?). This attention is merited; without intentional examination of these issues, existing power differentials will compound (CITE, the covid paper?) and new ones will be created (digital divide?), a result many deem undesirable.*