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Data Feminism as a guide for agricultural research

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Agricultural research reflects complex institutional and interpersonal relationships that have historically been, and continue to be, subject to power imbalances. Recently, interdisciplinary scholars developed the Data Feminism framework to aid scientists in understanding and addressing power in research. In this Perspective, we demonstrate the framework's utility in agricultural research and present evidence that explicit attention to power, reciprocity and values fosters both research creativity and positive societal outcomes.

Agriculture involves the cultivation of land to produce food, an arrangement inherently primed for power disparities. Indeed, over thousands of years and across civilizations, agriculture has reflected, enabled, and leveraged power hierarchies^{1,2}. It follows that the interpersonal and institutional relationships upon which modern agricultural research is built continues to mirror those artifacts, with profound ethical and social consequences. This is not unique to agricultural research; global recognition of the need to intentionally examine how power interacts with science has spurred the creation of new academic fields, particularly relating to data generation and use^{3–6}. While social scientists have long recognized these interactions⁷, biophysical scientists are increasingly being asked to consider the context of their work. There have been calls for and attempts to codify reflexivity in the fields of food studies and agroecology^{8–10}, reflecting both fields' inclusion of the human experience in their scope^{11,12}. However, carving out space for reflexivity remains a formidable task for those in the technical fields falling under the umbrella of agricultural science. The recently developed Data Feminism framework¹³ is particularly well-suited to support agricultural researchers in interrogating their research context. The framework is rooted in empirical studies of power (the reader is directed to D'Ignazio and Klein 2020 for discussion of these studies) and while the term Data Feminism may invoke an assumption of a gender focus, Data Feminism emphasizes intersectionality, or the need to study multiple dimensions of power¹⁴. Because it is action-oriented and domain-agnostic, 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 Feminism¹⁵.

We posit that explicit application of the Data Feminism framework positively contributes to research creativity, stakeholder participation, and agricultural sustainability overall. To support this thesis, we discuss the application of three select Data Feminism themes (power awareness, reciprocity, and framing) in the research process, with accompanying

reflections, activities and outcomes (Table 1). We chose these three themes due to their broad implications and ability to be addressed in the typical agricultural research context.

The goal of this paper is to serve as an encouraging resource for more intentional work in this area. Our perspectives are strongly framed by our collective personal, academic and professional experiences in the industrialized 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 vary, we believe the topics are universal. 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 Perspective empowers technically trained agricultural scientists to reflect on their work's broader societal implications. In this Perspective, we use the term "imbalance" to collectively refer to both power inequities (which result from contextual situations) and inequalities (resulting from laws).

Awareness of power

The ability to obtain one's will despite objections from others is an expression of power¹⁶. Central to Data Feminism is the fact that power is unevenly distributed and experienced in this world and equitable redistribution requires intentional examination and intervention. This foundation is particularly relevant in agriculture; overarching features of agriculture (both historical and contemporary) such as labor exploitation¹⁷, Native land dispossession^{18,19}, and selective land ownership rights^{20–23} intentionally embed power inequalities in agricultural systems. Research seeking to support the public good, therefore, requires an understanding of how research passively endorses or challenges power artifacts. However, because power is a complex topic with dedicated scholars, this pursuit may feel daunting to the average agricultural scientist. To aid non-experts in contextualizing their work, Data Feminism applies Collins' (1990) matrix of domination²³ to elucidate where and how both power inequities (contextual) and

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inequalities (structural) may manifest, and therefore clarify both their existence and how they may be challenged. To demonstrate its application, here we present a demonstrative (e.g., non-comprehensive) adaptation of the matrix applied to a woman farmer/farm landowner in the US (Table 2). The reader is directed to Sachs 1983 for a more thorough documentation of the history of women, power, and US agriculture.

For biophysical scientists, traditional training does not often include space or resources for building awareness of power imbalances, and it will likely require self-guided reflection. Actively questioning why certain groups seem over- or under-represented in agricultural language or contexts we encounter is a powerful starting point, and the matrix of domination can aid in parsing out the various drivers involved. Once the foundation of awareness has been built, as scientists, it is important to reflect on our roles in passively endorsing or challenging inequities. 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 research activities with attendant examples of positive outcomes: serving the margins, leveraging science, and expanding the concept of scientific measurements.

Serving the margins

In agricultural production, exclusion can occur due to individual characteristics (e.g., Table 2) as well as farm-level features (e.g., production system, degree of farm mechanization). This systemic and/or cultural exclusion often translates to omission from agricultural research activities^{34,25}. One method for addressing this power inequity is to conduct research with institutionally excluded groups. Beyond the direct benefits, this also leverages a researcher’s hegemonic power to culturally label the needs, experiences, and knowledge of the marginalized as equally valuable²⁶. It can also inspire solutions that benefit everyone. For example, in 1985 a group of farmers formed Practical Farmers of Iowa²⁷ (hereafter referred to as Practical Farmers) as a peer-to-peer learning community²⁸, partially in response to being excluded by the Land Grant’s extension systems²⁹. By listening to these farmers, a researcher was inspired to study low-input systems, implementing a trial that became an influential, long-term crop diversification experiment³⁰. Researcher participation in the Women, Food and Agricultural Network³¹ similarly inspired novel research activities with women landowners^{32,33}. More recently, Latino farmers in the Midwest have little institutional support, and Practical Farmers launched a Latino Engagement program (Supplementary References) that inspired research-

Table 1 | Summary of paper structure

Theme	Research phase(s) for application	Data Feminism-derived reflection	Reflection-motivated activities
Awareness of power	Hypothesis generation and study design.	Research for the public good should seek to equalize power.	Serving the margins, leveraging science, expanding the concept of scientific measurements.
Reciprocity	Conducting and implementing research.	Farmer-researcher relations should be reciprocal.	Multi-dimensional compensation, metrics for success.
Framing	Analysis and distribution.	All research is values-informed.	Acknowledging the presence of values in research, supporting diverse framings.

Table 2 | Domains through which power may be experienced as a woman farmer/landowner in the US (adapted from Collins 1990)

Domain	Description	Example power disparity
Structural domain	Laws and policies that distribute power in inequitable ways.	The US Government distributed land with a gender (and racial) bias under patrilineal inheritance, thus privileging male white settlers ⁷⁵ . Subsequent laws granted limited rights to white women married to white men ⁷⁶ , yet through the mid-20th century numerous laws prevented women from independently owning and operating farms and accessing credit ⁷⁵ . As recently as 1974 women were not permitted to apply for a credit card without a male co-applicant ⁷⁷ . Laws such as these also shaped hegemonic and interpersonal inequities in power that continue today ²⁴ .
Disciplinary domain	Entities that implement and enforce (or fail to implement and enforce) laws and policies distributing power.	The USDA has discriminated based on gender when granting credit ⁷⁸ . Effects of such discrimination (e.g., wealth accumulation, type of agricultural production) continue; after controlling for farm size and type, farming still has one of the largest (40%) gender-wage gaps of US professions ⁷⁹ .
Hegemonic domain	Entities that circulate ideas related to who has power.	Until 2017, USDA NASS census collection formats allowed for only one farm operator. This excluded many women from identifying as farm operators ⁸⁰ . Forcing a farm to identify a single operator also reinforced patriarchal stereotypes about exclusive and unilateral (rather than joint) decision-making power ⁸¹ . A study completed in 2024 found that online image searches in the US for “farmer” preferentially return images of men at a rate disproportionately higher than expected even using the pre-2017 census values ⁸² , meaning women farmers, even by conservative estimates, are under-represented in visual media. Additionally, women landowners are “not on the radar” of agricultural professionals who distribute funds and technical assistance ⁸³ which limits their access to needed resources ⁸⁴ . Even future agricultural professionals undervalue the experiences and knowledge of women landowners ⁵⁹ .
Interpersonal domain	Individual experiences, expression, and awareness of who has power.	Women farmers and landowners are rendered invisible by male-centric material in popular media ⁸⁵ and by the abundant use of male pronouns used in agricultural settings when referring to a generic farmer ⁸⁶ . Women are not perceived as having decision-making authority and experience gender-based discrimination from tenants, neighbors, lenders, and service providers, preventing them from equitable access to agricultural programs, information, and networks ^{32,33,84} .

USDA United States Department of Agriculture, NASS National Agricultural Statistics Service, an agency responsible for collecting and reporting information related to agricultural production within the USDA.

ers to explore “Tree-Range poultry”³⁴. These are select examples, and in US agriculture excluded groups may take many forms, including but not limited to minority, tenant, queer, or immigrant farmers; or organic, low-input, small, diversified, or low-mechanization farms. Seeking to support, serve, and listen to such groups is therefore a potentially impactful avenue for rebalancing power.

Leveraging science

By leveraging their scientific training, agricultural scientists have great potential to contribute to documentation of power imbalances (Table 2), and therefore support their mitigation. For example, inspired by farmers’ observations, a series of studies documented significantly longer-term soil degradation and crop yield losses on farmers’ fields than assumed by the laws dictating required remediation periods accompanying underground pipeline installation^{35–37}. This scientific effort thus documented an important structural inequality, with balanced participation from the science creators and users. However, science can also be used to passively implement power inequities between the creator and user. For example, US Land Grant universities traditionally wield unique power in generating nutrient application recommendations using top-down, siloed experiments (that often lack statistical power³⁸) using data that is not made publicly available and without extensive input from the public, farmers, or peer review. Driven largely by water quality concerns, the public has begun to demand more transparency in agricultural nutrient management in the US, prompting farmers and universities to reimagine how nutrient recommendations are created. New programs democratize and contextualize recommendations using open-source methodologies and modern computing power capabilities, while also supporting horizontal knowledge exchange³⁹. Iowa State University recently launched an ambitious program, the Iowa Nitrogen Initiative, wherein farmers voluntarily perform nitrogen rate trials in their production contexts⁴⁰. This not only increases the relevance of the data driving the recommendations, but also actively involves the users in creating the recommendations. The data are pooled and used to drive models that provide drastically more nuanced recommendations: as of 2025 the program supported 470 trials and currently provides recommendations for 21,384 scenarios (compared to the previous system where 10 sites provided recommendations for four scenarios). The Initiative has been accompanied by significant public engagement, with an average of 30 presentations and 60 popular press products per year and 3000 unique users registered for the recently launched recommendation tool⁴⁰. Scientifically, this program’s on-farm data have highlighted fall residual nitrogen as an important predictor of the subsequent year’s nitrogen needs, which has previously been overlooked as a driver of nitrogen recommendations⁴¹. These efforts are examples of leveraging science to redistribute power amongst farmers, scientists, and the public, blurring the lines between science creator and user. It also represents an important and positive shift in awareness regarding detrimental power inequities in previous applications of science.

Expanding the concept of scientific measurements

While traditional Western science methodologies can have a role in addressing power imbalances, expanding the definition of science is also an important component of redistributing power. The concept of “multiple ways of knowing” originates in Indigenous epistemologies but has recently migrated into the common vernacular. The concept recognizes the diverse means through which individuals and groups understand the world around them, including empirical observation and logical reasoning, but also personal experience and cultural traditions extending from place-based knowledge, for example. In dismissing knowledge originating outside traditional scientific observations, scientists limit the potential contribution such knowledge can have in enriching scientific understanding⁴². It follows that by utilizing non-traditional measurements, agricultural scientists can honor multiple ways of knowing while still working within a scientific framework. An apposite example is USDA NASS reporting of a “workable field day” - a day when weather and field conditions permit producers to work in their fields for the majority of the day⁴³. It has a scientific

underpinning⁴⁴ but represents a deeply personal interaction between the farmer and the land that has evaded modeling attempts⁴⁵. Workable-day survey data is commonly used in extension, but to our knowledge has had limited use within research. In an example of challenging hegemonic power around knowledge generation, Practical Farmers recently launched a study wherein farmers quantify their experiences with cover cropping through the metric of workable field days⁴⁶. This effort values farmers’ ways of knowing in a scientific framework and will uniquely enrich our understanding of how cover crops impact soil-water dynamics. Participatory plant breeding^{47,48} and mother-baby trial designs⁴⁹ are examples of formalized research methods that seek to include non-traditional measurements. There is clearly ample room for creativity in this area.

Reciprocity

In addition to what research is done, the way research is done presents myriad opportunities to balance power in agricultural research. A recent publication provides excellent guidance on working with communities and organizations in general⁸, however, we feel the farmer-researcher collaboration merits explicit attention for agricultural scientists in relation to power and chose to focus on that relationship for this Perspective. As agricultural research evolves, opportunities abound for blending research plots with farm fields to perform more statistically powerful and relevant public research in collaboration with farmers^{39,50,51}. As these types of arrangements become more common, the concept of reciprocity in farmer-researcher collaborations requires explicit attention. There are several guides for farmers when conducting on-farm research^{52,53}, but there are fewer resources suggesting best practices for the scientists, researchers and organizations they collaborate with.

Multi-dimensional compensation

The context for farmer involvement in research can vary widely^{54,55}, and while there are numerous publications examining the form of those relationships, to our knowledge there are few studies on mechanisms for farmer compensation, and even fewer on how those mechanisms influence collaboration dynamics⁵⁶. 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 similar 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 collaborators, but without an offer of fair compensation, collaborators may reasonably intuit a devaluation. Moreover, failing to provide compensation further exacerbates historical biases, favoring well-resourced farmers in access to on-farm research activities. Funders clearly have a role to play; researchers have highlighted barriers to budgeting for non-university research participants⁵⁷, and while select funding agencies explicitly allow for and expect farmer-participant compensation (e.g., USDA-SARE), to our knowledge, none provide guidance on how to craft compensation packages.

Fair remuneration is in everyone’s best interests, as equitable partnerships are more likely to be sustained in the long-term⁵⁸. For example, Practical Farmers has a robust farmer cooperator program that is still in operation after more than 30 years, a fact they attribute in part to their policy of monetarily compensating farmers for their participation in on-farm research (Supplementary References). For comparison, the Iowa Nitrogen Initiative (see *Leveraging Science*) 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 is likely to be most effective^{39,56}, and could be used to specifically support institutionally-excluded groups’ needs (e.g., childcare, language interpretation). We provide examples of blended compensation packages that coincided with high participant satisfaction and willingness to participate in subsequent grant

activities related to conservation⁵⁹ in supplemental files as a resource (Supplementary References). Explicit attention to compensation is therefore an accessible way for agricultural researchers to support more equitable power relations in agriculture.

Metrics for success

Researchers and farmers are often aiming to develop rich and equitable relationships. The form of compensation package can play a role in this goal, but tangible metrics can help articulate and measure success in those efforts (Fig. 1). Building on recommendations from various sources^{8,13,60}, we present the following four broad metrics to help guide the construction of equitable projects:

1. Were power and resources shared?
2. Was trust built?
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 on-farm research program, which has been in place since 1987. Practical Farmers has continually refined their post-program participation surveys, and the current form quantifies outcomes in the four metrics presented here (Supplementary References). As these questions have become guides for program design, participants have been highly satisfied (Supplementary References), and membership is growing. Other researchers and entities likely utilize some form of these metrics, but more explicit and ubiquitous use would likely benefit project designs and evaluations, while concomitantly promoting equitable partnerships.

Framing

The feasibility (or even desirability) of objectivity in science has long been debated, and recent discussions highlight its conceptual abuse in colonialism, eugenics, and other forms of oppression^{61,62}. Today, many disciplines embrace interpretation, plurality of methods, critical reflexivity, and fallibilism as inherent in the pursuit of knowledge^{63,64}. Rather than pursuing objectivism (and insinuating it is possible), Data Feminism acknowledges that all research is framed by the background, experiences, and training of the researcher.

Importantly, this plurality is desirable in a Data Feminism framework. To help cement framing as an inherent component of all agricultural research, here we discuss the barriers to and difficulty in acknowledging the frames shaping agricultural research, as well as the implications of such acknowledgment. These sections are designed to help researchers reflect on their training, as well as the values of their institutions.

Acknowledging the presence of values in research

A book written to illustrate how underlying value systems shape individuals' approaches to complex global challenges unwittingly uses agricultural research as its backdrop: *The Wizard and the Prophet*⁶⁵ explores the worldviews of Norman Borlaug and William Vogt, two white, Western men coming from divergent backgrounds, as they work on agricultural topics during the 20th century. Borlaug, raised on a Midwestern US farm, experienced a rural transformation born from the introduction of tractors and was trained as a scientist through US Land Grant agricultural programs. These experiences likely informed his approach to problems: Borlaug researched ways to leverage technology to increase food production, an effort that contributed to a larger collection of innovations referred to as the Green Revolution and for which Borlaug won a Nobel Peace Prize⁶⁶. Vogt also began his life in a rural area, but moved to the city and witnessed the urban development of the natural areas he associated with his childhood. He studied languages and moved into science by way of managing a bird sanctuary near his childhood home. Vogt's research emphasized the need to live within ecological limits rather than increase food production, and he formally developed the concept of ecological carrying-capacity⁶⁷ as well as a model for environmental activism that is still used today. Borlaug and Vogt were both scientists, but their divergent approaches and conclusions were strongly shaped by their experiences and training. Their differing motivations do not invalidate their work, but rather demonstrate how multiple valid, but values-informed, truths can co-exist. As scientists, we must accept that our training socializes us to value certain processes or outcomes in research—it influences the questions we ask, whom we engage with to answer them, what we measure, how we interpret results, and how we communicate those results. Data Feminism encourages interrogation of these passively inherited values and the attendant limitations these values may place on our ability to “see” the multiple, valid ways of approaching agricultural problems. Scientists who are self-aware of their own values and are able to acknowledge and navigate the existence of multiple truths are better equipped to provide solutions that do not preferentially disadvantage vulnerable groups⁶⁸ and are better able to bring clarity to complex topics^{69–71}.

The value of diverse framings

Practical Farmers highlights diversity in their membership as a cornerstone of its identity, often referencing their “big tent” policy (Supplementary References). In turn, Practical Farmers members explicitly highlight the organization's diversity in viewpoints as a distinguishing and valuable feature of the organization, and that this fosters trust in the information provided by Practical Farmers' programming^{28,72}. Diversity-as-an-asset is further demonstrated by Practical Farmers' growing membership, which is now larger than that of a prominent Iowan commodity organization (Supplementary References). In agricultural research, an increasing availability of diversely framed reflections concerning the Green Revolution that Borlaug's work contributed to has led to significantly more nuanced understandings of the motivations driving the Green Revolution, as well as the complex and contested impacts it had⁷³. As society navigates modern challenges to food systems, scientists must value and incorporate diverse voices to create fair and equitable paths for future food production. It follows that diversity in agricultural scientists is a necessary corollary⁷⁴.

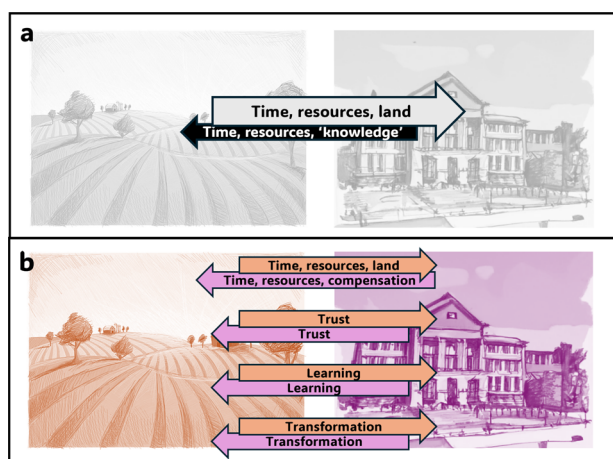


Fig. 1 | A conceptual representation of reciprocity in farmer-researcher relationships through resource sharing and multidimensional compensation. a A simple transactional (and in-equitable) exchange of resources wherein the metric of project success is measured by the increase in knowledge by the collaborating farmers. **b** A richer relationship built on exchanges and associated metrics that promote fair and sustainable relationships; an example survey for assessing these metrics is available in Supplementary References. Created in BioRender. Nichols, V. (2025) <https://BioRender.com/m69i249>.

Conclusions

In this Perspective, we show how agricultural scientists who examine, challenge, and work to redistribute power can uniquely contribute to ongoing work towards agricultural (and social) equity and may concomitantly experience positive impacts on research creativity and stakeholder participation. We also demonstrate how, by valuing reciprocity, researchers have engaged new participants in conservation activities, and that organizations that offer diversity in perspectives may be perceived as more trustworthy sources of information. For agricultural researchers, engaging with Data Feminism need not be overwhelming nor demand world-changing activities; it simply asks that one reflect on power disparities and values embedded in their research. We hope this perspective demonstrates both the worthiness and feasibility of such pursuits.

Data availability

No datasets were generated or analyzed during the current study.

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Author contributions

V.N. conceived and wrote the first draft of the manuscript; A.C. and S.G. were major contributors in writing the manuscript; V.N., A.C., S.G., A.B., and D.W. contributed to editing and approved the final manuscript.

Competing interests

The authors declare no competing interests.

Additional information

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