CHAPTER 10

Science and Justice
Beyond the New Orthodoxy of Value-Laden Science

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The New Orthodoxy of Value-Laden Science

In the face of climate change, the COVID-19 pandemic, and rising anti-science populism, an unlikely alliance of scholars has emerged to "regain some of the authority of science," as Bruno Latour puts it in an interview with *Science* (Vrieze 2017). Historians, philosophers, and sociologists of science, who have long operated in competing intellectual niches, find a common calling in highlighting the existential importance but also increasingly fragile position of science in society. The aim of this chapter is to trace the emergence of this new intellectual orthodoxy and its defense of science in times of global challenges. While the new orthodoxy conveys important insights about the interface between science and society, I argue that it also neglects the roles of science in enabling the exploitation of people and the destruction of ecosystems. I conclude that it is time to move beyond the new orthodoxy by addressing the intricate relationship between science and global justice.

In her TED talk "Why We Should Trust Scientists," historian of science Naomi Oreskes (2014; see also 2021) sets the stage with two salient issues: climate change and public health. Oreskes emphasizes that we need to trust scientists when it comes, for example, to a warming planet or vaccines. This is not because science is infallible, but rather because scientists collectively gather and evaluate evidence. Scientific consensus may be wrong, but it provides the best judgment that societies have when facing complex social-environmental challenges. In his essay "Science as craftwork with Integrity," sociologist of science Harry Collins (2021: 297) does not only recommend trust but even love for science: "We should love science other than that which is visibly corrupt, because basing political decisions upon it gives rise to the best decisions." Collins' love is qualified in ways similar to Oreskes' trust: Science is not characterized by its infallible objectivity but by its sophisticated craftwork. While science can be corrupted, noncorrupted science provides the best craftwork we have in addressing global challenges such as climate change and the COVID-19 pandemic.

Latour's authority, Oreskes' trust, and Collins' love for science provide a striking contrast with the legacy of the field of science and technology studies (STS). While philosophy of science became increasingly depoliticized in the postwar period (Reisch 2005), STS emerged as an interdisciplinary meeting ground of scholars who were often "involved in or influenced by counter-cultural and radical activities from the late 1960s, '70s and '80s" (Taylor and Patzke 2021) and challenged science as a social system that is intertwined with oppressive social realities of "racism, imperialism, heterosexism and class oppression" (Harding 1991). But the stakes are too high to focus exclusively on critique (Latour 2004b). Collins et al. (2020: 1) even go a step further in arguing that "STS erodes the cultural importance of scientific expertise and unwittingly supports the rise of populism." History, philosophy, and sociology of science needs to move beyond such a performance of critique, toward a serious understanding of scientific expertise and integrity. As philosopher of science Philip Kitcher (2020: 119) points out, recognition of scientific expertise has become a truly existential matter as failure to respond to climate change will leave us with "a world so bereft of resources, so buffeted by a different climate, that no voice within it could rise to mourn and accuse."

None of the scholars cited here want to return to an unquestioned authority of science. Science is not properly characterized in terms of value-free objectivity and "scientists invariably bring biases, values, and background assumptions into their work" (Oreskes 2021: 64). Science is not some kind of infallible "magic" but rather a very specific kind of "craftwork" (Collins 2021: 304) that can go wrong and can be corrupted. The answer to global crises is not an old-fashioned scientism that preaches from the pedestal of certainty and value freedom. On the contrary, we need "science with a human face" that is reflexive about its complex entanglement with society, honest about its own limitations, and still able to produce the most reliable knowledge about global challenges such as climate change, food production, loss of biodiversity, public health, social inequality, soil erosion, and sustainable energy production.

In an admittedly polemical simplification, I want to call this broad position the *New Orthodoxy of Value-Laden Science*. Talk of a New Orthodoxy is apt as the picture is promoted by many of our most prominent science scholars and synthesizes major insights from history, philosophy, and sociology of science. Talk of a New Orthodoxy is polemical as it glosses over the many substantial differences between the scholars that are thereby lumped together. Scholars such as Collins, Kitcher, Latour, and Oreskes engage with science through different intellectual traditions and styles of reasoning that have often created explicit disagreements (e.g., Collins and Yearley 2010 versus Callan and Latour 2010) and that remain reflected in overlapping but still distinct communities of research who identify with labels such as "sociology of science," "science and technology studies," or "history and philosophy of science."

However, the intellectual diversity of these scholars makes their converging voices all the more remarkable. From interviews in *Science* (Vrieze 2017) to TED talks (Oreskes 2014) to features in the *New York Times* (Kofman 2018), disagreements of academic scholarship vanish in the background of a publicly articulated vision of the role of science in society. Roughly, this common vision contains four elements. First, an existential *diagnosis of the fragility of science* in the face of a planetary crisis. Science is indispensable for addressing global challenges such as climate change and the COVID-19 pandemic but simultaneously threatened by rampant anti-intellectualism and anti-science populism. Second, an *opposition to the ideal of value-free science* that downplays the historical and social embedding of research in order to present science as an unquestionable authority of pure objectivity. Third, an *endorsement of "science with a human face"* that acknowledges the deep entanglement of science and values but stresses the epistemic integrity and success of value-laden science that is not epistemically corrupted. Fourth, an *emphasis on the public importance of science* that requires qualified authority, trust, and even love in the face of existential planetary crises.

The New Orthodoxy synthesizes insights from decades of historical, philosophical, and sociological debate about the nature of science and its relations with society while bracketing remaining scholarly disagreements. Methodologically, it reflects the waning of a simple dichotomy between realist defenders of science who highlight value-free objectivity and constructionist critics who highlight the historical and social contingency of science. While this dichotomy is familiar from debates about the so-called science wars of the 1990s, so is its rejection as a false dichotomy (Carrier et al. 2004). Yes, science is always embedded in values. Science is always shaped in sociocultural contexts and therefore does not lead to an absolute and subjectivity-free description of "the world as it is independent from our experience" (Williams 1985: 139). No, that does not mean that "anything goes" and it does not mean that reality somehow collapses into mere social constructions. It also does not mean that we have to give up on scientific objectivity or that scientists lack epistemic authority when rejecting the claims of climate change denialists or anti-vaxxers.

Politically, transcending "science war" dichotomies also suggests a realignment of the relations between science and society. According to the New Orthodoxy, the question is not anymore whether science needs to be defended against postmodern and poststructuralist obscurantists or criticized as relying on false claims of value freedom and universality. Instead, the question is how to develop a middle ground that aligns science and society in reasonable ways and takes their complex relations into account. Instead of being isolated from society, science needs to inform policy while cultivating reflexivity about its own social character.

Contradictions in Framing Science

The New Orthodoxy provides a reasonable and well-balanced compromise that has been forged through major intellectual controversies about the nature of science and its relations to society. It incorporates legitimate criticism of absolutist interpretations of the objectivity, universality, and value freedom of science while simultaneously articulating a positive vision of the epistemic authority of science that provides a robust response to anti-science populism. The arguments of the New Orthodoxy are well suited to addressing the problem of anti-science populism but their extrapolation into a generalized defense of science risks invisibilizing contradictions that characterize the institutional reality of the science system. The risk of structural blindness is especially pressing in the New Orthodoxy's lack of engagement with the role of science in society beyond Europe and North America. Programmatic statements in Oreskes' *Why Trust Science*, or Latour's *Down to Earth*, or Collins et al.'s *Experts and the Will of the People* depart from a rather uniform set of examples. Brexit and Donald Trump. Climate denialism and anti-vaxxers. Conspiracy theories and social media trolls. The Global South appears only if it conforms to this pattern, such as Jair Bolsonaro's attack on the Brazilian science system and evidence-based governance. Indeed, the Brazilian case illustrates that anti-science populism is not an issue exclusive to the Global North (Reyes-Galindo 2021). However, it is misleading to address global contestations of science exclusively through the problem of anti-science populism.

The New Orthodoxy does not explicitly deny that science has contradictory and sometimes exploitative roles on a global scale. In fact, most proponents of the New Orthodoxy would probably accept many of the arguments of this chapter. However, the New Orthodoxy de facto invisibilizes such issues by simply not talking about the complicity of science in global exploitation while presenting seemingly general defenses of science. This issue of epistemic silencing (Dotson 2011; Spivak 1988) becomes most salient when contrasting commentary from the New Orthodoxy with scholar activism that centers on questions of global justice. For example, Colombian post-development scholar Arturo Escobar challenges trust in science by arguing that "science has become the most central political technology of authoritarianism, irrationality, and oppression of peoples and nature" (2018: 89). According to Escobar, the science system is implicated in the production of global injustice in two ways. First, Escobar argues that science often constitutes a vehicle for "violent development" (2018: 89) in the Global South, where it contributes to neoliberal agendas of growth and modernization that deepen global economic inequality while redistributing the social and environmental burdens of biodiversity conservation, food production, and resource extraction onto the Global South. Second, Escobar argues that science functions as "a reason of state" that "even standardizes the formats of dissent" (2018: 89). Alternative visions of societies and environments are commonly articulated by social movements and scholars in the Global South who mobilize local philosophical resources such as *Buen Vivir* in Latin America (Varea and Zaragocin 2017), *Ubuntu* in Southern Africa (Simba 2021), and *Mātauranga Māori* in Aotearoa/New Zealand (Watene 2016). However, such alternatives remain invisible in mainstream development as they are not couched in academic vocabulary and therefore fail to adhere to formats of dissent that are defined by the science system. Despite notable exceptions in feminist scholarship (Harding 2010; Wylie 2015), they also remain invisible in mainstream philosophy of science that theorizes science almost exclusively through its expression in the Global North.

Escobar's perspective on science as promoting narrow agendas of growth and modernization is mirrored in contributions by scholar activists beyond Latin America, including the work of the Indian ecofeminist Vandana Shiva. Shiva's (1991) influential *The Violence of the Green Revolution* inverts the narrative of agricultural modernization in the second half of the twentieth century as the most shining success of humanitarian research that elevated much of the "Third World" out of hunger and poverty. Written in the wake of the Bhopal disaster and a decade-long armed conflict in Punjab, Shiva states that "two decades of the Green Revolution have left Punjab ravaged by violence and ecological scarcity. Instead of abundance, Punjab has been left with diseased soils, pestinfested crops, waterlogged deserts, and indebted and discontented farmers. Instead of peace, Punjab has inherited conflict and violence" (Shiva 1991: 11). According to Shiva, the web of economic, environmental, social, and religious conflicts in Punjab is not simply a failure of policy but was co-created by a science system that "offers technological fixes for social and political problems, but delinks itself from the new social and political problems it creates" (1991: 19). Shiva argues that the contradictions of the science system are obscured by a tendency to take credit for its societal benefits (e.g., climate change mitigation, poverty reduction, public health) while externalizing negative and destructive impacts as mere issues of misguided application and policy. "The tragic story of Punjab is a tale of the exaggerated sense of modern science's power to control nature and society, and the total absence of a sense of responsibility for creating natural and social situations which are totally out of control" (Shiva 1991: 21).

The perspectives of scholar activists such as Escobar and Shiva are also reflected in many social movements in the Global South such as the "Rhodes Must Fall" movement in South Africa. The Fallist movement emerged in 2015 at the University of Cape Town in protest against a statue commemorating the British colonialist and mining magnate Cecil Rhodes (1853–1902) but quickly turned into a broader protest movement against the colonial and apartheid legacy of the South African university system. The omnipresence of Rhodes in South African academia became challenged as representing a university system that served colonial oppression and often still remains inadequate – for example, in its student fees and admission procedures – for purposes of contemporary South African society. As most clearly expressed in a variation "Science Must Fall" (Harris 2021), a part of the movement pushed even further in locating the problem not merely in colonial symbols or administrative issues but also in the very structure of South African science – the problems that are prioritized by researchers, the questions that are asked, the methods that are employed, the theories that are taught, the interventions that are derived. In this sense, Harris (2021: 113) describes the Fallist movement as demanding a "path of accommodation and inclusion [that] leaves intact the integrity of scientific explanation while at the same time allowing for the possibility of tapping into African knowledge for a different type of edification."

Contradictions in the Science System

The examples of Escobar, Shiva, and Fallism exemplify framings that radically differ from the New Orthodoxy as expressed in Latour's authority, Oreskes' trust, and Collins' love for science. Of course, it may turn out that this is just an issue of framing that can be resolved through more nuanced analysis that highlights the qualified character of the New Orthodoxy's defense of science. Defending science as "craftwork with integrity" (Collins 2021), for example, is intimately linked to criticizing science that lacks integrity because it has been epistemically corrupted by corporate influence, political ideology, or other factors. The suggestion is not to trust every scientist but to trust science as a collective endeavor of evaluating evidence and establishing a consensus of experts (Oreskes 2021).

Highlighting this qualified case for trust may be seen as creating a middle ground for embracing some claims of scholar activists in the Global South, while rejecting others. Indeed, the influence of big corporations in areas such as agriculture and public health is worrying and justifies some of the concerns that Escobar and Shiva are articulating. The legacies of colonialism and apartheid did not magically vanish from the South African university system but require continued scrutiny as exemplified by Rhodes Must Fall. At the same time, science cannot be reduced to issues of corporate or colonial corruption as noncorrupted science remains the most reliable guide for addressing global challenges such as climate change or food security. In this sense, the New Orthodoxy may be seen as offering a compromise that acknowledges the need for critical reflexivity about epistemic corruption while dampening the sharp edges of activist criticism toward the science system as a whole.

Such a compromise fails, however, insofar as it frames all criticism of epistemically noncorrupted science as anti-science populism. For example, consider academic responses to Shiva's critique of genetic modification and mainstream agricultural development. When invited to speak at an event of Students for a Sustainable Stanford in 2019, for example, forty-five leading scientists from European and North American institutions signed an open letter condemning Shiva's alleged "use of anti-scientific rhetoric to support unethical positions" based on "preposterous," "ridiculous," and "nonsense" statements (Tabliabue et al. 2019). Positioning Shiva as an "anti-science populist" in analogy to climate change denialists or anti-vaxxers is also reflected in an article in the *New Yorker* with the title "Seeds of Doubt" (Specter 2014), in a variation of Oreskes and Conway's (2010) book *Merchants of Doubt*, which focuses on epistemic corruption of scientists by tobacco and oil industries rather than the contribution of agricultural sciences to the exploitation of people and planet.

There is plenty of room for criticism of Shiva's often relentlessly polemic engagement with mainstream agricultural sciences. Reducing her critique to anti-science populism, however, exposes a fundamental misunderstanding that risks being reinforced through the framing priorities of the New Orthodoxy. Contradictions at the interface of science and society are not merely the product of epistemic corruption. They do not only appear when academic integrity is seduced by corporate influence or political ideology. The case of agriculture highlights that the science system as a whole, and not just its epistemically corrupted fringes, is producing contradictions in the sense that scientific knowledge is indispensable for addressing social-environmental crises but is also often a driving force in creating them.

Much of this remains off the radar of public interventions of the New Orthodoxy that tend to focus on a narrow set of disciplines (often climatology and epidemiology) in an equally narrow set of societal contexts (often the UK and USA). In programmatic articulations of the New Orthodoxy, this narrow frame of reference finds a reliable expression in stage setting that involves trustworthy scientific actors such as the Intergovernmental Panel on Climate Change or the Centers for Disease Control and Prevention versus populist advisories from Trump to anti-vax Facebook groups. If the frame of reference is defined this way, many contradictions of the science system indeed become invisible, and the dominant concern becomes the defense of well-established but publicly contested scientific evidence.

The problem with this frame of reference, however, is that it invisibilizes large parts of the science system that affect social-environmental systems. Addressing this as an issue of reference frames allows an analogy with a familiar debate in the philosophy of science about the diversity of scientific practice (Radder 2012). Rather than assuming that a theory of the nature of science in general can be formulated through case studies from fundamental physics or evolutionary biology, philosophy of science has come to emphasize the diversity of disciplines from archaeology to biomedical sciences to engineering sciences to microbiology – not because fundamental physics or evolutionary biology do not matter but because the reality of scientific practice is too heterogeneous to be assessed through a narrow set of reference sciences. By analogy, engagement with the interface of science and society needs to look beyond a narrow set of examples from climatology or epidemiology – not because these fields do not matter but because the political structure of scientific practice is too heterogeneous to be assessed through a narrow set of reference sciences. The following sections, therefore, develop both critical and constructive diagnoses of social roles of science through a focus on disciplines and issues that are largely ignored by the New Orthodoxy.

The Case of Agricultural Production

Agriculture constitutes one of the most important junctions of science and society. The dramatic transformations of agricultural production shape the lives of billions of people around the world. Processes of "depeasantization" illustrate the scale and pace of these transformations: between 1991 and 2017, employment in agriculture fell from 58.01 percent to 36.55 percent in Nigeria, from 69.51 percent to 39.07 percent in Bangladesh, and from 55.31 percent to 17.51 percent in China (World Bank 2021a). However, focusing on depeasantization efforts and declining rates of agricultural employment only scratches the surface of the dramatic social effects of shifting agricultural production. As van der Ploeg (2018: 1) points out, "there are far more peasants in the world than ever before in human history. In absolute numbers, even the most conservative estimates suggest that there are between 500 and 560 million peasant farms in today's world, and this number is continually increasing." Peasant farming does not only continue to provide the livelihood basis for roughly two billion people, but depeasantization is also often intertwined with complex processes of repeasantization in the light of consequences such as urban poverty as well as declining profit margins for many farmers who compete on global commodity markets.

Transformations of agricultural production are worlds of contradictions. Scientific contributions to these transformations represent some of the brightest and darkest dimensions of the intersection of science and society. On the one hand, there is a positive narrative about a wide range of disciplines – for example, agronomy, chemistry, engineering, genetics, hydrology, plant breeding, and soil sciences – that have contributed to increasing yields and decreasing rates of hunger. Scientific contributions to pushing the boundaries of agricultural productivity have been so prominent in the challenge of "feeding the world" that they even produced a Nobel Peace Prize winner, Norman Borlaug, commonly described as the "father of the Green Revolution."

On the other hand, it has become widely recognized that generic appeals to decreasing rates of hunger only tell one part of a much more complex story. Food insecurity has actually been on the rise again since 2014 (von Grebmer et al. 2020) and has spiked since the COVID-19 pandemic in the light of reinforcing effects of "climate, conflict, zoonotic diseases and pests, as well as economic shocks" (World Bank 2021b). Scientific research has not only failed to mitigate this trend but has also contributed to deepening this crisis through cash crop monocultures that are vulnerable to economic and environmental disruption, and through unsustainable production systems that contribute to droughts, loss of biodiversity, soil erosion, and other environmental factors that drive food insecurity (La Via Campesina 2020).

Furthermore, rates of food insecurity are only one relevant factor that is not always positively correlated with other relevant factors such as rates of poverty (Gentilini and Webb 2008). Science-led increases in agricultural productivity often come in the form of "technological packages" of large-scale intensive agriculture that produce cheaper commodities through new seeds, fertilizers, pesticides, machines, seeding techniques, value chains, and so on. Even where these interventions have increased the availability of cheap food, they have often simultaneously driven land grabbing of peasant farms, rural unemployment, crumbling communities due to out-migration, and the explosion of urban underclasses (Sumberg, Thompson, and Woodhouse 2012). Societal contradictions are therefore deeply embedded in processes of agricultural modernization – for example, by rapidly increasing urban underclasses while simultaneously making food more cheaply available to them. In this way, agricultural modernization often creates and connects spaces of poverty (rural spaces for creating food commodities as cheaply as possible, urban spaces of expendable peasant labor) and spaces of richness (concentrated ownership across food value chains, affluent consumer markets) on a global scale (van der Ploeg 2018: 93).

While it is possible to highlight contradictions of agricultural production at a general level, it is often more informative to address specific cases of scientific knowledge production and the specific interventions they enable. For example, genetic modification (GM) constitutes a salient issue at the interface of science and society with many more specific case studies. GM has a lot of potential for agricultural productivity that is only further increased through the rapid development of novel gene-editing technologies that promise ease and precision in manipulating targeted genes (Shah, Ludwig, and Macnaghten 2021). Beyond abstract talk about potential, there is also plenty of real life evidence. Proponents of GM crops often focus on Bt cotton as the shining example of a "pro-poor" technology with straightforward benefits for farmers (Ali and Abdulai 2010). Containing a gene from the bacterium *Bacillus thuringiensis,* Bt cotton produces a toxin that kills bollworms. Growing Bt cotton can therefore reduce risk of crop failures, costs of inputs such as pesticides, and health risks associated with widespread pesticide application. Especially in India, the largest cotton producer in the world, the introduction of Bt cotton in 2002 became associated with narratives of "technological triumph" with adoption rates over 90 percent, increasing yield, and reduced pesticide application (Kranthi and Stone 2020).

The narrative of Bt cotton as a triumphal "pro-poor" technology is commonly contrasted with a counter-narrative, publicly most visible in Shiva's characterization of Bt cotton as "Seeds of Suicide" (Shiva et al. 2000) that create debt and dependency on global markets, allegedly causing an epidemic of farmer suicides in India. Almost thirty years after the approval of Bt cotton, it has become increasingly clear that these narratives of triumph and counter-narratives of failure capture parts of a complex and highly contradictory story (Kranthi and Stone 2020). Initially developed for large-scale farms in North America, Bt cotton did not turn out to be a universal "pro-poor" technology but had wildly different effects in different agrarian and ecological contexts (Glover 2010). Take the case of Burkina Faso, which approved Bt cotton in 2008. It was hailed as a "role model" for agricultural development in Africa with quickly rising adoption rates (2 percent in 2008, 70 percent in 2014) and sharply declining insecticide use (Pertry et al. 2016). In the midst of this developing story of technological triumph, the Burkinabè cotton sector announced that it would cease producing Bt cotton, ending GM crop production in Burkina Faso entirely. As Luna and Dowd-Uribe (2020) point out, a wide range of problems had accumulated. Most importantly, the shorter fiber length of Bt cotton compared to conventional Burkinabè varieties made the former less profitable on global markets and created substantial losses for Burkinabè cotton companies. Luna and Dowd-Uribe (2020) highlight the problem that the marginalization of Burkinabè stakeholders (local farmers, researchers, and companies) led to distorted external studies of the alleged success of Bt cotton that misrepresented local realities and culminated in an abrupt collapse of GM crops in Burkina Faso. The contradictory effects of the introduction of Bt cotton in Burkina Faso reflect the complex (economic, ecological, social) dynamics of GM-based agriculture in Africa, which have led to only three out of fifty-four countries in Africa commercializing any GM crops whatsoever (ISAAA 2019).

Cases such as Bt cotton in Burkina Faso provide an entry point for engaging with the complexity of the interface of science and society – both in its potential for improving local livelihoods and its reality of often failing to realize this potential. And indeed, historians, philosophers, and sociologists of science have produced excellent scholarship on issues of global agricultural production (Curry 2017; Hicks 2015; Lacey 2015; Millstein 2015; Motta 2014). However, this scholarship does not fit well into framings of the New Orthodoxy that contrast reliable scientific consensus with anti-science populism. Despite the contested role of large agrifood companies such as Monsanto, the majority of proponents of GM crops are clearly not "Merchants of Doubt" (Oreskes and Conway 2010) that trade epistemic integrity for corporate benefits; rather, they often include the most influential researchers in fields such as plant genetics at the most prestigious research institutions of the Global North. As a consequence, criticism of GM crops has often been rejected as "antiscience zealotry," as Norman Borlaug famously put it, or even as a "crime against humanity," as claimed in 2016 in an influential letter of 127 Nobel Prize laureates (Biddle 2018). History, philosophy, and social studies of science have the potential to highlight the need for a more substantial debate that acknowledges science as a key actor in addressing and producing global injustices in agricultural production. As much as research has the potential to improve agricultural production in ways that actually improve livelihoods, the reality of agricultural production often makes science central to the production of a wide range of injustices (e.g., environmental destruction, economic inequality and poverty, and health hazards).

Despite its undeniable virtues, the New Orthodoxy risks obscuring this complex and contradictory picture. Kitcher's (2011) discussion of GM crops in *Science in a Democratic Society* provides a striking example by developing a vision of "well-ordered science" in which citizens are tutored by scientists and eventually learn that there "is nothing special, or especially risky, about genetic modification of organisms" (2011: 567). Kitcher's discussion takes as its starting point a public ignorance of genetics (e.g., endorsements of the statement "GMOs [genetically modified organisms] contain genes, but ordinary organisms do not") and a "picture of genes as mysterious little agents of evil, inserted into healthy foods by the wicked minions of agribusiness" (2011: 567). Given such a framing, the contestation of GM crops indeed seems largely analogous to the contestation of vaccines by anti-vaxxers: While there is scientific consensus about the safety of many GM crops and vaccines, rampant ignorance about the actual science and diffuse concerns about "big business" regarding everything from Monsanto's seeds to Pfizer's vaccines leads to the rejection of technologies that are literally saving the lives of millions of people.

While Kitcher frames his discussion in terms of the knowledge deficit of citizens about genetics, he does not consider the knowledge deficit of scientists about the social-environmental context in which GM crops are implemented. Tutoring appears as a unidirectional process in which scientists already hold all the relevant expertise and other stakeholders are negatively characterized through their lack of expertise. However, the case of GM crops illustrates that it is crucial to recognize the diversity of situated knowledges (Haraway 1988) and that it is often the scientists who need tutoring about the social-environmental ramifications of scientific knowledge production. This lack of engagement with contested realities of agricultural production is also apparent in the way Kitcher's discussion characterizes GM opposition as "largely a European phenomenon" while "not much heard" among "many of the world's people, particularly in Africa and parts of Asia, [whose] current agriculture is unable to provide them [. . .] with ways of reliably growing the food they need" (2011: 318). The reality, however, is that GM adoption in the Global South has been hesitant at the policy level and publicly deeply contested. Burkina Faso is no exception. In 2018 (ISAAA 2019), GM crops covered 2.9 million hectares on the African continent – not even a quarter of Canada's 12.7 million hectares. In Asia, the largest producer is India with 11.6 million hectares, but only GM cotton and no other crops. Apart from Indian cotton, the whole of Africa and Asia combined cultivates less GM crops than Canada and less than 20 percent of the USA's 75 million hectares. Competing with the agricultural output of GM production in the Americas would risk the livelihoods of millions of farmers across Africa and Asia. Opposition is so strong that only three African countries (Eswatini, South Africa, and Sudan) commercialize any GM crops whatsoever.

While Africa and Asia illustrate hesitant GM adoption at the policy level, Latin America illustrates the public contestation of GM agriculture. For example, Brazil is the second biggest producer of GM crops in the world and GM varieties dominate the production of soy, maize, and cotton with an overall adoption rate over 90 percent (ISAAA 2019). The social contestation of GM crops in Brazil highlights the contradictions between visionary statements of biotechnological benefits "for the poor" and the economic reality of GM crops being part of technological packages that require land- and resource-intensive monocropping of cash crops for industrial use and export. GM agriculture is therefore often associated with a devaluation of traditional peasant production as underdeveloped and a push for agricultural industrialization that dispossess peasants and makes their labor expendable. It is therefore no surprise that peasants have been driving the resistance against GM crops in Brazil, most notably the Landless Workers' Movement (MST). The roughly 1.5 million members of the MST embody many of the contradictions of agricultural production and of modernist development projects such as the construction of the Itaipú hydroelectric dam in Paraná that resulted in the eviction of more than 10,000 mostly Indigenous or peasant families. In the MST case, opposition to GM crops is therefore not driven by affluent consumers, as imagined by Kitcher, but is part of a wider agrarian struggle for peasant livelihoods in rapidly globalizing agrifood commodity markets.

None of this is to suggest that GM crops only have negative effects in Brazil or the Global South more generally. But it is simply misleading to characterize its contestation as "a European phenomenon" that derives from the privilege of not having to worry about food security. Just as I was writing this chapter, the Court of Justice of Paraná, Brazil, confirmed the responsibility of the multinational biotech company Syngenta for the murder of the peasant farmer and activist Valmir Mota de Oliveira, who was killed on an experimental GM field by a corporately hired militia (Brasil247 2021). Syngenta is not some shady "merchant of doubt" who aims to undermine the established consensus of agricultural sciences. On the contrary, the position of Syngenta at the very heart of agricultural science is difficult to miss from my office at Wageningen University and Research. The president of my university, the "world's leading" agricultural university (WUR 2021), joined the nine-member board of directors of Syngenta in 2019 (Kleis et al. 2019). If only the contradictions of agricultural production could be modeled along the lines of familiar cases of climate change denialism or anti-vaxxers that demand a firm stance with the scientific mainstream against a vocal minority of "merchants of doubt." Unfortunately, such a model is deeply misleading in many cases. The contradictions of agricultural production are embedded in our best science at the very heart of the science system.

Science as a Site of Injustice

The case of agriculture is not a strange outlier but illustrates a more general discrepancy between the potentials and realities of scientific knowledge production in global contexts. Indeed, scientific knowledge production has enormous potential for addressing social-environmental challenges while mitigating inequality. Agricultural sciences are a shining example of this potential as they can contribute to making food more affordable, more nutritious, and more sustainable for current and future generations. The reality of the agricultural sciences, however, not only highlights this potential but also the point that science can become a site of injustice that actually deepens inequality and social-environmental crises.

There may be a possible world in which the science system is entirely aligned with the public good wherever it is efficiently defended against epistemic corruption. In the actual world, however, the science system is deeply entangled with economic and governance regimes that also turn it into a source of justice and injustice. Agriculture may be an especially salient example, but similarly obvious stories could clearly be told in other domains, such as the health sciences. The ethically and politically outrageous handling of intellectual property regimes during the COVID-19 pandemic, which often prioritized corporate profits in the Global North over vaccine access in the Global South (Krishtel and Malpani 2021), provides just one straightforward example of contradictions in the health domain of similar magnitude to those in the agricultural domain.

Contradictions also appear in domains such as biodiversity conservation, which typically have more pristine reputations for being directed toward the common good. While corporate influence in agrifood and health domains raise relatively straightforward concerns about science as a source of injustice, fields such as conservation biology may appear as uncontroversially positive cases: scientific contributions to conserving biodiversity are of existential importance for all of humanity and the planet as a whole. There is no question that scientific contributions to biodiversity conservation are urgently needed and involve research in a wide range of disciplines such as conservation biology, ecology, engineering, environmental sciences, economics, ethnobiology, geology, management studies, policy studies, soil sciences, and sustainability sciences. Again, however, one-sided stories about scientific contributions to saving biodiversity risk distorting a complex picture. As political ecologists have documented for decades (Bryant and Bailey 1997), not only the destruction but also the conservation of biodiversity is embedded in economic and governance structures that commonly deepen rather than address global inequality.

Indigenous peoples, peasants, and other marginalized communities are indeed often most directly threatened by the destruction of biodiversity through industrial agriculture, logging, mining, and other forms of resource extraction. However, this does not mean that they are always beneficiaries of biodiversity conservation. There are countless counterexamples. "Green grabbing" (Fairhead, Leach, and Scoones 2012), including the expulsion of Indigenous communities for the creation of conservation areas free of humans, provides an example. The criminalization of traditional and subsistence forms of resource extraction offers another case in point (Boelens, Guevara-Gil, and Panfichi 2009). Yet another example are human–wildlife conflicts that almost exclusively affect marginalized communities "when wildlife forage on crops, attack livestock, or otherwise threaten human security" (Treves et al. 2006: 383). As biodiversity has increasingly become a commodity for "green capitalism," familiar contradictions appear in global biodiversity governance: As in the case of food commodities, biodiversity is also most cheaply produced in spaces of poverty to be consumed from spaces of richness – from carbon offsetting markets to ecotourism (Büscher and Fletcher 2020). Opportunity costs for the production of biodiversity are simply the lowest in spaces of poverty. Biodiversity regimes often contribute to stabilizing or actively creating those spaces by making other forms of economic activity illegal and concentrating economic benefits in the hands of large producers of biodiversity, such as owners of large carbon offsetting plantations or wildlife parks. "Science-led" or "evidence-based" approaches to biodiversity conservation are by no means a guarantee of resolving or even mitigating these tensions. On the contrary, the transformation of biodiversity into a form of capital (e.g., in ecotourism) and into a commodity (e.g., in carbon offsetting) are shaped by the mainstream producers of scientific knowledge.

Of course, it would be disingenuous to blame the science system for all injustices in domains such as agriculture, biodiversity, and health. However, it would be equally disingenuous to hail the science system for its potential to "feed the world," "save biodiversity," or "achieve global health" without addressing the reality of the science system with its wide range of both positive and negative effects in these domains. This does not mean ignoring the potential of the science system but rather not conflating potential with reality. A sober assessment of the current state of relations between science and society is crucial for developing normative visions of relations that actually harness the positive potential of the science system. The following section moves toward such a positive vision by emphasizing the role of three justice dimensions – distribution, recognition, and representation – for outlining an account of just science.

Science as a Site of Justice: Distribution, Recognition, Representation

My labeling of a "New Orthodoxy of Value-Laden Science" highlights the formative role of debates about values in creating an intellectual middle ground that transcends the dichotomies of the "science wars": Values permeate scientific practice from the choice of research questions to methods to theories to dissemination. At the same time, appropriately situated values do not undermine the epistemic authority of science and create entry points for substantial conversations about socially engaged and democratically legitimized science. While there is indeed a lot to be learned from debates about "science and values" (Brown 2020; Douglas 2009; Elliott 2017), they are no substitutes for debates about "science and justice." First, much of the "science and values" debate has been focused on making a general case for the legitimacy of values rather than trying to identify *just* values in science (e.g., Ludwig 2016). As such, the debate is helpful for navigating theoretical issues such as expertise, objectivity, or relativism but often provides much less guidance for engagement with the politics of scientific practices in contested social-environmental settings. Second, the focus on values can encourage a methodological individualism that focuses on the values of individual scientists in making certain choices (e.g., about conceptual framings, inductive risks, and theory choices) rather than the economic and governance structures in which these choices are embedded.

Rather than limiting the analysis to values in scientific practice, this section therefore outlines a broader, justice-oriented perspective. Political philosophy provides a wide range of frameworks for debates about justice (Kolm 2002) that also suggest different angles for debates about just science. For example, procedural accounts of justice will highlight stakeholder participation in science, while substantive accounts of justice will directly address the impact of science on livelihoods and well-being. Although it may be philosophically interesting to aim for one fundamentally unified account of justice, engagement with the messy reality of scientific practice suggests a multidimensional framework that can facilitate discussion of heterogeneous dimensions of scientific practice that relate to the production of heterogeneous (in)justices. Fraser's (2009) account of global justice provides such a framework by highlighting two substantive dimensions (distribution and recognition), and one procedural dimension (representation), that are of immediate relevance to a positive vision of just science.

Distribution: One angle for thinking about just science is provided by debates about *distributive* justice. Scientific research shapes a wide range of practices with direct effects on the global distribution of benefits and burdens across and within societies. Some effects are of a direct, economic nature – for example, research facilitates novel technologies that lead to commercialized innovations with often varied effects on different societies and on different members within a society. At the same time, scientific research is also central to a wide range of further issues of distributive justice, such as exposure to environmental hazards, access to health services, and access to educational resources.

The food system illustrates the broad and differential effects of science on distributive justice. As argued in the previous section, research in fields such as agronomy, engineering, genetics, organic chemistry, plant breeding, and soil science has contributed to a radical transformation of food systems with differential impact on stakeholders. For many stakeholders, agricultural modernization has made food more accessible, as reflected in declining long-term rates of undernutrition. As previous sections have highlighted, however, the reality is much more complex. Not only have global rates of undernutrition been on the rise recently, but an exclusive focus on rates of undernutrition obscures the social and environmental price of agricultural modernization in many areas of the world. The reduction of production costs of food has often come with dispossession of land and loss of labor for peasant populations, creating novel spaces of poverty of enormous scales. Distributive concerns also extend beyond food itself toward issues such as exposure to environmental hazards such as synthetic fertilizers and pesticides. In all of these cases, scientific contributions are complex and multidimensional: For example, new seed varieties can reduce the need for synthetic fertilizers and pesticides and thereby reduce exposure to environmental hazards. At the same time, synthetic fertilizers and pesticides are themselves a product of scientific research and dependency on such chemical inputs is a mark of science-led industrialization of agriculture.

Distributive justice provides a lens for substantial engagement with such complex causal effects of agricultural research on the distribution of material benefits and burdens. Indeed, increasing the productivity of agriculture has the potential to contribute to distributive justice. Scientific research that contributes to agricultural sustainability is indispensable for addressing a wide range of distributive justice issues. At the same time, potential impact is not the same thing as actual impact, and the food system illustrates how deeply the current state of agricultural research is implicated in the production of distributive injustices. From the perspective of distributive justice, a focus on just science therefore highlights the importance of transforming the role of science in society for redistributing its diverse benefits and burdens, such as income, stable access to food, food safety, nutritional diversity, health hazards, or environmental degradation.

Recognition: While distribution is at the center of many justice concerns, it has been widely argued that justice is not exhausted by matters of distribution but also raises complex questions of recognition (Young 1990). As Fraser and Honneth (2003) put it: "Whether the issue is indigenous land claims or women's carework, homosexual marriage or Muslim headscarves, moral philosophers increasingly use the term 'recognition' to unpack the normative bases of political claims." Issues of recognition are closely entangled with issues of distribution, but the former often do not reduce to the latter. A woman who is sexually harassed in the workplace may be negatively affected in her career and income but clearly experiences injustices beyond such distributive effects. An Indigenous community that loses its land loses much more than simply the distributive benefits of control over natural resources. Thus, Fraser (2009: 377) stresses "the demand for recognition of people's standing as full partners in social interaction, able to participate as peers with others in social life. That aspiration is fundamental to justice and cannot be satisfied by the politics of redistribution alone."

In the case of the global food system, concerns about recognition are most clearly reflected in the expansion of political activism from food security to food sovereignty (Noll and Murdock 2020). While the concept of food security is typically operationalized in distributive terms through stable access to nutritious and safe food, the influential Declaration of Nyéléni defines food sovereignty as "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems" (Forum for Food Sovereignty 2007). Food sovereignty expands the scope of food security along two dimensions. First, the recognition of cultural (e.g., culinary, farming, fishing, hunting) practices and values that are crucial to the identities and self-determination of peoples. Even when agricultural intensification provides secure access to food, it may still constitute misrecognition of Indigenous peoples or peasants whose community structures, food practices, and ways of relating to environments are dismantled in the process. Second, the idea of food sovereignty highlights how recognition often turns out to be a condition for distributive justice. As Iris Marion Young (1990: 22) already argued, an exclusive focus on distributive indicators often "ignores and tends to obscure the institutional context within which those distributions take place, and which is often at least partly the cause of patterns of distribution." The institutional context of agricultural modernization in the Global South is often based on misrecognition of local communities and food systems that contributes to unjust patterns of distribution – for example, through dominance of exogenous cash crops that replace Indigenous food crops but are vulnerable to crop failures or market fluctuations.

Expanding the scope of concern from distribution to recognition provides important and challenging lessons for an account of just science. While distributive concerns are of crucial importance, they need to be complemented through serious intercultural dialogue about the structure of the science system and a recognition of global epistemic diversity including the knowledge of Indigenous communities (Chilisa 2019; Rivera Cusicanqui 2010; Solano and Speed 2008; Vijayan et al. 2022). Modern science and technology are deeply disruptive in peoples' lives, and the food system provides some of the most dramatic illustrations of this, having fundamentally transformed rural spaces through dynamics of depeasantization and repeasantization, as described in previous sections. Not all forms of disruptive change are negative, but they are fraught with contradictions that can (and will) be evaluated in radically different ways from different, culturally situated standpoints. There is no "view from nowhere" in evaluating the global ramifications of science through a neutral set of distributive indicators. This lesson is especially challenging for scientists in the Global North who may be inclined to think of just science through well-intended distributive indicators rather than serious intercultural dialogue that recognizes heterogenous aspirations, needs, practices, and values.

Representation: Nancy Fraser (2009) identifies distribution and recognition as "first-order questions of substance." In the domain of agriculture, they include: How do transformations of agricultural productivity affect profits and wages, and whose? How do they affect patterns of land ownership and issues such as land grabbing? What are the effects on local community structures, from capital accumulation to division of labor to migration patterns? What are the effects on culinary cultures and diets? Who is exposed to what kinds of environmental and health hazards? What are the effects on local agrobiodiversity? How do they interact with processes of deforestation and soil erosion? What are the effects on community resilience in the face of disruptive events such as climate change and economic shocks? What are the effects on local relations with ecosystems such as leisure activities and spiritual connections?

Second-order questions of representation address the ways in which these first-order questions are negotiated. In the agricultural context, representation is crucial for two reasons. First, due to the entanglement of various issues of distribution and recognition that make evaluations of first-order questions deeply contested: How to weigh cheaper access to food against increased exposure to environmental hazards? How to weigh benefits for one group of stakeholders (say, the urban poor) against burdens for another group (say, the rural poor)? What is the weight of recognizing cultural dimensions of food sovereignty compared to more straightforward distributive aspects of food security? Second, issues of global justice often involve deep procedural inequality in negotiating these first-order questions. Agricultural development constitutes a prime example as it usually involves a dramatic discrepancy between dominant actors (e.g., corporations, donor countries, nongovernmental organizations [NGOs], scientists) and those who are most profoundly affected by interventions (e.g., Indigenous communities, peasants, urban underclasses). Second-order injustices of representation therefore often feed back into first-order injustices of distribution and recognition, since the former are often shaped by the interests of dominant actors. And even interventions that focus on benefits for marginalized communities can deepen injustices if they are grounded in a paternalistic second-order mode that evaluates first-order issues *for* rather than *with* these communities. For example, an NGO and a local community may have very different priorities in evaluating the complex ramifications of introducing a new cash crop for issues of distribution and recognition.

Expanding the scope of this discussion from first- to second-order questions of justice has important implications for a positive perspective of just science, as it highlights procedural aspects of the interface of science and society. Indeed, these procedural concerns have become increasingly prominent in science governance, reflecting broad shifts toward "transdisciplinary research methods," "participatory action research," and "public engagement" (Ludwig and Boogaard 2021). Especially in development contexts, a wide range of debates about "inclusive development" reflects a reckoning with the paternalistic legacy of the science system that highlights epistemic diversity and the need to codevelop interventions *with* (rather than merely *for*) marginalized groups (Ludwig et al. 2021). Second-order questions of representational justice thus have substantial implications for a positive vision of just science. It is not sufficient to incorporate first-order questions of distribution and recognition into research projects. The science system needs to become more inclusive and responsible in shaping practices together with affected stakeholders (Wittrock et al. 2021).

Fraser's distinction between distribution, recognition, and representation provides a helpful heuristic for engaging with questions of just science.

On the one hand, it provides an angle for critical engagement with contradictions of the science system that often remain invisible in debates about climate change denialism, anti-vaxxers, and other forms of epistemically corrupt anti-science sentiment. While these debates clearly matter, epistemic integrity does not guarantee just science. Beyond this critical attitude, however, an account of just science also provides an entry point for positive visions of the science system that aim to address the contradictions it produces. Scientific research can contribute to a more just distribution of resources, just as it can be shaped by an intercultural recognition of diverse standpoints and create spaces for their representation in scientific practice.

Lovable Science

Polemics aside, there are many important insights in the literature that I have lumped together as the "New Orthodoxy." Yes, the world is facing social-environmental crises that require urgent action. Indeed, science is indispensable for addressing these crises. And yes, this requires challenging anti-intellectualism and anti-science populism as exemplified by climate change denialism and anti-vaxxers. Furthermore, much of the literature of the New Orthodoxy reflects an understandable frustration with the legacy of critique in STS (Latour 2004b), which has often focused on a negative program of challenging scientific authority rather than a positive program of aligning science and society. Against this backdrop, Collins' (2021) plea for loving science can be situated in a wider humanist tradition that recognizes that "the application of the fruits of scientific investigation by reason is crucial to shaping a better, collective future" (see the Introduction to this volume).

There are many reasons to highlight this humanist tradition in the light of global challenges, and it finds a beautiful expression in Collins' call for loving science. Loving science, however, should motivate us to strive for lovable science. And epistemic integrity is not enough. Large parts of the science system are epistemically successful and still play deeply contradictory roles in both addressing and producing social-environmental crises. Science that is deserving of our love demands not only epistemic but also political integrity in confronting its impact on the world. Or, to put it as a slogan, *lovable science is just science*.

Engaging with science through first-order questions of distribution and recognition as well as second-order questions of representation opens spaces for a positive vision of both epistemic and political integrity in science. Realizing a humanist perspective on lovable science therefore demands an equally critical and constructive attitude. Engagement with the contested and sometimes fragile position of science in society is most convincing when showing that a more just science system is possible – that there can be science that is deserving of our love. Historians, philosophers, and sociologists of science have a lot to contribute to developing such positive and disruptive perspectives on the position of science in society. Indeed, such perspectives are a crucial part of the legacy of political philosophy of science from Otto Neurath to W. E. B. du Bois to Paul Feyerabend to Sandra Harding to Paulo Freire. Rather than simply accepting that "critique has run out of steam" (Latour 2004b), however, this requires a constructive reading of critique that diagnoses current contradictions in order to open new directions for a more just interface of science and society.