

RESEARCH ARTICLE

Dismantling agroecology: The coming of the genetically modified cotton-agrochemical complex in an Indian highland frontier

Chitrangada Choudhury^{1,*} 

This article traces the coming of a genetically modified (GM) cotton-agrochemical complex to highland eastern India. In this region of rich biodiversity and Indigenous systems of food and agroecology, GM cotton cultivation has seen a meteoric rise over the past decade. I explore how this shift from a no-input polyculture cultivation of community-held heirloom varieties to market-provisioned cotton seeds and agrochemicals marks a rupture that is fundamentally transforming the relationship of cultivators to land, seeds, and knowledge systems around agroecological practices. I contextualize this ongoing material and knowledge rupture in the specificities of location—both in an agroecological space and in a sociohistorical matrix of caste and region. Thus, what enables or erodes agroecological practices and ways of knowing is not simply the socioeconomic marginalization of smallholder cultivation, but more fundamentally a caste-prejudiced logic in India that, on the one hand, disrupts ecological ties of Indigenous communities to seeds, biodiversity, and land, and on the other denies the contributions of Indigenous knowledge, agriculture, and food cultures toward sustainability and biodiversity. This coming together of an industrial productivist logic with casteist prejudice is what I call casteist capitalism. Casteist capitalism structures both state programs of “tribal development” and agribusiness strategies in the region. Together they work to deride long-standing agroecological practices, and the Indigenous communities which practice them as “backward” and in need of reform toward a modern, commercial agriculture, as represented by chemical-intensive cotton monocropping.

Keywords: Agroecology, Odisha, Indigenous communities, GM cotton, Agrochemicals, Knowledge

Introduction

In the past 2 decades, a focus on agroecology has emerged as a powerful political and intellectual counterpoint to the reigning paradigm of capital-intensive agriculture (Gliessman, 2007; Rosset and Altieri, 2017). It has not only built on older research in political ecology (Guha and Martinez-Alier, 1997) to argue for alternatives to resource-intensive, chemicalized food systems, but also engaged with decolonial, abolitionist and anti-racist movements to highlight the violence, exploitation, and inequity that underlies the global food regime (McMichael, 2014; Montenegro, 2021). Whereas capital-intensive, commodity-trade based agriculture offers the paradox of massive surpluses in a few grains and meats amid wide swathes of hunger and malnutrition¹—the

paradox of “stuffed and starved” in Raj Patel’s (2007) telling metaphor—agroecology calls for culturally appropriate and nutritious food access for all, backed by a just and sustainable agriculture.

In this light, the question of transitioning out of industrial agriculture toward agroecology has attracted impressive and insightful research. This growing body of literature suggests that agroecological interventions can improve soil health, on-farm biodiversity, and household food security and diversity, while emerging evidence also suggests that agroecological interventions can, under certain conditions, improve livelihood outcomes and promote well-being for certain sections of farmers (Saj et al., 2017; Debray et al., 2019; High Level Panel of Experts, 2019; Mbow et al., 2019; Mdee et al., 2019; Bezner Kerr et al., 2021).² As Bezner Kerr et al. (2023) state, “While organic agriculture includes many agroecological practices, agroecology has more transformative approaches to the broader food system, including attention to political, sociocultural dimensions, markets and dietary change.” This has prompted reflections on how such

1. India represents a telling example of this disparity as it combines food grain self-sufficiency, record production, and food exports with being home to over 190 million undernourished people and a quarter of the world’s hungry. Available at <https://www.fao.org/india/fao-in-india/india-at-a-glance/en/>. Accessed January 20, 2024.

¹ Department of Geography, University of Zurich, Zurich, Switzerland

* Corresponding author:
Email: chitrangada.c@gmail.com

² More systematic research is needed into the implications of agroecological farming for the livelihoods and food security of agrarian labor.

transitions can be promoted, legitimized, and enabled (Montenegro and Iles, 2016). As Coe and Coe (2023) argue, “If agroecology is to influence local and global food and agricultural systems in a meaningful way, then many more people—farmers, consumers, policy makers, and others—need to become agroecologists.”

However, a different set of issues confront researchers in the Global South working with smallholder and Indigenous farmers at the expanding frontiers of commodity agriculture, where strong cultural traditions of ecologically appropriate Indigenous foodways still persist. Here the question is not how can we “transition to agroecology,” but rather how do communities steeped in what researchers would today call agroecological knowledge, get schooled and pushed out of it. How are the knowledge systems of ecosystem people (Gadgil, 2023) who practice agroecological principles actively dismantled? What are the processes (Berndt and Boeckler, 2023) and commodities via which Indigenous communities are taught to denigrate their ways of knowing (and by extension, themselves), and asked to valorize capital-intensive agriculture and its markets as more advanced and profitable? What broader structures limit people’s capacity and desire to continue practicing agroecology? In brief, how does the coming of capitalist agriculture erode Indigenous foodways and agroecological ways of knowing and being?

These questions are significant because agroecology is fundamentally premised on a vast diversity of knowledge-rich practices, access to resources including land and heirloom seeds, biodiversity-sustaining cultivation, and farmer sovereignty. As Losada Cubillos et al. (2022) write, “What makes agroecology epistemically distinctive is the emphasis on ancestral knowledge as a blueprint for the pairing of agriculture with the ecosystem and cultural dynamics of the territories.”

In a world where agriculture speedily gets more capitalist and homogenous—as witnessed in the global spread of monocrops (Arya, 2023) and agrochemicals (Hayes and Hansen, 2017; Shattuck, 2021)—these frontier spaces, where Indigenous food systems and noncommodified seeds and accompanying knowledge systems persist, then stand out as critical counter-hegemonic repositories of cultivating and consuming food, and of relating to land and nature. As Bezner Kerr et al. (2022) note, there is limited research in agroecology on intersecting racial and ethnic inequities, as well as on how agroecological systems are embedded in these broader regional sociocultural, political, and economic contexts.

Responding to such calls, I offer a case study of agroecology’s ongoing erasure in the Niyamgiri hills in highlands Odisha in eastern India.³ I focus on Rayagada district,⁴ where I have conducted fieldwork among farmers

and conservationists since 2018, and on which I have reported as a journalist for over a decade. The mineral-rich forested state of Odisha has close to 83% of its people living in rural areas and over 60% of its workforce employed in agriculture and agroforestry. It is routinely portrayed in the media and public policy as one of India’s “least developed” states, and its Adivasi or Indigenous communities, known in official parlance as Scheduled Tribes, as among the country’s “most backward.” Indigenous communities constitute nearly a fourth of Odisha’s population, but are particularly concentrated in the state’s forested highland districts such as Rayagada, where they make up 56% of the population as per India’s last census of 2011.

Odisha’s Indigenous communities are overwhelmingly rural, and deeply marginal in the state’s polity and economy (Mohanty, 2014). In particular, they have been violently excluded from policymaking and development processes around agriculture, forests, and environment (Kumar, 2014; Sarangi et al., 2016; Choudhury and Aga, 2020a). The state is currently at the center of a boom in cotton cultivation fueled by smallholder farmers, and in districts like Rayagada, smallholder Indigenous farmers. I investigate the meteoric rise over the past decade of genetically modified (GM) insect-resistant (Bt) and herbicide-tolerant (HT) cotton cultivation, and along with it, agrochemicals such as glyphosate. Cotton’s spread is coming at the expense of a long-standing low-inputs polycropping of heirloom millets, paddy, pulses, and beans by Indigenous communities, which are critical to household food security and farmer and seed sovereignty in the region.

While hybrid cotton was introduced and promoted by state policy in Odisha in the 1990s with the stated aim to “reform” highland agriculture from subsistence food crops to “remunerative” cash cropping, a more aggressive push of chemical-intensive transgenic cotton in the past decade has come from India’s booming private agribusiness sector. As a result, Bt cotton has now become the second-most cultivated crop in Rayagada district, overtaking millets—the premier traditional food crops of the region. Cotton acreage in the district has risen almost 6 times in 15 years, from 8,605 hectares in 2007 to 45,967 hectares in 2022, as per data from Rayagada’s Department of Agriculture. Significantly, the state government is yet to authorize the cultivation of GM cotton in Odisha. But it takes no steps to regulate its rapid spread on the ground—thus aiding the dismantling of agroecology by enabling private markets for transgenic seeds and chemicals, and agribusiness accumulation.

This unfolding story of chemicalized cotton in these highlands is located in a longer history of state policy in India that has pushed ecologically inappropriate, input-intensive, and debt-inducing monocultures through the Green Revolution paradigm (Ramanjaneyulu, 2015). This long Green Revolution (Patel, 2013), that began in the plains areas of regions already witness to colonial programs of agricultural intensification and commodity production, is in recent decades being rolled out in the highland areas of eastern India. This is within broader calls

3. Some of this field research was carried out with Aniket Aga, with some preliminary reportage jointly published in 2 features in the People’s Archive of Rural India. See Choudhury and Aga (2019) and Aga and Choudhury (2019).

4. This article primarily looks at the spread of chemicalized cotton and undermining of agroecology in Kondh villages in the Niyamgiri foothills of Rayagada. The Kondhs are one of Odisha’s 62 Scheduled Tribe communities.

by the state for a “Second Green Revolution” in states of eastern India such as Odisha, which got “left out” of the country’s first Green Revolution (Ministry of Agriculture, 2015; Pathak et al., 2019). Unlike the first Green Revolution, these calls place the private sector at the forefront.

My research builds on insightful studies of the material and knowledge disruptions entailed by the Green Revolution in the plains (Shiva, 1993; Yapa, 1993; Gupta, 1998; Vasavi, 1999; Deb, 2004). I also argue that the unschooling entailed by the coming of the GM cotton-chemical package to the biodiversity-rich Niyamgiri highlands constitutes a qualitatively different rupture. The stakes are different in such agrarian environments (Agrawal and Sivaramakrishnan, 2000): unlike the settled agriculture of the plain areas with long histories of differentiation, and of an entrenched dependence on the state and companies for seeds and inputs, the Indigenous communities of Niyamgiri have so far sustained an array of heirloom seed varieties by persisting with intergenerational seed saving traditions and sophisticated routines of polyculture through shifting cultivation on rain-fed hill slopes. In essence these communities practice a distinctively agroecological episteme, building on ancestral knowledge around cultivation practices and forest ecosystems.

Seen in its context, the shift to a cotton monoculture is unfolding not just in the choice of cultivated crops, but more fundamentally, in the very ways in which state agencies and agribusinesses push Indigenous farmers to understand and practice agriculture. I argue that what enables or erodes agroecological practices and ways of knowing is not simply the socioeconomic marginalization of these communities but a caste-prejudiced logic in India that, on the one hand, undermines Indigenous cultivators’ ties to seeds, biodiversity, and agroecological knowledge, and on the other, denies the contributions of Indigenous knowledge, agriculture, and food cultures toward sustainability and biodiversity.

This coming together of an industrial productivist logic (Montenegro and Iles, 2016) with caste prejudice (Ilaiah, 2009; Ramdas, 2021) is what I call casteist capitalism. In parallel with Robinson’s (1983) work on racialized capitalism, this signals capitalism working through and rearticulating fundamentally unequal structures of caste (see also Teltumbde, 2018). Casteist capitalism structures both state programs of “tribal development” and agribusiness strategies in the region. Together they work to deride long-standing agroecological practices, and the communities which practice them as “backward” and in need of reform toward a modern, commercial “remunerative” agriculture, as represented by market-purchased cotton seeds and agrochemicals.

Communities too are taking to such cultivation in the hope of making some money. But they are getting folded into the global supply chains of cotton, with virtually no knowledge of these transgenic seeds and agrochemicals, and with great vulnerability to the climate and market risks of this new form of cultivation. As Li (1999) writes in the context of upland Indonesia, while push and pull factors drive smallholder adoption of commodity agriculture, such market-oriented production takes place on

terms that reflect a highly unequal distribution of power. In the context of Rayagada, caste mediates such power asymmetries vis-à-vis both the state and private capital, that is, caste structures the terms on which the state and agribusinesses dominated by forward castes (Jayakumar, 2022; see also Ajit et al., 2012) engage Indigenous cultivators.

The vernacular calculus driving the adoption of cotton here then is similar to that of Dalit farmers in Ramamurthy’s (2011) research, in that it is intelligible in the context of deep socioeconomic marginalization. It is also different in that the calculus entails the loss of agroecological knowledge and sovereignty over resources such as seeds, as I explain further. In linking agroecological ways of knowing with casteist capitalism, this research also contributes to the growing scholarship that reckons with the violence of caste in denying the claims to knowledge of the vast majority of producer communities.

The rest of the article is organized as follows. First, I provide a brief overview of Indigenous foodways in the Niyamgiri region of the eastern highlands. Next, I highlight how cotton was introduced and encouraged among Indigenous farmers, as part of official state policy in the 1990s and 2000s, with agribusinesses now dominating the push toward Bt-HT cotton in this region. Drawing on my field research, I excavate the changing episteme of cultivation by contrasting the perspective of Kunu, a Kondh Adivasi woman farmer steadfastly persisting with agroecological traditions, vis-à-vis that of other Adivasi farmers who are switching over to cotton cultivation. In conclusion, I suggest that the ongoing dismantling of agroecology and the emerging chemically driven agriculture (Werner et al., 2022) in this region should be understood as an extension of the long-standing regime of Indigenous marginalization and ecological dispossession at the hands of a casteist state and capitalist apparatus. Ultimately, contending with the historical and intersectional structures of marginalization that erode farmers’ knowledge frameworks is critical to sustaining agroecology, with particular reference to surviving traditions of Indigenous foodways across the world.

The article draws on field research that I conducted in Rayagada in 7 spells of 2–6 weeks each between 2018 and 2024. I visited the field sites at different points of the year, including in the lockdown months following the COVID-19 pandemic. My principal field sites were villages around the block town of Bishamakatak in Rayagada district, where households were taking to cotton cultivation while not giving up entirely on their Indigenous practices of agroforestry. As part of studying this transition, I spent time with cultivators at different points through the rain-fed farming season (June to December), and especially during the sowing season as they labored on the hill slopes and planted seeds, both market-purchased cotton seeds and of their own food crops. I also interviewed over 30 Indigenous farmers, in connection with their cultivation practices and seed choices. For a deeper insight into agroecological routines, I spent many hours with 6 households over successive field trips, including a household headed by an Indigenous woman who has consciously not taken to cotton cultivation, even as most of her village has.

I also visited seed and agrochemical shops in the Bishamakatak area, and in the wider district. In particular, I repeatedly met a former agriculture extension officer, who doubles up as the main private retailer servicing the Bishamakatak region. I interviewed him regarding his former career in the government promoting cotton, his seeds and chemicals retail business, and also spent time in his shop and observed his interactions with farmers. I similarly interviewed and spent time over multiple visits with a first-time village-level retailer located in the Niyamgiri foothills and selling transgenic cotton seeds and associated agrochemicals to households in the area. I interviewed state officials in Rayagada around government regulation and agrarian change in the district, and discussed and cross-checked my findings with key interlocutors including local conservationists, environmental activists, and civil society groups. As such, while this article primarily chronicles the field research described above, my arguments and insights draw on my larger work in this region as an environmental journalist who has reported on Odisha and India's Indigenous communities, environment, agrarian policies, and developmental dispossession for over a decade. My practical engagements with the land and ecology as a farm volunteer on an agroecological conservation farm in the Niyamgiri foothills for a few weeks every year since 2018 also inform this article. Finally, I have forged longer-term relationships with a smaller number of informants among farmers to track deeper changes that I report in this article, and recently concluded a documentary film on agrarian change in the Niyamgiri (Choudhury, 2024) out of a sense of a broader commitment (Pickerill, 2019), reciprocity and engagement with people in Rayagada and wider audiences (Montenegro et al., 2021).

Niyamgiri as a knowledge frontier

The Niyamgiri hills are part of the Eastern Ghats, an ancient series of mountains running along the length of eastern India. Spread over 250 square kilometers across the Rayagada and Kalahandi districts of south Odisha, the Niyamgiri region marks a frontier—ecologically, culturally, and politically. It has lush deciduous forests, bauxite-capped mountains, and immensely rich biodiversity and wildlife (Tatpati et al., 2016). This landscape is home to Indigenous communities, including the Kondh and Dongaria (literally “Mountain”) Kondh Adivasi communities, with long-standing systems of shifting cultivation and agroforestry. Rayagada district, which is the focus of this article, has close to a million people, and is part of the wider Koraput region of southern Odisha—one of the world's great biodiversity hotspots, and a historical area of rice diversification. To illustrate, a survey of the Central Rice Research Institute over 1955–1959, that is, in the pre-Green Revolution era, showed that the Koraput region had over 1,700 Indigenous rice varieties (Mishra, 2009).

Indigenous communities revere the Niyamgiri range as an integrated landscape, in which their lives, spiritual identities, and multiple resource rights are embedded (Choudhury, 2016). As villagers laid out in landmark anti-mining resolutions to deny consent in 2013 to

a proposed bauxite mine⁵ being pushed by the state for the transnational mining giant Vedanta Resources Limited, the Niyamgiri ecosystem encompasses perennial mountain streams, grazing lands on the plateau, wildlife, as well as vital sacred sites of clan deities including the revered God, Niyam Raja, the “giver of law,” sources of forest foods and marketable produce, and *podu chaas*. The latter refers to hill or upland shifting cultivation of heirloom crops, which, as the ecologist working in the Niyamgiri region Debal Deb explains, have adapted to these ecological niches over centuries (Choudhury, 2024). Indigenous communities supplement their food crops with meats and over a hundred different kinds of uncultivated forest foods harvested through the year including varieties of greens, roots, tubers, wild fruits, and mushrooms (Deb et al., 2014).

Food crops cultivated in the Niyamgiri include a varied basket of millets, pulses, maize, paddy, oil seeds, and beans. The basis of cultivation is noncommodified, heirloom seeds which are not provisioned by the market but saved by households from one season to another and held in the community. Cultivators broadcast heirloom seeds of multiple crops with different durations in order to have successive harvests through the year in a way that enhances food security. These heirloom crops require no chemical inputs to grow, as multiple cultivators told me and as I witnessed. Cultivation practices build on ancestral knowledge and involve continuous attuning to the dynamics of local ecology. They are biodiversity sustaining, and oriented toward provisioning domestic food security, thus showcasing many of the features that are associated with agroecology (Gliessman, 2007; Deb and Shiburaj, 2022). In sum these practices are not a monolithic package that replicates year to year, but instead result from “continuous observation and praxis derived from their closed bonds and connection to their natural realities” (Losada Cubillos et al., 2022). There is no sharp caste-based division between land ownership and landless labor as common in the lowland agrarian plains of India—cultivators here themselves clear the slopes and labor on it. Thus, agroecological systems remain largely manual and draw on household labor.

The broader context of caste bears upon the invisibilizing of Indigenous contributions to food and agriculture, and condemning the millets, tubers, and other foods of Indigenous communities as impure and inferior. Caste is a hierarchical structure which arrays different groups on a sliding scale of status and power (Ambedkar, 1936). It structures different groups' differential access to land, resources, dignity, and claims upon knowledge. Dalits and Indigenous communities are the most severely marginalized by the caste system, but with some key differences. Historically, Indigenous communities,

5. The Niyamgiri range is rich in bauxite—72 million tonnes of the ore lie under the mountains and constitute its distinct ecology of forests, flora, and fauna watered by perennial mountain streams; the surrounding Eastern Ghats tracts contain 1.8 billion tonnes of bauxite. Following the liberalization of the Indian economy since the mid-1980s, these lucrative mineral resources have been at the center of escalating resource conflicts (Damodaran and Padel, 2018).

concentrated in and around forested uplands, have worked with and sustained highly biodiverse ecosystems straddling forests and swidden plots. The richness of this knowledge base, arising from long-standing awareness and fine-tuned engagement with food crops and ecology has enabled a certain amount of autonomy and a rich Indigenous food culture (Ilaiah, 2009; Deb et al., 2014).

In contrast, since colonial times and then in the post-independence period, the state in Odisha—peopled largely by forward caste politicians and bureaucrats (Mohanty, 2014)—has made concerted attempts to “mainstream” and “civilize” the Indigenous communities, who are categorized as “primitive” by government policies and agencies. In the name of developing them, the state has targeted communities such as the Kondhs with programs such as residential schools dispensing education in non-Adivasi languages, monocropping practices of cash crops, eucalyptus plantations, and the promotion of paper mills and extractive industries (Sarangi et al., 2016). Rolling out the Green Revolution paradigm here with an emphasis on hybrid, “high-yielding” varieties of paddy and commodity crops over the region’s rich agrobiodiversity is part of this larger modernizing mission of the state.

Mining has particularly been a long-running flashpoint. Through the past decade, paramilitary camps have come to dot the Niyamgiri region, and combing operations by security forces in the name of maintaining law and order in the villages and mountains are a regular feature. But local communities argue that the state is deploying such powers to suppress movements against land and forest grabs. These much-publicized conflicts (Padhi and Sadangi, 2020) have laid bare the severe power asymmetries that communities are up against, and exemplified the blurred lines between the public sector and private industry, between the elected government and the corporation, when it comes to lucrative resource extraction (Choudhury, 2016). However, a more insidious and pervasive phenomenon of ecological erasure and knowledge displacement is being set in motion with the transformation of the landscape by the swift spread of GM cotton seeds and associated agrochemicals.

Thus, as much as a resource frontier, Niyamgiri also represents an epistemic frontier where agroecological ways of knowing internal to communities are being displaced for chemicalized cash cropping largely serving off-farm state and corporate interests. There is a larger body of literature on frontiers, but for the purpose of this article I limit my use of the concept to the realm of agroecological knowledge which is ruptured by cotton expansion. In other words, while cotton is not spreading through violent enclosures and expropriation of land (Peluso and Lund, 2011), it is fundamentally altering ties to land, seeds, and biodiversity. And it must be reiterated, Indigenous communities have no say in the design of agricultural development frameworks and in agribusiness firms. Corresponding to this, the agroecosystems are themselves a frontier where GM cotton monocultures are slowly overtaking a highly biodiverse landscape.⁶

6. I am grateful to Maywa Montenegro de Wit for this insight.

The GM cotton-agrochemical complex

Cotton in general and GM cotton in particular is a premier political crop (Rauchecker, 2022), that is, an assemblage involving the state, seed companies, farmers, and non-humans (Fischer et al., 2022). Cotton was key to the British imperial textile industry and a commodity of struggle between Indian peasants and the colonial regime. After India won independence from the British Empire in 1947, cotton remained a priority crop for the state, both for the “modernization” of agriculture and the development of the domestic textile industry (Menon and Uzramma, 2017).

Of immediate interest to this article is the case of GM cotton in India. In the late 1990s, some small seed companies smuggled Bt cotton into India. They bred the trait into their proprietary hybrids and released Bt cotton illegally (Shah, 2005; Herring, 2007). The Indian government took some action against the contraband Bt cotton and officially allowed the Indian seeds company Mahyco, which was in a partnership with Monsanto, to release its Bt hybrids in 2002 (Aga, 2021). India’s cotton seed market was valued at US\$800 million in 2024 and around 95% of the cotton crop in India in 2022 came from GM seeds (Mordor Intelligence, 2024a). As with GM soy in Argentina and Brazil, the Indian state retains a strong interest in expanding cotton production, both for exports and to feed the domestic textiles industry (Parija, 2021). The country is already the world’s largest producer of cotton. In 2022, India was the third-largest exporter of raw cotton in the world.

In a parallel and far-reaching phenomenon, India is now the world’s fourth largest producer of agrochemicals. The Indian agrochemicals industry was estimated at US\$8.22 billion in 2024 and is forecasted to grow to US\$13.08 billion by 2029 (Mordor Intelligence, 2024b). The industry’s rapid growth in the past decade has also now made it the world’s second largest exporter of agrochemicals: exports have doubled from US\$2.6 billion in 2017–2018 to US\$5.5 billion in 2022–2023 (Agro Pages, 2023), even as industry bodies envision turning India into a global agrochemical production hub with state support for the sector’s expansion through favorable policies around manufacturing, taxes, and exports.

As patents on chemicals like glyphosate expire, and Chinese private and state-led firms expand in generic manufacturing (Shattuck, 2021), Indian companies have profitably imported active ingredients from China, and manufactured formulations for domestic consumption and export (Pray and Nagarajan, 2014). For example, annual herbicide production in India has almost tripled in the decade between 2005–2006 and 2015–2016, on account of successive liberalization policies and shifts in global production regimes (Das Gupta et al., 2017).

What ties these trends to this research is that nearly half of India’s booming agrochemical production is consumed domestically. Generic pesticides sell at lower price points vis-à-vis those produced by Monsanto and other transnational companies. For example, more than Monsanto’s blockbuster RoundUp, generic herbicides by domestic firms are ubiquitous in agri-inputs shops, including in village-level shops in the Niyamgiri foothills. And

cotton is the most critical crop for the agrochemical industry. It occupies roughly 5% of India's gross cropped area, but consumes 36%–50% of the total quantum of insecticides, herbicides, and fungicides applied nationally (Ranganathan et al., 2018).⁷ The upshot is that with a booming agrochemical sector, companies are looking to expand into new areas, in the process remaking knowledge frontier zones like the Niyamgiri mountains into “chemical geographies” (Romero et al., 2017) via the sale of transgenic cotton seeds and associated chemicals.

Cotton and casteist capitalism

As mentioned earlier, Bt cotton has now become the second-most cultivated crop in Rayagada after paddy, overtaking millets—the premier traditional food crops of the region. This far-reaching change originated through the state's development regime and its discourses of progress that cast Indigenous agroecological systems of the region as primitive which needed to be replaced by modern, commercial agriculture oriented toward economic growth. Here, as in much of the Green Revolution advocacy, “forwardness” gets defined as settled, capital-intensive agriculture of commodity crops (Kumar, 2019; Vasavi, 2020), and knowledge and skills are seen as residing outside Indigenous food systems.

In 1996, Odisha's inaugural State Agriculture Policy set out this new direction, stating, “For the first time in history, the Government has taken the revolutionary step of announcing a bold Agricultural Policy which sets the agenda for growth” (Orissa Reference Annual, 2005). The policy stated the following objectives:

- “(b) To enhance the status of agriculture from the present level of subsistence agriculture to a profitable, commercial venture . . .
- (e) To take the knowledge of modern farming system available to the doorstep of the farmers . . .
- (g) To create entrepreneurship in the field of agriculture
- (h) To create skilled labourers for management of modern agriculture
- (i) To help mechanisation of agriculture for increased productivity . . .
- (q) To re-orient agriculture towards export” (Orissa Reference Annual, 2005).

Cotton arrived in this context, with the 1996 policy setting a target to extend its cultivation to 200,000 hectares across Rayagada and nearby districts within 5 years. The government tasked extension officers with promoting the commodity crop in villages across the district, and created dedicated “Cotton Technician” posts for this purpose. For an insight into the on-the-ground dynamics of promoting cotton, consider the case of the former Cotton Technician Mr Mishra,⁸ who served in Rayagada district's Agriculture Department for 3 decades. He is so deeply identified with cotton promotion in this region that in

conversations with several villagers, I heard many of them refer to him as “Kappa Mishra,” literally Cotton Mishra. Many farmers recalled that “Kappa Mishra” organized training sessions around cotton in their village, told them how to cultivate the crop and crucially, distributed cotton seeds to them for free.

When I first met Mishra one cool monsoon evening in July 2019, he was managing his seeds and agrochemicals shop, KK Traders in Bishamakatak, where he lived. He had taken “voluntary retirement” from government service by then. I spent a few hours at his shop located along a busy state highway and conversed with him in the pauses between different customers. I also had a chance to see him transact many sales that evening and in subsequent visits over 2019–2022.

“It did not come easy, I had to work very hard to get them [Adivasi farmers] to switch to cotton,” Mishra told me about his work as an extension agent. For 30 years, starting in 1987, he worked in the district's agriculture department. He opened the shop in the early 1990s, and had it licensed in his son's name. As a government officer, Mishra pushed villagers to abandon their “backward” agriculture for cotton. Meanwhile his shop sold them commercial seeds and associated agrochemicals. Mishra saw no conflict of interest in these 2 roles, saying, “Government policies introduced cotton as a cash crop for farmers. The crop needed market inputs, so I established a shop.”

Across multiple conversations I had in his shop, I saw villagers dropping in to purchase seeds and chemicals, invariably seeking Mishra's counsel on what to buy, when to sow, how much to spray, and so on. All of them prefaced their questions for Mishra, who is from a Brahmin caste, with the term “*Aagyaan*”—a local honorific denoting the superior social, usually caste, status of the person it is used for. Mishra answered each villager with an air of infallible authority, often looking into the distance with cool detachment while answering their questions, and dismissing their doubts. To illustrate, a young Adivasi farmer came to the shop asking for small pigeon pea seeds. Mishra offered him large sized seeds instead. The farmer weakly insisted on buying the small sized seeds, saying that his wife prefers them. Mishra looked away into the distance and told him, “Tell your wife that Sir is recommending these large seeds.” The farmer finally left with the large sized seeds. Effectively, for farmers, he was the scientific expert, the state extension officer, the government authority and their advisor, all rolled into one. Retailers double up as experts elsewhere too (Aga, 2018; Taylor and Bhasme, 2018; Flachs, 2019), but here the dynamic had a pronounced casteist edge.

One morning in December 2022, Mishra sat down with me at his shop to narrate the history of government promotion of cotton in the region. In his telling, the state government pushed cotton as a cash crop “for the economic benefit of the region's mind-free (sic) Adivasi farmers.” He explained, “Earlier Adivasi villagers were not interested in commercial crops. We started by convincing them to sow 1, 2, 3 lines of cotton within their traditional food crops of small millets and pigeon pea.

7. It is also a crop with an overwhelming correlation to indebtedness and farmer suicides across India (Shah, 2012).

8. Names have been changed to protect identity.

[State] extension was necessary to stuff a new thing in their minds. Because they are all illiterate people. Mind-free (sic). Whatever you fill in their mind, that will get set.”

While traditional Indigenous systems of multicropping are knowledge and labor-intensive, officials like Mishra channelized the new state policies which disparaged the Kondh agroforestry systems as spawning idle, unproductive subjects. He added, “Villagers used to sit idle at home. But when we introduced the cotton crop, they got many benefits. In cotton cultivation, the labor component is greater. So the entire family, which was earlier sitting idle, got engaged. [That’s how] in commercial cultivation, they got a good return.”

The forward caste Mishra and the agriculture department he served thus overlooked the sophisticated, biodiverse traditions of agroforestry prevalent in the region. For the state, expertise resided in its policies and extension officers like Mishra, whose job was to imbibe in “mind-free” Adivasis the virtues of commercial cotton cultivation with market-purchased seeds. Mishra concluded by telling me, “As a cash crop, cotton has now got well established in this region. When I started my work, there were hardly a few acres. But now cotton has spread here over thousands of acres.”

While state policies and key figures like Mishra helped inaugurate the cotton crop in Rayagada through the late 1990s and 2000s, a more aggressive push for chemicalized cotton monocropping has come in recent years from private agribusiness. Almost all the seeds and chemicals circulating in Rayagada come from companies located in states with capital-intensive commercial agriculture, such as Maharashtra, Gujarat, and Andhra Pradesh.⁹ For example, Andhra Pradesh, which adjoins Rayagada, has not just seen intensive GM cotton cultivation over the past 2 decades, but it is also a hub of large and small seed companies (Stone, 2007; Flachs, 2019). These agribusiness manufacturers and retailers belong to higher castes, while their clientele in Rayagada is largely Adivasi farmers. Further, with public policy controversies around farm suicides and indebtedness in cotton-growing states triggering state programs to reduce or eliminate pesticide use (e.g., the Andhra Pradesh state government’s Zero Budget Natural Farming program), agribusinesses have begun penetrating upland regions.

The state facilitates the emergence of these lucrative markets by continuing to advocate for cotton cultivation, most recently under a program it ironically calls “Diversification of Cropping Patterns”—“a concept aimed at diverting the highland less remunerative crops to more remunerative crops and plantation crops.” Another district agriculture document from 2023 advises farmers “to grow remunerative non-paddy crops particularly cotton to

overcome moisture stress.” This is a particularly inappropriate prescription given transgenic cotton cultivation is expensive and unsuited to the unirrigated rocky uplands (Kranthi, 2012; see also Karamchedu, 2023) and susceptible to climate risks such as delayed and unseasonal rain, as has been witnessed in Rayagada in recent years. As mentioned earlier, Bt cotton seeds are not authorized for release in the state of Odisha and yet their cultivation is widespread on the ground. During an interview in October 2020, an officer in the district agricultural office told me, “About 99.9 per cent of the cotton in Rayagada today is Bt cotton—non-Bt seeds are just not available.”¹⁰

There are no data being gathered by the agriculture department around agrochemical usage, but my fieldwork in the district indicates that the use of such inputs, in particular herbicides like glyphosate and glufosinate, is rapidly spreading. I routinely saw bare-bodied farmers spraying these toxic chemicals with bare hands—protective gear is completely absent in this landscape as are state or business-led trainings on safe use. Warnings and directions on packets and bottles are unintelligible to Kondh villagers since they feature in languages such as in English, and those of other states, such as Gujarati and Marathi, where most of the companies are located. I also found used glyphosate bottles lying alongside mountainside streams and around village handpumps, hanging from trees, scattered on the borders of farms, and even being recycled by unsuspecting farmers as containers to carry their drinking water or to harvest and sip local brew. Farmers assured me that they had rinsed the bottles before recycling them for such domestic uses. In the sowing season of July 2022, another official in Rayagada’s Agriculture Department told me, “Everyone is spraying glyphosate now. It is impossible to stop it.”

Herbicides as a subset of agrochemicals are particularly disruptive for traditionally polycropping routines—when cultivators start intercropping HT cotton seeds with their traditional seeds, the latter cannot withstand herbicide applications and end up dying. It is the obverse of developments in Mexico, where a presidential decree to substitute glyphosate encourages agroecology (Toledo and Argueta, 2024). This rapid expansion of herbicide use for cotton is taking place even as the Odisha government has introduced restrictions on the sale and use of glyphosate, and India is yet to clear the cultivation of HT cotton seeds.

The implications of this patchwork of contradictory policies are that the state encourages cotton cultivation but leaves the provisioning of seeds and agrochemicals to the private sector. The state proscribes transgenic cotton and glyphosate but does not enforce this policy. This has allowed agribusinesses a free hand to court Indigenous clientele in Rayagada. As an illustration, in 2021 there were 2,829 private input retailers in Odisha, as opposed to just 141 state-run points of sale (Indiastat, 2021), and

9. This southern Indian state which borders Rayagada, saw over 33,000 suicides by farmers between 1995 and 2011, and remains among the top 5 states in India where farmers are resorting to suicides to escape debt and distress over the past 2 decades. As Shah (2012) notes, many of these farmers have been GM cotton farmers.

10. A 2016 Ministry of Agriculture “cotton status” report in fact shows figures for Bt cotton in Odisha year upon year as “nil” suggesting that governments would rather not acknowledge its existence.

official data significantly underestimate the number of private retailers because it does not include the large number of unlicensed retailers who dot the rural landscape. On the other side, Indigenous buyers of seeds and chemicals directly feed agribusiness sales and profits.

Undermining agroecological ways of knowing New cotton farmers

Transgenic cotton seeds and associated chemical technologies are transforming farmers' relationship with seeds and agroecological practices, producing epistemic breaks along the axes of seeds and cultivation practices. Consider the case of Ramnath, a Kondh cultivator from a village in the Niyamgiri foothills. I first met him in the monsoon season of 2019 as he was walking back from a village grocery shop started by another young Kondh Adivasi man, who had recently begun stocking cotton seed packets and associated agrochemicals including herbicides and fungicides. Ramnath held 3 packets of seeds, 2 of one brand and one of another, which he had just purchased on credit for 1,000 rupees each (roughly US\$12). By way of perspective, the daily wage rate for farm labor here ranges from 250 to 350 rupees (US\$3–5), and the official mandated price ceiling for cotton seeds was 730 rupees (roughly US\$8) per packet.

One of the glossy pink seed packets in Ramnath's hands displayed a bouquet of 2,000 rupee notes and a caption emblazoned "Prosperous Farmer, Strong Farming." None of the packets displayed a printed price, dates of manufacturing, and expiry or other statutory information about purity and germination rates. They featured a large red "X" overlaid on an image of a bollworm, but the packets were not labeled per se as containing Bt seeds. They were also not labeled as HT seeds, but Ramnath told me that they could be sprayed with "*ghaasa maraa*" (literally grass killer) or glyphosate because the shopkeeper had told him so.

When I asked Ramnath how did he decide which seeds to purchase, and in particular why had he purchased 2 packets of one brand and 1 packet of the other, he shrugged and responded that it was a strategy to mitigate risk given he could not know what kind of harvest the seeds would give. "Maybe one will grow big and one will not. Or maybe it will not grow at all. That is why we have to buy like this." Surendra, another farmer in the village, told me that they relied entirely on shopkeepers to tell them what to buy. "We go to the shop and say 'Aagyaan (Sir), please give us some seeds.'" He mused, "If they come up well, it is okay. Otherwise, all our money and labour goes to waste." This uncertainty, and the consequent vulnerability, is similar to that observed among cotton farmers by Glenn Stone (2007) in the adjacent state of (undivided) Andhra Pradesh. The proliferation of new brands offered pseudo choices that might do little to mitigate actual risk (see also Stone et al., 2014).

Through 2019–2022, I encountered several cultivators who had abandoned their food crops to shift to market-purchased cotton seeds, as well as those who were sowing such seeds for the first time in their lives. Among the latter was Sabi, a Kondh Adivasi cultivator in her 40s,

whom I saw one morning, sowing the dark pink, poisoned cotton seeds on a hill slope in her village near Bishamakatak. The penetration of cotton into long-standing shifting cultivation practices was striking, and I asked her about how she had come to make this switch. Sabi laughed uncertainly and told me, "Everyone is doing it. So we are too. Everyone is leaving *mandia* (millets) and going after cotton in the hope of making money." Sabi told me that she was sowing only market-purchased cotton seeds that season and had not planted a single of her heirloom food crops of millets, pulses, and beans as had thus far been her practice every year. Seed companies too sell the promise of cotton cultivation as equaling money, with seductive marketing such as images of bundles of large denomination notes on seed packets, and names like "Money-maker" and "*Moksha* (Salvation)."

Like every cotton farmer I spoke to over 2019–2022 in Rayagada, Ramnath, and Sabi were unaware that HT seeds are not officially cleared for sale in India, and that there are restrictions on glyphosate. They also did not know that companies cannot sell un-labeled seeds and that there are state-mandated price caps. Given that none of the information on the seed packets, agrochemical bottles, and cartons was in the Kondh Adivasi language of Kui, let alone the state language of Odia, farmers here had no way to access or question the claims manufacturers and retailers were making.

"We are illiterate people. That is why we do not know much about these seeds and how to grow them, and we have to ask the shopkeeper for everything," Ramnath explained. In contrast, when I asked him who told villagers how to plant their traditional food crops, Ramnath broke into an amused smile and retorted, "Those are our own seeds. Why will anyone else tell us how to grow them!?" Ramnath's statement about Kondh farmers like him being "illiterate people" tellingly illustrates how official and agribusiness-driven narratives that "backward" Indigenous communities do not possess knowledge and need to be schooled into a superior way of farming by adopting external seeds and agrochemicals, had powerfully seeped into self-perceptions.

What the farmers do know is that market-purchased transgenic cotton seeds are unlike anything they have planted before—in terms of the capital investments they require, the steady infusions of chemicals they demand through the cultivation cycle and the uncertain outcomes they yield in terms of production and income. Pirikaka, a villager, said, "With our seeds such as *mandia* (millet), you just broadcast them and they come up and give a harvest. But with these cotton seeds, the way one takes care of a child, one has to constantly take care of the cotton plants." By "care," the farmers meant feeding the cotton plants a steady diet of agrochemicals that they had to purchase from the market. Ramnath said, "Each of these seed packets requires a further expense of 10,000 rupees (roughly US\$125). Only if you can spend that much on herbicides, fertilizers, vitamins and pesticides, will the cotton plant grow and flower. Otherwise it will not."

Because of the uncertain nature of the cotton harvest outcome and the expenses that had to be incurred

through the growing season on inputs—both new experiences for cultivators—none of them could state just how remunerative growing cotton was. Surendra, who spoke to me while his family planted cotton on a recently cleared hillside in July 2022 instead asserted that farmers “do not get a rupee of profit from cotton cultivation.”

Surendra and his family cultivate the hill slopes during the monsoon season, and he works as a footloose daily wage laborer on construction sites, brick kilns, and small factories in the towns and cities of other states like Andhra Pradesh and Kerala for the rest of the year. Such migrant laborers have few legal or institutional protections and are often overworked and underpaid (Choudhury and Aga, 2020b). Yet, Surendra told me that he found daily wage work as a footloose laborer more secure economically than cotton cultivation. “There, at least I know that when I work, I will earn 300 or 400 rupees (US\$4–5) a day. Here we can labor for a season and yet end up with nothing because all the work we did was for our own household.” Accounts of self-exploitation of household labor and risk by multiple farmers thus complicated the sanguine picture advanced by the state and agribusinesses on how cotton signals economic prosperity for Indigenous farmers.

At the same time, it is important to note that despite deep insecurity and confusion around the seeds, and uncertainty about cultivation practices and crop yields, the prospect of and need for cash earnings are drawing farmers across the district away from their traditional food crops to the risky project of cotton cultivation. In the words of Surendra, “You might get a bundle of notes (money) in one go during harvest season. That is why farmers like cotton a little.” Every farmer I spoke to mentioned the prospect of making cash, and in one go as a key reason to adopt cotton seeds, especially when they had seen others in the area do so, and get money.

Millets, paddy, oilseeds, lentils, and other traditional crops of this region enable food sovereignty but not “a bundle of cash in one go” as transgenic cotton might. As public investments including in agriculture, health, and education decline, the rising costs of private schooling and health care as well as new aspirations of consumption such as mobile phones, a satellite television connection, or a motorcycle are increasing farmers’ requirements and desire for money. “If we grow this cotton, we might make some money which we will need next year for my son’s fees in a private English-medium school,” a Dalit farmer told me in the monsoon season of 2019 as he and his Kondh wife and two children were hard at work sowing cotton seeds on a slope in the foothills of Niyamgiri.

Agroecological farmers

The insecurity, helplessness, and total dependence on retailers for information and advice on cotton cultivation is not unique to Rayagada. But the phenomena, no doubt pushed by official targets to expand cotton cultivation, are particularly poignant and jarring here given the sharp rupture chemical-laden cotton monocropping brings to the long history of skilled, biodiversity-enhancing

agroforestry and mixed cropping that has been practiced by generations of Adivasi farmers.

Consider Kunu, a Kondh Adivasi farmer in her 40s and among the few shifting cultivators in her village in the Niyamgiri who have resisted switching to cotton. I first met her in the monsoon season of 2019, as she was hard at work on a patch of land on a hill slope, manually weeding the soil and clearing small stones in order to sow heirloom seeds of beans and millets, which she had conserved from her previous year’s harvest. When I visited her home later in the week, she became visibly excited about showing the heirloom seeds that she saves and grows, year upon year. She raced into her house and emerged with seeds of different varieties, which she had stored in bamboo baskets, cloth bundles, plastic jars, or strung in bunches from wooden rafters of the roof. She first showed 2 varieties of pigeon pea, “to be sown depending on the incline of the land.” This was followed by an upland variety of paddy which did not require irrigation. She also had seeds of maize, niger seeds, mustard seeds, green gram, black gram, and 2 types of finger millets and of beans. Her collection of seeds also included *siali*—a forest food, few of which she roasted on the spot. She said, “If it rains too much, and we have to stay home-bound, we roast these and eat them.”

Kunu, who cultivates on mountain slopes, does not rely on external agents such as government officials or seed and agrochemical retailers for inputs and know-how. Her swidden practices are labor intensive (e.g., she manually weeds, and does not use any fossil fuel-powered implements), and also knowledge-intensive—she decides what food crops to sow when and where, and retains control over resources such as seeds. She said, “My in-laws were growing these seeds before us, and now we are continuing it. This is what we have cultivated every year. A little bit of this, and a little bit of that, a little bit of everything—that is how we do our agriculture.”

Farmers like Kunu, increasingly a minority in Rayagada, have a markedly different understanding of how they do agriculture from those growing cotton. They see their agroforestry practices as something that sustains them in meaningful ways. They do not just possess an intimate knowledge of a wide variety of seeds and of how to sustain them year upon year and work with them, but also display a fondness and even love for the seeds, and the act of growing and harvesting them.

As another agroecological farmer in the village Jagat, roughly in his 60s, told me while walking me through his mountainside plot of mixed cropping one rain-soaked morning in 2021, “Coming here to the mountain every morning, and seeing all these crops growing—even though it is not harvest time yet, one gets so much *ananda* (bliss) from seeing them.” Such ties of place and affect to agroecological practices and Indigenous food systems recall Neera Singh’s (2013) insightful work on community forest protection practices in Odisha, where she writes, “Villagers’ daily practices of caring for and regenerating degraded forests in Odisha can be seen as affective labour in which mind and body, reason and passion, intellect and feeling are employed together.”

Kunu explained why she resisted switching to market-purchased cotton seeds: “Do we not have our own seeds that we will go to the market to buy them? And if we abandon our own crops, how will we replenish them?” She also highlighted the capital-intensive and risky nature of cotton cultivation, pointing out that her own seeds required no inputs. “But how much pesticides, fertilizers and herbicides we will have to spray that cotton with. And who can even say whether it will come up or not?”

“One different crop after another, our aim is to harvest them in succession through the year,” Jagat told me. As stated earlier, this foundational characteristic of Indigenous food systems, that is, polycropping is not possible when farmers take to HT cotton and herbicides. Rupa, a Kondh woman farmer, told me she had intercropped cotton with her own seeds of pulses but all of the latter died after she had sprayed her land with herbicide. “Only a few remained in a patch on the farm where I had manually removed the grass.”

Further with increasing application of herbicides and other agrochemicals, local soils, and ecosystems get impacted (Hayes and Hansen, 2017). While this phenomenon is yet to be studied systematically in the Rayagada and wider Koraput region, many farmers told me that when they tried to plant their own seeds such as millets on the land on which they had sown chemical-intensive cotton, the crop turned out stunted, assailed by unwanted grasses and did not give a good harvest. For example, Rupa stated that she had sown her traditional millet seeds where she had grown cotton in previous years but the former did not ripen well. “It does not come up as it would. So I am not cultivating them anymore,” she said (see also Kannuri and Jadhav, 2018).

In 2021, when there was unseasonal rain at the end of December (the monsoon season runs from June to September), I found cultivators who had sown transgenic cotton in anguish over their standing cotton pods getting soaked and blackened by the showers, and the economic losses they were going to suffer when they would have to sell this damaged cotton in some weeks. In contrast, when I met Kunu, she was self-assured as her millet crop had only lodged. “We can still harvest and eat it, the crop has only lodged, it has not got spoilt,” she said. As the climate crisis intensifies erratic weather patterns, cotton monocropping represents greater risk and less resilience than the diverse cropping and agroecological food systems which it is replacing.

Dismantling agroecology

The state, dominated by forward caste groups, cleared the ground for the introduction of cotton into the polycropping routines of Indigenous communities, and private agribusinesses are reaping the fruits. When figures like Mishra point out that communities in the region were not interested in commercial crops and an economic mindset (Coe and Coe, 2023) had to be created by the state by giving free cotton seeds and inputs and setting official targets of cash crop acreage, this also meant actively undermining the ecological mindsets which had for long nurtured Indigenous agroforestry and food systems. In its

latest iteration, farmers are now buying and sowing store-purchased GM seeds and spraying their plots and crops with agrochemicals, thus entering global supply chains of cotton on profoundly unequal terms that articulate with older caste hierarchies.

The spread of the GM cotton-agrochemical complex is an outcome of the working of casteist capitalism. Officials-turned-retailers like Mishra confuse neat binaries of state and private enterprise, but in caste terms, the division is clear. And for Kondh farmers, the state-private capital distinction is largely meaningless—Mishra is the dominating face of both. It is not coincidental that private firms too are dominated by forward castes and reflect the casteist hierarchy of knowledge. Both state policy and agribusinesses share the prejudice of Indigenous “backwardness” and refuse to recognize that there could be anything of value or expertise in the traditional agroecological systems of these communities. And as the activist-social scientist Balagopal (1990) wrote, the caste system propagates a “most undemocratic definition of knowledge that dismisses as not worth knowing all that the working people know by the very nature of the work they do . . . which is the basis of reproduction of society’s material life.”

The ecologist Debal Deb points out that the areas India’s policymakers and economic and caste elites categorize as backward are precisely where a vast amount of biodiversity survives (Choudhury, 2014). This recognition of knowledge systems is virtually absent in state policies and corporate business plans, which reflect a casteist and productivist epistemology. This blindness that marks privileged caste Indians, whether in the state or in agribusinesses, and that serves to marginalize Indigenous farmers, is a critical constituent of casteist capitalism.

In switching to cotton, Indigenous farmers have no recourse to the depth of intergenerational knowledge across polycropping, seed saving, and cultivation practices. By transitioning from agroecology into cotton monocropping, cultivators like Ramnath, Sabi, and Rupa thus get alienated from their own knowledge systems, biodiversity, and ties of place and affect (see also Araya, 2023). And the more farmers abandon heirloom seeds and long-standing agroecological practices for chemical-intensive cotton, the more they end up relying on what Stone (2016) calls “didactic knowledge,” that is, knowledge promoted by agents external to farming communities and aligned to off-farm interests. Decisions about what seeds to plant and how to raise these crops move out of farmers’ hands to market-oriented prescriptions (Vasavi, 1999). I would add the caveat that the off-farm interests in this research are overwhelmingly forward-caste interests.

And switching back or away from capital-intensive monocropping to agroecological routines is difficult. Once a farmer gets onto the cotton-pesticide treadmill (Stone and Flachs, 2018), it is hard to reclaim access to older, heirloom seeds and material-epistemic resources, as farmers like Kunu warn. For one, as community resources such as heirloom seeds get abandoned on a large scale, it is nearly impossible to retrieve them. Second, the erosion of knowledge ensures that subsequent generations of farmers lose the know-how of cultivating heirloom varieties,

even if somehow, they were able to access such seeds. Indeed, this phenomenon has already taken place in India's states of "advanced" agriculture such as Andhra Pradesh, Telangana, Maharashtra, and Punjab (Vasavi, 1999, 2012). Finally, the soil and land too get transformed by the cotton-agrochemical complex and farmers say they find it hard to grow their heirloom seeds there. It is striking to note that despite the Odisha state government launching a Millet Mission in 2016 to belatedly advocate for millets cultivation, official data show that in Rayagada district, the area under millets has fallen from 42,582 hectares in 2010 to 18,485 hectares in 2020.

In brief, agroecological knowledge resides with farming communities. It renews and regenerates itself through situated practices of farming with heirloom varieties, in interaction with a dynamic environment (Deb, 2016). Pushing cotton destabilizes agroecology by both undermining Indigenous ways of knowing and the biodiversity which shapes them and is shaped by them. Kondh farmers adopt cotton with legitimate aspirations for socioeconomic mobility, but casteist capitalism engages them on an unequal terrain, entailing their deskilling (Stone, 2007) and transformation into cogs in the supply chains for corporate seeds and agrochemicals (Bair and Werner, 2011). Again, not coincidentally, the promotion of cotton begins from a prejudice of Indigenous ignorance and ends up creating the very conditions of deskilling and dependence on markets and states for "knowledge."

Conclusion

Bt and HT cotton's swift expansion through Rayagada is reshaping a geography and a people, thus far steeped in agroecological knowledge and practices. This is a frontier both in terms of knowledge and agroecosystems, where the promotion of cotton is necessarily at the expense of, and premised on, dismantling agroecology. Thus, the spread of chemicalized cotton through the Niyamgiri highlands is setting in motion logics of industrial extractivism, adversely integrating Kondh cultivators into the global cotton supply chain. Such logics are not of outright land enclosures and takeover but constitute a less dramatic and yet equally if not more far reaching and pervasive extraction of biodiversity, seeds, soil fertility, and knowledge. The ongoing erasure of agroecology in the Niyamgiri highlands is thus cognitive, material, and ecological. For these reasons, the adoption of chemicalized cotton represents a profound shift from a knowledge-rich food cultivation powered by ties of place and affective labor to a deskilled farming that is rife with economic risk, and which serves off-farm accumulation by forward-caste interests cutting across the state and corporate capital.

Against development strategies of commercial agriculture backed by state power and apparatus, and agribusiness strategies aimed at expanding markets by homogenizing agrarian landscapes for their products, there is then little to meaningfully support the fast-disappearing ranks of agroecological cultivators who retain their own seeds and practice low-input multicropping, and the contributions their knowledge makes to preserving genetic resources, biodiversity, and enhancing

sustainability. This even as research indicates that the world's remaining biodiversity survives in such landscapes, and that traditional ecological knowledge and strategies of empowering communities will be key to preventing further erasure (Sobrevila, 2008; Rights and Resources Initiative, 2020; Imoro et al., 2021).

For these reasons it is vital to not just find ways to transition to agroecology but to also arrest its undermining in the landscapes where it has continued to survive so far. As a constructive program, we need research into sociocultural and political transformations that will reinvigorate the skills, knowledge systems, dignity, and livelihoods of Indigenous agroecological farmers. Particularly, in the global South, there is a strong case for agroecology movements to join hands with and work alongside broader Indigenous movements for resource rights, food sovereignty, and inclusive development. Efforts to make agroecology a viable, global alternative cannot be divorced from wider movements for social and environmental justice, which resist the dominance of casteist and racialized capitalism, the state agendas that back it, and the resource concentration and knowledge dispossession that this denotes (see also Ramdas and Pimbert, 2024). In this light, ongoing movements for social and environmental justice; Indigenous land, forest, and water rights; and more broadly, movements against dispossession by mining, plantations, and forest logging acquire even more urgency.

Data accessibility statement

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Knowledge Domain: Sustainability Transitions

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