Earth System Governance 12 (2022) 100137

Contents lists available at ScienceDirect

Earth System Governance

journal homepage: www.sciencedirect.com/journal/earth-system-governance

Arrays and algorithms: Emerging regimes of dispossession at the frontiers of agrarian technological governance

Ryan Stock [a], Maaz Gardezi [b,*]

[a] Northern Michigan University, Department of Earth, Environmental and Geographical Sciences, 1401 Presque Isle Ave, Marquette, MI, 49855, United States
[b] Virginia Tech, Department of Sociology, 518 McBryde Hall, 225 Stanger Street, Blacksburg, VA, 24061, United States

A R T I C L E I N F O

Keywords:
Precision agriculture
Big data
Solar
Governance
Regimes of dispossession

A B S T R A C T

Emerging technologies in food and energy systems present unique problems of resource governance. Here, we present distinct case studies to examine two emerging technologies in energy and food systems; solar parks in India and precision agriculture technologies in the US. We ask the following question: How do existing modes of governance of new and emerging technologies create physical and virtual dispossessionary enclosures for rural producers? We argue that emerging technologies for sustainability in energy and food systems present unique problems of resource governance, insofar as the neoliberal state enables energy and agritech firm hegemony at the expense of local producers. Albeit unevenly, such technological interventions have brought some social and environmental benefits to people and the environment. However, we contend that the constellation of institutions, policies and regulatory approaches that govern these technologies in agrarian spaces constitute regimes of dispossession—socially and historically specific political apparatuses for coercively redistributing resources.

1. Introduction

Responding to accelerating earth system transformations and their potentially disruptive societal consequences requires a fundamental shift in our understanding of the complex interactions between new and emerging technologies, environment, and policy. Anthropogenic climate change poses place-specific risks to social and ecological systems globally, albeit highly variegated as vulnerability is mediated by one's positionality within the political economy and multiple and intersecting social identities (Sultana, 2014; Rao et al., 2019; Djoudi et al., 2016; Kaijser and Kronsell, 2014). For many earth system governance researchers, "inequality is the seed, driver and consequence of unjust social and ecological systems" (Burch et al., 2019: 5). This is especially true in rural spaces, where climate-driven hazards interact with capital-intensive food production systems and have unevenly transformed agrarian relations of production. Aspiring to the essential and existential task of reducing global greenhouse gas emissions to cap surface temperature warming to 1.5°C by 2030 to stave off irreversible damage to planetary systems—while prioritizing sustainable and equitable agrarian transformations—will require innovations not only in science and technology, but will also require an unprecedented bricolage of policies and interventions emergent from multiple scales of governance (IPCC, 2018). Essentially, this means identifying how emerging technologies and their uses are currently governed in agrarian spaces, by whom, and to what ends.

New and emerging technologies, such as solar energy systems and precision agriculture technologies, can facilitate mitigation, adaptation and resiliency against the climate crisis for human and non-human species. For instance, solar energy systems are reducing the reliance on declining reserves of fossil fuels and mitigating emissions-related negative health outcomes. Precision agriculture technologies, through big data, robotics, artificial intelligence (AI) and machine learning algorithms, have the potential to produce more food, fuel, and fiber with a reduced ecological footprint. However, new and emerging technologies for sustainability in food and energy systems present unique problems of resource governance, with little historical precedent for the equitable distribution of burdens and benefits among differently positioned rural actors. New and emerging solutions to climate change, such as solar energy and precision agriculture, are largely technical in nature. By implementing technical fixes, institutions can obscure the political causality of the problem and avoid directly addressing the disproportionate precarity of particular populations (Watts and Bohle, 2015;

* Corresponding author.
E-mail addresses: rystock@nmu.edu (R. Stock), maaz@vt.edu (M. Gardezi).

https://doi.org/10.1016/j.esg.2022.100137
Received 30 April 2021; Received in revised form 2 March 2022; Accepted 5 March 2022
Available online 13 March 2022
2589-8116/

Ribot, 2014; Taylor, 2014; Nightingale et al., 2019). Although recent work has importantly explored how social and ecological vulnerabilities are produced by the interactions between climate change, structural inequality and power imbalances (Gupta et al., 2015), less is known about the processes by which inequality becomes embedded in complex interactions of governance of new and emerging technologies, within highly variable and unpredictable natural systems.

Here, we present two cases to showcase how emerging technologies in energy and agriculture transform agrarian political economies and reproduce existing forms of social hierarchization through capital accumulation and labor reconfigurations. Specifically, we argue that these emerging technologies can dispossess producers of land and livelihoods and give rise to new governance challenges. Drawing from literature in political ecology, critical agrarian studies and environmental sociology, we ask the following research question: *How do existing modes of governance of new and emerging technologies create physical and virtual dispossessionary enclosures for rural producers?*

In this paper, we profile two case studies—1) solar parks in India; 2) precision agriculture in the USA—that elucidate distinct regimes of dispossession in heterogeneous agrarian geographical settings to identify relevant parallels that support the overall argument of the article. Discursively articulated as sustainable solutions to climate-driven agrarian crises, both of these capital-intensive technological interventions pose new challenges for environmental governance. This paper proceeds in 5 additional sections. In section 2, we outline the theoretical basis and conceptual framework which informs our research and its relevance to governance of emerging technologies for sustainability. In section 3, we discuss the methods by which primary data was collected for each case study and briefly describe each study area. Section 4 presents the results of the two case studies—solar park in India, precision agriculture in USA—that illustrate governance challenges associated with new and emerging technologies and their disparate and dispossessive impacts across adjacent communities and user groups. In section 5, we put the case studies in conversation with each other, contrasting the regimes of dispossession and their temporal and legal geographies. We conclude this paper in section 6 with a reflection on research findings that illustrate the necessity of new policies and regulations to govern these increasingly ubiquitous yet under-regulated climate interventions and land-use transformations.

2. Crisis as opportunity: climate discourses prefigure dispossession and influence intervention governance

2.1. Constructing the climate crisis

Agrarian spaces and livelihoods are commonly represented through discursive formations that prefigure their erasure. Ostensibly, small towns are dying and “the future is cities” (Harriss-White, 2008; Karagianis, 2014). Cornucopian urban imaginaries of sustainability intelligentsia suggest a ‘smart’ future of abundance, opportunity, modernity and innovation (De Jong et al., 2015; White, 2016). In contrast, rural places are refracted through frontier discourses that foreground their economic possibility for external entrepreneurs against the backdrop of desolate, depopulated and degraded terrains—wastelands inhabited by wastrels (Baka, 2017). Rural people are pitied for withstanding “… the harsh reality of living in, and sometimes having to leave, a small town with few job prospects or a failing family farm” (Harris and Tarchak, 2018). These dialectical and mutually constitutive discursive representations—urban utopias versus rural dystopias—are spatial imaginaries (Wolford, 2004). As such, they facilitate an uneven politics around the production of spaces rural and urban (Lefebvre, 1991).

Spatial imaginaries are powerful discursive mechanisms for rationalizing and realizing the transformation of human-environment relations. This often emerges from and is formulated through agendas of ecological modernization (Deutz, 2014), defined as “the discourse that recognizes the structural character of the environmental problematique but nonetheless assumes that existing political, economic, and social institutions can internalize the care for the environment” (Hajer, 1995: 25). Situated in the milieu of concomitant crises (e.g. agrarian, climate), influential actors and institutions view the countryside as a laboratory for technological interventions teleologically elaborated to solve wicked problems—socio-technical imaginaries of sustainable futures (Jasanoff and Kim, 2015). Antipolitical sustainable imaginaries discursively render certain technologies and infrastructures as necessary and ‘modern’ interventions for maintaining or restoring the global or regional ‘public good.’ For example, the government of India frames solar parks as inevitable solutions to climate change and energy poverty: “Today, when the energy sources and excesses of our industrial age have put our planet in peril, the world must turn to Sun to power our future” (Modi, 2015). Likewise, Syngenta (2017) promotes its precision agriculture technologies as the solution to future food insecurity: “By the year 2050, U.S. growers will need to reach an impressive level of food production to help feed a growing world population. Fewer in number, they will operate multifaceted businesses with stunning new technology to increase efficiency on farms.” Such cases present us with a politics of knowledge, insofar as the sustainable socio-technical imaginaries of non-local authorities or industry experts are disproportionately privileged in influencing policymaking and project implementation than the imagined futures of local populations.

Technological initiatives to ‘modernize’ rural ecologies are perceived as urgent, essential and inevitable if refracted through crisis discourses. “Calamities only become a political issue if they are constituted as such in environmental discourse” (Hajer, 1995: 20–21). Crisis discourses help justify the mobilization of political and ideological forces that ensure specific responses and outcomes to the problem (Roitman, 2013). Agrarian crises are overdetermined by numerous social, political and ecological phenomena. The uneven integration of food production systems into an increasingly global neoliberal marketplace has, in many instances, (re)produced social vulnerabilities for historically marginalized agrarian populations (McMichael, 2009). India’s agrarian crises are overdetermined by (inter alia) transformations in the political economy of agriculture that favor commercial crops for export (Flachs, 2016; McMichael, 2012), predatory lending and pernicious debt relations (Taylor, 2013; Ramprasad, 2019), volatile market conditions likely to worsen with recent agricultural reforms (Shankar, 2021) and asymmetrical local social power relations heightened by an ascendant rightwing politics of casteism and religious nationalism that disempowers marginalized farmers (Sud, 2020; Gidwani, 2008; see also Reddy and Mishra, 2010). Rural USA is also undergoing a radical social and demographic transformation. Many small towns and rural communities are experiencing shrinking populations, an exodus of younger people, an aging populace, the consolidation of smaller farms, job losses, and frail infrastructure. Changes in the American political economy of agriculture has been driven partly by the production of high-input, capital-intensive technologies that contributed to substantial increases in crop yields, but created negative impacts on the sustainability of farm income and well-being of farming communities driven by a consolidation in the agriculture value chain (Lobao and Meyer, 2001). Indeed, the development of chemicals and genetically modified seeds to overcome the crisis of food insecurity has mainly favored a sustainable ‘productivist’ food system, mainly monocropping conventional agriculture systems over other less dominant and peripheral systems, such as agroecology, bioeconomy, and regenerative agriculture (Klerkx and Rose, 2020). Twentieth century agricultural technologies that have aimed to prevent crises of food insecurity in the US have privileged large-scale and commodity crop farmers and exaggerated social differences between large-scale industrial farms and small-scale farms, farm owner operators and renter operators. As with the case in India, the rise of rightwing and xenophobic populism has led to the deregulation of America’s agrarian spaces and exacerbated the animus and stratification of farm laborers (see McCarthy, 2019; Pulido et al., 2019; Graddy-Lovelace, 2019; Horst and Marion, 2018).

Climate risks to rural spaces are becoming central to modernization discourses that rationalize the reconfiguration of capital flows, labor arrangements and governance in production systems (Paprocki, 2018). Although indisputable that climate change poses unprecedented disruptions in planetary systems that undermine our species' vitality—alarming scientists enough that they now refer to the climate crisis as a 'climate emergency' (Ripple et al., 2019)—the politics are highly contested. Responses to climate change are debated within largely exclusive domains of policymaking or project design (Nagoda and Nightingale, 2017), and the asymmetrical power relations therein can produce suboptimal outcomes for excluded populations (Rice et al., 2021). Increasingly, climate change is becoming the axis around which all policy approaches and technological interventions are centered (Ayers et al., 2014). Echoing Paprocki (2020: 249): "… climate change becomes the ecological and temporal context within which new models of development are imagined for the present and future." Discursive formations of the climate crisis help legitimate top-down, technical and capital-intensive solutions (Nightingale et al., 2019; Stock, 2020a). This paper will explore how two ostensible solutions to climate change (i.e. solar parks, precision agriculture) are fraught with inequities, dispossessing producers of land and livelihoods (actual and virtual) and giving rise to new governance challenges.

2.2. Regimes of dispossession

Technological interventions to the climate crisis are indisputably urgent and very profitable. Considering capitalism as "*a way of organizing nature*" in which labor is a metabolic relation with nature (Moore, 2015; italics in original), climate change can be thought of as a result of capitalism's overmetabolizing of nature (O'Connor, 1998). Capitalism responds to crises (i.e. agrarian, climate, economic) by restructuring the relations of production (Braudel, 1982). Throughout the *longue* durée of capitalism, agrarian transformation occurs through accumulation cycles (Arrighi, 1994), many of which are predicated on improving upon rural production systems and livelihoods (Patel, 2013). The penetration of capital into the countryside and the subsequent transformation of peasant politics has animated academic debate for over a century (Kautsky, 1988; Bernstein, 2004; Akram-Lodhi and Kay, 2010a, 2010b). Dispossession is the typical corollary of technological accumulation strategies to modernize the crisis-ridden hinterlands.

The classic case of the English enclosures, marking the transition from feudalism to industrial capitalism (Wood, 2017), is a common starting point for theorizing dispossession. Land enclosure laws, over a span of three centuries, seized customarily tenured rural land. In a process Karl Marx (1990) referred to as *primitive accumulation*, English land dispossessions severed peasants from the means of production who were left to sell their labor power as proletarians to the new bourgeoisie landowners. David Harvey (2003) asserted that this process of *accumulation by dispossession* is ongoing in the neoliberal era, economically driven by finance and credit systems, and a response to the crisis of overaccumulated capital. In seeking to further refine this concept, Levien insists we pay attention to the actors and institutions behind the coercive upward redistribution of capital and resources by state entities for the private sector. *Regimes of dispossession* are the "… socially and historically specific constellations of state structures, economic logics tied to particular class interests, and ideological justifications that generate a consistent pattern of dispossession" (Levien, 2013: 383). Levien (2018) elaborates on this concept by revealing how the Jaipur Development Association served as development broker for private capital firms, which then dispossessed peasant lands in the village of Rajpura to facilitate the construction of a Special Economic Zone in Rajasthan (Mahindra World City). Building upon the regimes of dispossession concept, Paprocki (2018) describes an adaptation regime that circulates discourses of climate risks in Bangladesh centered around inevitable dystopian futures. These crisis discourses are used to pressure farmers from Khulna into transitioning away from rice agriculture and into adopting shrimp aquaculture as an adaptation strategy, resulting in a transformation of the coastal ecology that dispossesses residents of both land and livelihoods. As these aforementioned cases reveal, agrarian transformations often involve the state reconfiguring land tenure or labor relations for the benefit of private firms, often at the expense of local populations. Such agrarian transformations often involve land, resource and data dispossession and can exacerbate agrarian crises and disrupt agrarian livelihoods. If no alternative employment is made available to locals, rupturing the relations of production can render them irrelevant to the reproduction of capital—surplus populations struggling to survive (Li, 2010, 2011; Taylor and Bhasme, 2020). Albeit heterogeneous and place-specific, regimes of dispossession are increasingly defining agrarian transformations in the Anthropocene.

3. Methods and study areas

Primary data was obtained from a mixed methods approach to fieldwork in India and in the USA. Fieldwork in India (2018) for this case consisted of semi-structured interviews ($n = 84$) and discourse analysis of technical and policy documents ($n = 26$) in the locations of the Gujarat Solar Park (and nearby villages), the Kurnool Solar Park (and nearby villages), Gandhinagar, Hyderabad and New Delhi. The Gujarat Solar Park (GSP) has a generation capacity of 640 MW and was built on 5384 acres of land, roughly 2669 acres of which were designated as government 'wastelands' and the remaining portion was local farmers' private land from the village of Charanka. Agriculture in this region is typically rainfed by smallholders growing cumin, pearl millet, sorghum and wheat. The Kurnool Solar Park (KSP) is an ultra-mega solar park with 1000 MW generation capacity built on 5683.22 acres of semi-arid land, of which 3494.29 acres is government 'wasteland' and the remaining portion was local farmers' private land from the villages of Gani and Sakunala. Agriculture in this region is typically rainfed by smallholders growing cotton, sorghum, and chili peppers. The Gujarat Solar Park was chosen as a case study because it was India's first solar park and the Kurnool Solar Park was chosen because it was India's solar park with the highest generation capacity at the time of fieldwork. Semi-structured interviews were administered with farmers, solar park employees, and government officials at the aforementioned locations. Interviews were conducted in Gujarati, Telugu, Hindi or Urdu languages, per the respondents' fluency and preference.

Fieldwork in the USA (2019) was conducted in two locations: Vermont (VT) and South Dakota (SD), consisting of focus group discussions ($n = 6$) and a follow up survey with focus group participants ($n = 52$). A snowball sampling technique was used to select participants representing different sections of the food and PA system, including: precision agriculture technology software and hardware developers; university extension; crop, livestock, and dairy farmers; academics; government regulators; farm and non-farm non-profit organizations. Vermont and South Dakota have wide variance in terms of social, political, and environmental characteristics of agriculture and society. For instance, VT has a majority of small and medium scale farms while SD contains a majority of medium and large-scale farms. The average acreage in VT is 176 acres compared to 1459 acres in SD. Further, VT farms tend to be family owned, organic, mixed cropping/grazing-based while SD has mostly industrial scale and conventional monocropping farming systems. With a total of 719 certified organic farms in 2017, VT had more organic farms than any other state per capita. A mixed methods approach to data collection was used, which consisted of six homogenous focus group discussions (FGDs) and a follow-up survey with participating stakeholders. During the FGDs, participants deliberated on the risks and benefits of AI, big data, and machine learning algorithms for agronomic and financial decision-making in crop, livestock and dairy production systems. The FGDs were followed by a survey questionnaire completed by 52 participants that elicited their attitudes, beliefs, and perceived risks and benefits of PA technologies Our team adopted a qualitative interpretive method to analyze FGDs, allowing the emergence of concepts based on perspectives guiding this study (responsible innovation, data ownership, accessibility, sharing and control, power (re)distribution; impacts on human life and society). The qualitative approach was chosen to understand how participants understand social phenomena, with the emergent realities associated with their social lives.

4. Results: case studies of regimes of dispossession

The celerity and complexity of the climate crisis warrants urgent and place-specific action. The neoliberal state has predominantly focused on implementing new and emerging technological interventions on behalf of private firms that are inadequately regulated and lead to the uneven distribution of costs and benefits across population and user groups. This is particularly the case within renewable energy transitions and climate-smart agriculture. Two case studies exemplify governance challenges within sustainable solutions to energy and food systems. First, we examine solar park development in India. Second, we profile precision agriculture technologies in the USA. We situate each case study within an emerging regime of dispossession and make a case for equitable technological innovation, implementation and regulation.

4.1. [Case Study 1] Farming photons: Solar regimes of agrarian dispossession

Announcing the National Action Plan on Climate Change, former Prime Minister Manmohan Singh triumphantly declared: “We will pool our scientific, technical and managerial talents, with sufficient financial resources, to develop solar energy as a source of abundant energy to power our economy and to transform the lives of our people” (MNRE, 2016). To achieve its Nationally Determined Contributions to the 2015 Paris Climate Agreement of 40% non-fossil fuel share of cumulative power generation capacity by 2030, the government of India is rapidly developing 500 GW of renewable energy and working to achieve net-zero by 2070 (Government of India, 2015; Mitra et al., 2021). By 2022, India will have developed roughly 100 GW of solar power, 60 GW of which will be from large-scale ground mounted solar infrastructures. Solar parks will comprise the lion’s share of large-scale solar projects, particularly the so-called ‘ultra-mega’ solar parks with the capacity to generate 500 MW of electricity or more. Solar parks are institutionally configured like Special Economic Zones, investment spaces to attract financial capital and foreign direct investment, insofar as they are fully-equipped with sustaining infrastructures, minimal taxes and regulations for firms generating energy. In addition to being an essential decarbonization strategy, ultra-mega solar parks are also an effective accumulation strategy as they are estimated to receive USD $500–700 billion in financial investments by 2030 (Shah, 2020). Prime Minister Modi discursively articulated a techno-optimistic imaginary of India’s future at COP21: “So, convergence between economy, ecology and energy should define our future” (Modi, 2015). India’s solar parks represent socio-technical imaginaries of a neoliberally constrained sustainable future.

The government of India established the Solar Energy Corporation of India (SECI) to manage solar development nationally. SECI, in coordination with state governments, functions as a ‘development broker’ for project developers and private firms wishing to generate renewable energy in solar parks (see Levien, 2018). SECI identifies specific states to locate solar parks and opens tenders of a specific megawattage for companies to bid on. Winners of the tender work with the state government to identify a location for the solar park. Land acquisition for solar parks is undertaken by subnational and local units of government. State governments designate specific institutions to develop a solar park. Developing institutions work with the Revenue Department to acquire land upon which the solar park will be built. The Revenue Department works through district-level and block-level government offices to identify specific land parcels in the area. Block-level officers, revenue inspectors and tax collectors then work through village councils to acquire identified plots of land in a village. Once project developers obtain the land, they then lease it to investors or firms eager to generate solar energy on-site. Middlemen also mediate land sales for solar development (see Sud, 2014a). Village elites often intercept project elaborations and may influence the outcome in their favor (Yenneti and Day, 2015). For example, in Charanka village beside the Gujarat Solar Park, elites spoke on behalf of residents and did not necessarily represent their intentions or anxieties, even pressuring residents to sell their land to the project developers (Yenneti et al., 2016). As we will show with the Kurnool Solar Park, the constellation of actors and institutions identified above constitute an emerging regime of dispossession for solar development in rural India.

The Kurnool Solar Park was developed by the Andhra Pradesh Solar Power Corporation Limited (APSPCL), a joint venture company between SECI, the New and Renewable Energy Development Corporation of Andhra Pradesh Limited (NREDCAP) and the Andhra Pradesh Power Generation Corporation (APGENCO). As per SECI’s established protocol for solar park development, the Revenue Department worked through district and block-level government offices to identify suitable tracts of contiguous lands in nearby Gani and Sakunala village to host the project, with the preference being public marginal lands (i.e. wastelands). Local revenue inspectors and tax collectors acquired the identified parcels of land with the assistance of the village councils. Coercive land enclosures for the solar park dispossessed farmers of land and livelihoods from Gani and Sakunala villages, thereby transforming the agrarian political economy where cotton, sorghum and chili peppers flourished. Erstwhile farmers, contract farmers or laborers experienced the removal of 5683.22 acres from the regional farming system, depriving them of income and labor opportunities. The new solar economy required a highly credentialed labor force with skill-sets that local farmers did not possess, leaving the majority of them unemployed and landless. The vast majority of farmers whose land was acquired for this solar park were not offered employment at the solar park, except for a few who were offered menial employment that included serving tea, cutting weeds, and security (Stock and Birkenholtz, 2019). Although discursively articulated as equitable solutions to climate catastrophe (Stock, 2020a), India’s large-scale solar parks have transformed agrarian relations of production and exacerbated peasant marginalization (Stock and Birkenholtz, 2019; Yenneti et al., 2016). Mitigating the climate crisis through this vital renewable energy infrastructure has produced a new surplus population that is not absorbed into the local labor force, peasants whose labor is redundant to the reproduction of solar capital (Stock and Birkenholtz, 2019; Stock, 2021; see Li, 2010; Li, 2011; Taylor and Bhasme, 2020).

Beyond the production of a surplus population, the Kurnool Solar Park exemplifies complex legal geographies of energy transitions. Wielding the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act of 2013 (LARR), APSPCL obtained 454.62 acres of private land from local farmers who possess so-called ‘clear’ titles. However, 1875.5 acres of ‘wastelands’ were enclosed that were actually distributed to Dalit, lower caste and landless farmers as ‘assigned’ titles through the Government of Andhra Pradesh’s Land Assignment (Prohibition of Transfer) Act of 1977, conditional upon farming the land within three years. The Revenue Department categorized much of these ‘assigned’ lands as ‘wastelands’ and coercively dispossessed them from local subaltern populations (Jonnalagadda et al., 2021). Farmers with ‘clear’ titles were offered ₹5,50,000 (USD $7350.03) per acre,[1] yet those with conditional titles were given ₹4,20,000 (USD $5612.75) per acre or less (Stock and Birkenholtz, 2019). Many subaltern peasants were not remunerated at all for their

[1] The authors use the following currency conversion rate: $1 USD = ₹74.83 rupees.

lands. The Ministry of New and Renewable Energy's guidelines for solar park development stipulate that the enclosure of wastelands invalidates any claims for rehabilitation or resettlement because it defines wastelands as inhabitable and infertile lands. "1.3 In case waste land is acquired for setting up solar parks, there is no Project Affected Persons (PAPs) or Project Affected Families (PAFs) and hence there is no requirement of Rehabilitation and Resettlement" (MNRE, 2016; Jonnalagadda et al., 2021). In the case of the Kurnool Solar Park, LARR afforded the legal shield to dispossess vast tracts of private land from marginalized populations.

Implemented in semi-arid regions to alleviate energy poverty while mitigating climate change, the development of solar parks shares similar patterns of land dispossession across the country. In Madhya Pradesh, indigenous agropastoralists had their lands dispossessed to build the Wellspun Solar project. They were also excluded from accessing spaces to forage because the solar park acquired nearby commons land (Trivedi, 2017). To build the Kasaragod solar Park in Kerala, indigenous groups had their lands dispossessed because, although customarily tenured, they lacked proper land titles. The land acquisition process included the reclassification of farmers' lands as 'wastelands,' thus more easily dispossessed (Bedi, 2019). This was also the case in Rajasthan, where the state reclassified the customarily tenured farmlands of marginalized agropastoralists as wastelands for the purpose of land acquisition for the Fatehgarh Solar Park (Chari, 2020). In Assam, local land brokers coerced indigenous groups to sell or forfeit their lands to develop an Azure Power solar plant (Jairath, 2021). In each of these cases (as with Kurnool), disruptions in farming livelihoods were not replaced by employment opportunities in the new political economy of solar. These cases of solar development represent environmental injustices in service of climate change mitigation (Sovacool, 2021). Decarbonizing India's electrical grid through utility-scale solar parks, in a herculean effort to mitigate climate change, presents new dilemmas of resource and technological governance in agrarian spaces.

4.2. [Case Study 2] Precision agriculture: Regimes of data grabbing

Climate risks can be unanticipated, disruptive and pose serious distributional implications for food production systems globally. Agricultural technology (agritech) firms are stepping up to address challenges of climate change, food, and water security through the development of a suite of precision agriculture (PA) technologies that depend on the collection of large amounts of data from varied sources and in different types of formats, popularly known as 'big data' (Ferris 2017). According to a recent large-scale study conducted by the United States Department of Agriculture (USDA), about 50 percent of U.S. farmers have already adopted some type of PA on their farming operation (Schimmelpfennig, 2016). As an example of PA technologies, Bayer-Monsanto's the Climate Corporation collects different types of data (such as soil moisture and irrigation) from different sources (such as weather stations and farm equipment sensors) and uses machine learning algorithms to provide farmers with time and site-specific recommendation about what agricultural inputs to purchase, when and where to apply inputs to farms, and how to monitor cattle and livestock health (The Climate Corporation, 2021a). John Deere promises more than $100 per acre increase in profits to farmers who adopt their analytics software, which merely costs $15 per acre to purchase (Ryan, 2019), a net gain of $85 per acre for every farmer who adopts John Deere's agricultural decision support tool. Most new proprietary PA farm equipment, such as John Deere tractors, come pre-installed with GPS and various sensors, which passively collect on-farm data (e.g. location, crop yield, soil, weather) and transmit it back to the agritech firm, who then use big data analytics to make recommendations and predictions to the farmer, ranging from animal movements, irrigation schedules, and crop growth patterns to market pricing (Bennett 2015). Through the sensing and analysis of large and unstructured datasets, agritech firms like John Deere and Bayer-Monsanto promise to help farmers achieve environmental benefits and economic profitability by, for instance, reducing the need for a blanket application of agricultural chemicals on crop fields, improving carbon retention in soil and precise prediction of diseases in dairy cows and cattle (Gardezi and Stock, 2021). Agritech firms improve analysis from the integration of data across many production sites, collecting and aggregating data from a broader spatial and temporal scale, and by including variables such as soil quality, weather conditions, and management practices. This integration of data from thousands of farms allows for a more robust analysis for determining yield or early warning against pests and diseases (Sonka 2016).

Continuous engagement with farmers' data is exceedingly necessary for agritech firms to compete for market share in a highly concentrated agrochemical industry. Agritech collects and manages farm data and develops a relationship with farmers by subscribing them to their digital platforms, which farmers can access on a cellphone or a tablet. These platforms provide dynamic maps of the field and help manage agriculture data from planting to harvest (Fig. 1). For instance, Bayer-Monsanto's FieldView application, which is a big data analytics platform, promises farmers a broad range of decision support tools including "yield analysis, field region reports, field health imagery, manual seed scripts and fertility scripts" (The Climate Corporation, 2021b). FieldView application claims to have over 60 million acres of farm data (Successful Farmer, 2020). The price paid by the farmer for data analytics tools have been drastically lowered in recent times. Presently, Climate FieldView Plus is offered to farmers for a subscription fee of $100 per year. However, this application is 'free' to users who also sign up to Bayer PLUS Rewards. The agrochemical company Bayer purchased Monsanto in recent years, and it uses the digital advice from FieldView to make recommendations to farmers about purchasing Bayer's own agrochemicals. Many agritech firms sustain engagement with farmers using complex end user license agreements that may allow farmers to download data from digital platforms and save it on their private server, but their data is in a format that cannot be easily useable if the farmer chose to move to another agritech data manager (Library of Congress, 2017). This constrains and ties farmers to a single agritech provider. Moving to another agritech firm could mean giving up their farm data.

While the collection of large datasets and their processing through artificial neural networks, a type of machine learning algorithm, can produce reliable and site-specific farming recommendations, the process of data accumulation by agritech firms has alarmed several critical social science commentators. Recent studies highlight that agritech's accumulation of large agricultural datasets through machine observations is a newer form of dispossession (Fraser, 2019; Gardezi and Stock, 2021). Unlike—but also in some ways similar to the process of—land grabs for solar parks, data grabbing in PA involves agritech firms "gathering as much data as possible from customers (and from those with whom customers interact online)…an opportunistic endeavor…to inform innovations and direct strategic investment with respect to a changing context" (Fraser, 2019, p. 895). Accumulation of large datasets is problematic for at least two reasons: First, companies such as Monsanto not only sell digital advice embedded in digital devices, such as their proprietary handheld device Climate FieldView, but also products (e.g. seeds, equipment) to farmers (Kshetri 2014). Agritech firms could utilize data gathered from farmers to recommend new products to sell and profit from this arrangement (Bunge 2014). This is a form of information capitalism, where firms rationalize the use of surveillance technologies to provide 'profitable' and 'smart' recommendations to farmers (Stock and Gardezi, 2021). Secondly, the data and regulations that protect agritech's intellectual property rights also ties farmers to a specific agritech firm. If the farmer chose to change to a different agritech firm, they risk breaching their contract. For example, some commentators have observed that companies such as Bayer-Monsanto "have tight legislative controls over their intellectual property and data analytics, and if a farmer breaches their contract, this may lead to penalties and/or court-cases against them" (Ryan 2019, pg. 9). Through the

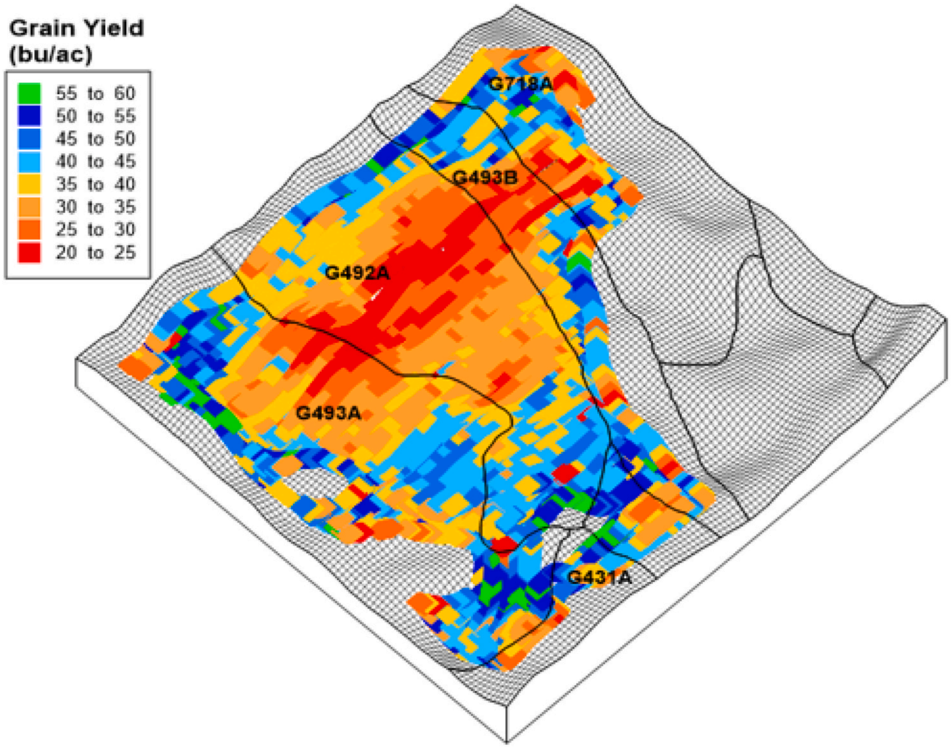

Fig. 1. 3D map of a field from yield monitor data. The map shows yield variation, where red indicates lowest yields and green indicates highest yields. (Image courtesy of Deepak Joshi). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

enclosure of data stored in virtual spaces for the intent to produce recommendations to farmers, agritech firms are dispossessing farmers of their data and expensive farm equipment.

The emerging regimes that govern big data and predictive analytics in agriculture are questionable, not least because they permit an unfettered transfer of digital representations of land to agritech firms. Through complex end user license agreements, agritech firms retain the rights to any data produced by the equipment sold to farmers (Kamilaris, 2017). Thus, farmers do not own their data and, instead, the agritech firms can include a royalty-free license over this data, giving them unrestricted permission to access. On the surface, it may seem like that agritech firms are simply relying on big agricultural data "… to piece together a rich (and valuable) cartography and database from which new understandings of soil variability, nitrogen, and climate might emerge" (Fraser, 2019, p. 905). However, this data can be used by the agritech firm to increase costs of farming—instead of reducing them—by selling products to farmers that they may not necessarily require. An NGO worker from South Dakota questioned agritech's motive behind data collection and providing digital advice: "Is this [data] going to be used just to sell more product? Or, you know, you were saying about fungicides, maybe we're going to make these recommendations based on the need to sell more product versus what's actually good for the farmer and for the farm. Do you trust an organization that you think is trying to sell you something even if maybe it is in your best interest, but how do you feel about if the purpose is trying to sell you something?" The process of collecting data (anonymous and aggregated) with the intention of selling more products and services or manipulating prices or markets is a form of surveillance capitalism (Stock and Gardezi, 2021). Through complex legal agreements and lax data regulation and user protection in the agriculture sector, farmers' data is in the clutches of agritech firms who can sell it to third-party vendors and use it to increase their profits (Taylor 2017). The consequences of surveillance capitalism can be serious for farmers. For example, Bayer-Monsanto's FieldView "collects information for farmers on variables such as soil health and pest pressures but this data could also be used by the company to promote their own pesticides and to identify new R&D needs" (Weersink et al., 2018; pg. 19). To highlight this concern, a university extension agent in Vermont warned: "You know speculators get ahold of that data and it changes what you're [farmer] going to get when you go to market with your crop." Indeed, many farmers lack confidence that their data will be protected from potential misuse for economic or marketing purposes (Ryan, 2019). Among workshop participants at South Dakota and Vermont, 78% of survey respondents agreed or strongly agreed with the statement: *Farmers are concerned that corporations could use farmers' planting and harvest data to manipulate markets.*

The regimes of data grabbing are not only dispossessing farmers from control of their farm data, but also in this process, reconfiguring farm labor. Companies such as John Deere prevent farmers from tinkering with their machinery, on intellectual property grounds (Carolan, 2017a, 2017b; Taylor and Broeders, 2015). Farmers, who were previously able to make small repairs and changes to their farm equipment to better suit their farm needs, are now legally required to seek assistance by a trained and certified technician. The technician is the only legal and knowledgeable authority to make repairs to precision farming equipment (Gardezi and Stock 2021). While this creates opportunities for new types of occupations to emerge in rural areas, it can take agency away from younger farmers, who are able and willing to repair their equipment. Thus, the modes of governance of big data in PA are generating two interrelated forms of dispossessions: data and knowledge dispossessions through legal and digital locks established by private agritech firms. This case suggests that either type of dispossession is reconfiguring farm labor by rapidly transforming knowledge needed to be a modern farmer, and allow movement of control of farm decision-making out of the hands of farmers and into consolidation of power in the hands of a few agritech firms. In this study, we have identified how the accumulation strategies of institutions developing new and emerging technologies that address the climate crisis (i.e. solar parks, precision agriculture) reconfigure labor arrangements (see also Stock and Gardezi, 2021; Stock and Birkenholtz, 2019). In both the solar and the PA cases, the regime of dispossession "… proposes the death of the peasantry as a foreordained consequence of an impending climate crisis" (Paprocki, 2018: 3). In contrast, we argue that governing agrarian spaces in the era of the Anthropocene must be centered in considerations of equity and need not involve the (physical or virtual) alienation of land from laborer.

5. Discussion

Dispossession in these agrarian systems is historically centered around unlocking the value of land by the state for capital accumulation by the private sector (Li, 2014; Levien, 2018; Sud, 2014b; Le Billon and Sommerville, 2017). In Kurnool, the solar regime of dispossession opens up public wastelands and privately held marginal lands of subaltern populations to facilitate spaces for renewable energy investments. Land once used for production becomes land for the market. Although land in the USA is not as easily alienated today when compared with the era of indigenous genocide, agritech control over big data is a digital manifestation of a land grab. PA is an accumulation strategy that involves the alienation of digital representations of land and food production systems. The neoliberal state performs the role of a land and development broker to facilitate solar and PA technological interventions in agrarian spaces. In India, land acquisition legislation and institutional guidelines for project development provide legal cover for corporate land grabbing for solar. In the USA, the strategic absence of legislation and regulation over PA technologies enables agritech grabbing of data that represents landed production systems. In response to the climate crisis, both regimes of dispossession capitalize within different temporal frontiers of accumulation. Solar firms grab land and erect solar arrays in the present to mitigate greenhouse gas emissions now and into the future. Solar capital is accumulated on dispossessed peasant land for twenty-five years or more, dependent upon contractual agreements and leases, renewable by leases for the lifespan of the solar panels. Agritech firms develop technologies and enroll farmers into using these technologies to respond to variable climatic conditions and improve climate-affected harvests in the present and future, providing recommendations based upon an aggregation of past and present data (Stock and Gardezi, 2021). Through virtually unrestricted data grabbing of farms and farmers, agritech firms can continue to accumulate PA capital far into the future irrespective of land and labor conditions. Alienated producers from Kurnool are not absorbed into the solar economy, producing a surplus population whose economic position is rendered more precarious (Stock, 2021). By collecting torrents of big data from PA, agritech possesses the ability to collect and store visual and recorded manifestations of the past; all management decisions taken by the farmer are stored into a database. The digital extraction of farmer knowledge and farm management practices are getting coded into data and stored for the future automation of farm labor that will dispossess farmers of livelihoods (Gardezi and Stock, 2021). Agrarian governance in the Anthropocene will require innovative policies and regulatory approaches centered on equity and resource sovereignty.

Earth system governance research is indispensable at this critical moment in history. Through technological innovation and digitalization, large-scale transformations in society are on the horizon. In this vein, recent work at the intersection of global environmental politics and technological change have interrogated the governance of emerging technologies, such as blockchain and distributed ledger technology (DLT), for innovative digital international climate financing (Schulz and Feist 2020). This research highlights that while emerging technologies such as DLT can facilitate more inclusive processes for ensuring accountability and transparency in international climate finance, challenges of governing these emerging technologies (their design and deployment) are deeply and truly political (Schulz and Feist 2020). The fragmentation of governance for new technologies, as was argued in this paper, is being constructed within a highly inequitable social milieu and neoliberal forms of public-private sector engagements. Emergence of new technologies, actors, interests and scales (broadly construed as governance) are being driven by interactions between the neoliberal state and private sector firms. This is problematic because emerging technologies can also create new interdependencies that can deeply impact all aspects of agrarian life, including economics and finance, security, labor markets, politics, laws and ethics (United Nations, 2019). Moreover, many technologies can widen social and political inequalities already embedded within systems of governance, through sharing or grabbing power by and from actors. The governance of emerging technologies deployed to combat the climate crisis is influenced and often incubated through discursive formations circulated by industry or agencies to rationalize apolitical technological interventions.

There are two important implications of these studies. Our case in India found that the utility-scale solar parks are being erected according to formal laws (i.e. LARR) with clearly articulated provisions along with institutional policies and guidelines (MNRE, 2016). Yet the process by which the Revenue Department acquires private lands through LARR for developers is historically fraught with procedural injustices and coercive tactics that ultimately separate farmers from their lands. The concentration of energy generated through utility-scale solar parks, despite adequate legislation on electricity provision and utilities abiding by established regulatory frameworks, often perpetuates the energy insecurity of adjacent communities (Stock and Birkenholtz, 2019). Therefore, India should place equity at the center of its ambitious efforts to transition to renewable energies by drafting new legislation that promotes the decentralization of solar energy generation and distribution. Distributed community solar has proven to be an effective mitigation mechanism with less potential for exacerbating social vulnerabilities. In 2015, the IWMI-TATA Water Policy Research Program implemented a solar micro-grid in Dhundi, Gujarat for the purposes of irrigating local agricultural plots. After becoming a formal solar irrigation cooperative, the Dhundi Saur Urja Utpadak Sahakari Mandali began generating more money by harvesting photons than harvesting crops because they were able to sell the surplus energy to the distributor Madhya Gujarat Vij Company Limited through a 25-year power purchase agreement (DSUUSM, 2018; Shah et al., 2018). The Dhundi cooperative has recently inspired the central government's KUSUM scheme that seeks to replace diesel and electric irrigation pumps for solar irrigation pumps (Shah, 2018). The Dhundi cooperative represents an equitable alternative to dispossessive utility-scale solar parks, a successful model for mitigating climate change through solar energy in a way that provides an economic benefit to smallholders, promotes energy sovereignty and preserves their ownership over the land.

Second, the complex and unclear ownership and privacy agreements between agritech firms and farmers raise questions about how big agricultural data are currently governed in agrarian spaces, by whom, and to what ends. The governance of PA and regulations by US federal and state governments for protecting farmers' agricultural data have been inadequate. Most current regulatory options for user's data privacy come under the purview of the Federal Trade Commission (FTC) framework. The FTC framework does not regulate and protect against privacy breeches associated with farm data (e.g. weather, soil, nutrients) because this is categorized as non-personalized agricultural data (Atik and Martens, 2021). Moreover, the data ecosystem is currently "chaotic and fractured" (Weersink et al., 2018: 17). Private sector corporations, government entities, and universities are developing (or have developed) their own regulatory protocols based on their interpretation of transparency and privacy. This fractured data ecosystem has created space for agritech firms to develop voluntary rules and principles for enhancing user's data privacy. In 2014, the American Farm Bureau Federation (AFBF) working with commodity groups, farmers and agritech firms, helped to establish the Privacy and Security Principles for Farm Data. Since then, numerous agricultural organizations in the USA have agreed to follow the unenforceable and non-binding Core Principles from AFBF. How effective are self-regulating voluntary mechanisms for a big data ecosystem characterized by corporate control over agricultural data and analytics platforms? In light of these challenges, new policy measures are needed to proactively identify and address concerns about data dispossession under PA. Several public-private partnerships in North America and Western Europe are advocating for open data platform for agriculture. An initiative named Global Open Data for Agriculture and Nutrition (GODAN) supports open data platforms for farmers and other agricultural stakeholders. It strives to develop clear and transparent rules for ownership and access of farm data. A USA-based organization called the Grower's Information Services Coop claims to be the only "grower-owned and governed data cooperative" that use member's data to provide independent and unbiased farming recommendations to them (Grower's Information Services Coop, 2021). More recently, at the US federal government level, new legislations are proposed that would protect the principles of openness of data into law, and bind future administrations to maintain sanctity of user's agricultural data (New, 2016). However, it remains to be seen how various stakeholders with diverging interests and priorities will tackle issues of asymmetry in market control by large agritech firms. Emerging regimes of dispossession in the spheres of digital agriculture and solar energy present numerous governance challenges and constrain environmental decision-making. Governing the Earth's agrarian spaces far into the Anthropocene, wherein critical climate interventions are implemented, will require pro-poor, participatory and publicly accountable policy-making processes.

6. Conclusion

Technological innovations aiming to address some of the most complex and grand challenges of the 21st century, especially those that are implemented to address the climate crisis, are transforming the political economy of agriculture and agrarian labor geographies. Using a case study approach, we examine two technologies emerging in the areas of energy and agri-food systems (i.e. solar parks in India, precision agriculture in USA) to highlight unique problems of resource governance. Our case studies show how these new and emerging technologies do not have a historical precedent for the equitable distribution of burdens and benefits among differently positioned actors. The neoliberal state enables agritech and energy firm hegemony at the expense of local producers under the auspices of climate mitigation and adaptation. *Tout court,* crisis becomes market opportunities that mask power relations. The enclosure of both natural and virtual resources is discursively articulated as being for the 'common good' to implement 'smart' sustainable solutions to the socioecological crises of climate change and food insecurity. In doing so, solar and agritech firms (re)produce social frictions throughout the value chain. In Kurnool, the development of utility-scale solar energy infrastructures has resulted in land and energy dispossessions for local farmers. In Vermont and South Dakota, the proliferation of AI-assisted farm technologies has dispossessed farmers of data. Albeit unevenly, such technological interventions have brought some social and environmental benefits to people and the environment. However, we contend that the constellation of institutions, policies and regulatory approaches that govern these technologies in agrarian spaces constitute *regimes of dispossession*—socially and historically specific political apparatuses for coercively redistributing resources. Although the modalities of dispossession are unique in each case, the outcome of alienation links them together across disparate governance regimes and geographies. New and emerging technologies that alienate producers from the means of production through dispossessing land and data need new and emerging policy and regulatory frameworks to ensure equitable agrarian futures.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The paper is based upon work supported by the National Science Foundation under Grant Numbers (2202706 and 2026431). We would like to thank all focus group and survey participants for their valuable gift of time and input. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

Akram-Lodhi, A.H., Kay, C., 2010a. Surveying the agrarian question (part 1): unearthing foundations, exploring diversity. J. Peasant Stud. 37 (1), 177–202. https://doi.org/10.1080/03066150903498838.
Akram-Lodhi, A.H., Kay, C., 2010b. Surveying the agrarian question (part 2): current debates and beyond. J. Peasant Stud. 37 (2), 255–284. https://doi.org/10.1080/03066151003594906.
Arrighi, G., 1994. The Long Twentieth Century: Money, Power, and the Origins of Our Times. Verso.
Atik, C., Martens, B., 2021. Competition problems and governance of non-personal agricultural machine data: comparing voluntary initiatives in the US and EU. SSRN Electron. J. https://doi.org/10.2139/ssrn.3766293.
Ayers, J.M., Huq, S., Faisal, A.M., Hussain, S.T., 2014. Mainstreaming climate change adaptation into development: a case study of Bangladesh. Wiley Interdisciplinary Reviews: Clim. Change 5 (1), 37–51.
Baka, J., 2017. Making space for energy: wasteland development, enclosures, and energy dispossessions. Antipode 49 (4), 977–996.
Bedi, H.P., 2019. Lead the district into the light": solar energy infrastructure injustices in Kerala, India. Global Transitions 1, 181–189.
Bennett, J.M., 2015. Agricultural Big Data: utilisation to discover the unknown and instigate practice change. Farm Policy Journal 12 (1), 43–50.
Bernstein, H., 2004. 'Changing before our very eyes': Agrarian questions and the politics of land in capitalism today. J. Agrar. Change 4 (1/2), 190–225.
Braudel, F., 1982. Civilization and Capitalism, 15th–18th Century. Harper & Row, New York.
Bunge, J., 2014. Big data comes to the farm, sowing mistrust. Wall St. J. 25.
Burch, S., Gupta, A., Inoue, C.Y., Kalfagianni, A., Persson, Å., Gerlak, A.K., et al., 2019. New directions in earth system governance research. Earth. Syst.Govern 1, 100006.
Carolan, M., 2017a. Agro-digital governance and life itself: food politics at the intersection of code and affect. Sociol. Rural. 57, 816–835.
Carolan, M., 2017b. Publicising food: big data, precision agriculture, and co-experimental techniques of addition. Sociol. Rural. 57 (2), 135–154.
Chari, M., 2020. How solar farms fuel land conflicts. September 21 Mint. https://www.livemint.com/news/india/how-solar-farms-fuel-land-conflicts-11600612526037.html.
De Jong, M., Joss, S., Schraven, D., Zhan, C., Weijnen, M., 2015. Sustainable–smart–resilient–low carbon–eco–knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. J. Clean. Prod. 109, 25–38.
Deutz, P., 2014. A class-based analysis of sustainable development: developing a radical perspective on environmental justice. Sustain. Dev. 22 (4), 243–252.
Djoudi, H., Locatelli, B., Vaast, C., Asher, K., Brockhaus, M., & Sijapati, B. B. (2016). Beyond dichotomies: gender and intersecting inequalities in climate change studies. AMBIO A J. Hum. Environ., 45(Suppl. 3), S248–S262. https://doi.org/10.1007/s13280-016-0825-2.
DSUUSM (2018). Dhundi solar energy producers' cooperative society: Tri-annual report, 2015-18. Dhundi Saur Urja Utpadak Sahakari Mandali. Retrieved from: http://www.iwmi.cgiar.org/iwmi-tata/PDFs/dhundi_solar_energy_producers_cooperative_society-tri-annual_report-2015-18.pdf.
Successful Farmer (2020). Retrieved from: https://www.agriculture.com/news/technology/the-fieldview-tillable-breakup-what-went-wrong.
Ferris, J.L., 2017. Data privacy and protection in the agriculture industry: is federal regulation necessary. Minn. JL Sci. & Tech 18 (1), 309–342.
Flachs, A., 2016. Redefining success: the political ecology of genetically modified and organic cotton as solutions to agrarian crisis. J. Polit. Ecol. 23 (1), 49–70.
Fraser, A., 2019. Land grab/data grab: precision agriculture and its new horizons. J. Peasant Stud. 46 (5), 893–912.
Gardezi, M., Stock, R., 2021. Growing algorithmic governmentality: interrogating the social construction of trust in precision agriculture. J. Rural Stud. 84, 1–11.
Gidwani, V.K., 2008. Capital, Interrupted: Agrarian Development and the Politics of Work in India. U of Minnesota Press.
Government of India, 2015. India's Intended Nationally Determined Contribution: Working towards climate justice. Government of India, New Delhi. Retrieved 10 March 2022.
Graddy-Lovelace, G., 2019. US farm policy as fraught populism: tracing the scalar tensions of nationalist agricultural governance. Ann. Assoc. Am. Geogr. 109 (2), 395–411.
Grower's information services Coop. Retrieved from: https://www.gisc.coop/.
Gupta, J., Pouw, N.R., Ros-Tonen, M.A., 2015. Towards an elaborated theory of inclusive development. Eur. J. Dev. Res. 27 (4), 541–559.
Hajer, M.A., 1995. The Politics of Environmental Discourse: Ecological Modernization and the Policy Process. Oxford University Press, Oxford, UK.

Harris, R.L., Tarchak, L., 2018. Small-town America is dying. How can we save it? December 28 N. Y. Times. Retrieved from: https://www.nytimes.com/2018/12/22/opinion/rural-america-economy-revive.html.
Harriss-White, B., 2008. Introduction: India's rainfed agricultural dystopia. Eur. J. Dev. Res. 20 (4), 549–561.
Harvey, D., 2003. The New Imperialism. Oxford University Press, Oxford.
Horst, M., Marion, A., 2018. Racial, ethnic and gender inequities in farmland ownership and farming in the US. Agric. Hum. Val. 36 (1), 1–16.
IPCC, 2018. Summary for Policymakers: Global Warming of 1.5°C. Intergovernmental Panel on Climate Change. United Nations. Retrieved from: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf.
Jairath, V., 2021. Assam, a 'green' energy plant is bulldozing claims of small and marginal farmers. January 3 Wire. Retrieved from. https://thewire.in/rights/assam-nagaon-azure-solar-energy-plant-small-marginal-farmers-rights.
Jasanoff, S., Kim, S.-H. (Eds.), 2015. Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power. University of Chicago Press, Chicago.
Jonnalagadda, I., Stock, R., Misquitta, K., 2021. Titling as a contested process: conditional land rights and subaltern citizenship in South India. Int. J. Urban Reg. Res. https://doi.org/10.1111/1468-2427.13002.
Kaijser, A., Kronsell, A., 2014. Climate change through the lens of intersectionality. Environ. Polit. 23 (3), 417–433. https://doi.org/10.1080/09644016.2013.835203.
Kamilaris, 2017. Andreas, Andreas Kartakoullis, and Francesc X. Prenafeta-Boldú. "A review on the practice of big data analysis in agriculture. Comput. Electron. Agric. 143, 23–37.
Karagianis, L., 2014. The Future Is Cities. Winter. MIT Spectrum. Retrieved from. https://spectrum.mit.edu/winter-2014/the-future-is-cities/.
Kautsky, K., 1988. The Agrarian Question. Zwan Publications, London.
Klerkx, L., Rose, D., 2020. Dealing with the game-changing technologies of Agriculture 4.0: how do we manage diversity and responsibility in food system transition pathways? Global Food Security. https://doi.org/10.1016/j.gfs.2019.100347.
Kshetri, Nir, 2014. The emerging role of Big Data in key development issues: opportunities, challenges, and concerns. Big Data.Soc. 1 (2), 2053951714564227.
Le Billon, P., Sommerville, M., 2017. Landing capital and assembling 'investable land' in the extractive and agricultural sectors. Geoforum 82, 212–224. https://doi.org/10.1016/j.geoforum.2016.08.011.
Lefebvre, H., 1991. The Production of Space. Basil Blackwell, Cambridge, MA.
Levien, M., 2013. Regimes of dispossession: from steel towns to special economic Zones. Dev. Change 44 (2), 381–407.
Levien, M., 2018. Dispossession without Development: Land Grabs in Neoliberal India. Oxford University Press, Oxford.
Li, T., 2010. To make live or let die? Rural dispossession and the protection of surplus populations. Antipode 41 (S1), 66—93.
Li, T., 2011. Centering labor in the land grab debate. J. Peasant Stud. 38 (2), 281–299.
Li, T., 2014. What is land? Assembling a resource for global investment. Trans. Inst. Br. Geogr. 39 (4), 589–602.
Library of Congress, 2017. The Future of Farming: Technological Innovations, Opportunities, and Challenges for Producers | Congress.gov | Library of Congress, 115th Congress. https://www.congress.gov/event/115th-congress/house-event/106220?q=%7B%22search%22%3A%5B%22%5C%22Agriculture%7CGeneral%5C%5C%22%2C%22Farm%5C%5C%22%2C%22Commodities%5C%5C%22%2C%22and%5C%5C%22%2C%22Risk%5C%5C%22%2C%22Management%5C%22%22%5D%7D&s=3&r=1.
Lobao, L., Meyer, K., 2001. The great agricultural transition: crisis, change, and social consequences of twentieth century US farming. Annu. Rev. Sociol. 27, 103–124. https://doi.org/10.1146/annurev.soc.27.1.103.
New, J. 2016. "Congress is stepping up to protect open data," Centre for Data Innovation (blog), April 19, 2016, Retrieved from: https://datainnovation.org/2016/04/congress-is-stepping-up-to-protect-open-data/.
Marx, K. (1990). Capital: A Critique of Political Economy, Vol. vol. I. London: Penguin Classics..
McCarthy, J., 2019. Authoritarianism, populism, and the environment: comparative experiences, insights, and perspectives. Ann. Assoc. Am. Geogr. 109 (2), 301–313.
McMichael, P., 2009. A food regime genealogy. J. Peasant Stud. 36 (1), 139–169.
McMichael, P., 2012. The land grab and corporate food regime restructuring. J. Peasant Stud. 39 (3–4), 681–701.
Mitra, A., Gajjar, C., Kelkar, U., 2021. COP26: unpacking India's major new climate targets. WRI India. November 2. https://wri-india.org/blog/cop26-unpacking-india%E2%80%99s-major-new-climate-targets.
MNRE, 2016. Jawaharlal Nehru National Solar Mission: Guidelines for Development of Solar Parks. Ministry of New and Renewable Energy, Government of India, New Delhi, India.
Modi, N., 2015. Let us turn to the sun to power our future: PM Narendra Modi at the launch of the International Solar Alliance in Paris. Retrieved from. https://www.narendramodi.in/pmmodi-at-thelaunch-of-international-solar-alliance-385253.
Moore, J.W., 2015. Capitalism in the Web of life. Verso, London.
Nagoda, S., Nightingale, A.J., 2017. Participation and Power in Climate Change Adaptation Policies: Vulnerability in Food Security Programs in Nepal, vol. 100. World Development, pp. 85–93.
Nightingale, A.J., Eriksen, S., Taylor, M., Forsyth, T., Pelling, M., Newsham, A., et al., 2019. Beyond Technical Fixes: climate solutions and the great derangement. Clim. Dev. 1–10.
O'Connor, J.R., 1998. Natural Causes: Essays in Ecological Marxism. Guilford Press.
Paprocki, K., 2018. Threatening dystopias: development and adaptation regimes in Bangladesh. Ann. Assoc. Am. Geogr. 108 (4), 955–973.
Paprocki, K., 2020. The climate change of your desires: Climate migration and imaginaries of urban and rural climate futures. Environ. Plan. D: Soc. Space 38 (2), 248–266.
Patel, R., 2013. The long green revolution. J. Peasant Stud. 40 (1), 1–63.
Pulido, L., Bruno, T., Faiver-Serna, C., Galentine, C., 2019. Environmental deregulation, spectacular racism, and white nationalism in the Trump era. Ann. Assoc. Am. Geogr. 109 (2), 520–532.
Ramprasad, V., 2019. Debt and vulnerability: indebtedness, institutions and smallholder agriculture in South India. J. Peasant Stud. 46 (6), 1286–1307.
Rao, N., Lawson, E.T., Raditloaneng, W.N., Solomon, D., Angula, M.N., 2019. Gendered vulnerabilities to climate change: insights from the semi-arid regions of Africa and Asia. Clim. Dev. 11 (1), 14–26.
Reddy, D.N., Mishra, S. (Eds.), 2010. Agrarian Crisis in India. Oxford University Press.
Ribot, J., 2014. Cause and response: vulnerability and climate in the Anthropocene. J. Peasant Stud. 41 (5), 667–705.
Rice, J.L., Long, J., Levenda, A., 2021. Against climate apartheid: confronting the persistent legacies of expendability for climate justice. Environ. Plann.: Nature and Space, 2514848621999286.
Ripple, W., Wolf, C., Newsome, T., Barnard, P., Moomaw, W., Grandcolas, P., 2019. World scientists' warning of a climate emergency. Bioscience 70 (1), 8–12.
Roitman, J., 2013. Crisis demands. In: Anti-Crisis. Duke University Press, Durham, pp. 15–40.
Ryan, M., 2019. Ethics of using AI and big data in agriculture: the case of a large agriculture multinational. ORBIT Journal 2 (2). Article-2.
Schimmelpfennig, D., 2016. Farm Profits and Adoption of Precision Agriculture (No. 1477-2016-121190).
Schulz, K., Feist, M., 2020. Leveraging Blockchain Technology for Innovative Climate Finance under the Green Climate Fund. Earth System Governance, p. 100084.
Shah, T., 2018. Kick-starting the Kisan Urja Suraksha evam utthaan Mahabhiyan. Econ. Polit. Wkly. 54, 13–16.
Shah, K., 2020, May. India's Utility-Scale Solar Parks a Global Success Story. Institute for Energy Economics and Financial Analysis. Retrieved from: https://ieefa.org/wp-content/uploads/2020/05/Indias-Utility-Scale-Solar-Parks-Success-Story_May-2020.pdf.
Shah, T., Rajan, A., Rai, G.P., Verma, S., Durga, N., 2018. Solar pumps and South Asia's energy-groundwater nexus: exploring implications and reimagining its future. Environ. Res. Lett. 13 (11), 115003.
Shankar, B., 2021, February 1. Why Indian Farmers Are So Angry about the Modi Government's Agricultural Reforms. *The Conversation*. Retrieved from: https://theconversation.com/why-indian-farmers-are-so-angry-about-the-modi-governments-agricultural-reforms-154428.
Sonka, S., 2016. Big data: fueling the next evolution of agricultural innovation. J. Innovation Manag 4 (1), 114–136.
Sovacool, B.K., 2021. Who are the victims of low-carbon transitions? Towards a political ecology of climate change mitigation. Energy Res. Social Sci. 73, 101916.
Stock, R., 2020. *Deus ex mitigata*: denaturalizing the discursive power of Solar India. Environ. Plann.: Nature and Space. https://doi.org/10.1177/2514848620908166.
Stock, R., 2021. Praeclariat: theorising precarious labour geographies of solar energy. Antipode 53 (3), 928–949. https://doi.org/10.1111/ANTI.12698.
Stock, R., Birkenholtz, T., 2019. The sun and the scythe: energy dispossessions and the agrarian question of labor in solar parks. J. Peasant Stud. https://doi.org/10.1080/03066150.2019.1683002.
Stock, R., Gardezi, M., 2021. Make bloom and let wither: biopolitics of precision agriculture at the dawn of surveillance capitalism. Geoforum.
Sud, N., 2014a. The men in the middle: a missing dimension in global land deals. J. Peasant Stud. 41 (4), 593–612.
Sud, N., 2014b. Governing India's land. World Dev. 60, 43–56.
Sud, N., 2020. The actual Gujarat model: authoritarianism, capitalism, Hindu nationalism and populism in the time of Modi. J. Contemp. Asia 1–25.
Sultana, F., 2014. Gendering climate change: geographical insights. Prof. Geogr. 66 (3), 372–381.
Syngenta, 2017. Trending 2050: The Future of Farming | Syngenta Thrive. Retrieved March 9, 2022, from. https://www.syngenta-us.com/thrive/research/future-of-farming.html.
Taylor, M., 2013. Liquid debts: credit, groundwater and the social ecology of agrarian distress in Andhra Pradesh, India. Third World Q. 34 (4), 691–709.
Taylor, M., 2014. The Political Ecology of Climate Change Adaptation: Livelihoods, Agrarian Change and the Conflicts of Development. Earthscan, London.
Taylor, L., 2017. Safety in numbers? Group privacy and big data analytics in the developing world. In: Group Privacy. Springer, Cham, pp. 13–36.
Taylor, M., Bhasme, S., 2020. Between deficit rains and surplus populations: the political ecology of a climate-resilient village in South India. Geoforum.
Taylor, L., Broeders, D., 2015. In the name of Development: power, profit and the datafication of the global South. Geoforum 64, 229–237.
The Climate Corporation, 2021a. Crop performance analysis. Retrieved from. https://climate.com/features/crop-performance-analysis.
The Climate Corporation (2021b). Retrieved from: https://climate.com/bayer-PLUS.
Trivedi, D., 2017. Solar betrayal. August 18 Frontline. Retrieved from. https://frontline.thehindu.com/the-nation/solar-betrayal/article9794731.ece.
United Nations, 2019. Report of the UN Secretary-General's High-Level Panel on Digital Cooperation: the Age of Digital Interdependence. United Nations, New York, 2019.
Watts, M.J., Bohle, H.G., 2015. The origins of political ecology and the rebirth of adaptation as a form of thought. Routledge.Handb. Polit. Ecol. 19–50.
Weersink, A., Fraser, E., Pannell, D., Duncan, E., Rotz, S., 2018. Opportunities and challenges for big data in agricultural and environmental analysis. Ann. Rev. Resource Econ. 10, 19–37.

White, J.M., 2016. Anticipatory logics of the smart city's global imaginary. Urban Geogr. 37 (4), 572–589.

Wolford, W., 2004. This land is ours now: spatial imaginaries and the struggle for land in Brazil. Ann. Assoc. Am. Geogr. 94 (2), 409–424.

Wood, E.M., 2017. The Origins of Capitalism: A Longer View. Verso, New York.

Yenneti, K., Day, R., 2015. Procedural (in)justice in the implementation of solar energy: the case of charanaka solar park, Gujarat, India. Energy Pol. 86, 664–673.

Yenneti, K., Day, R., Golubchikov, O., 2016. Spatial justice and the land politics of renewables: dispossessing vulnerable communities through solar energy mega-projects. Geoforum 76, 90–99.