



Sustainability governance for agrarian transformation under climate change

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Abstract

Scholarship at the intersection of agrarian studies and climate change has made substantial contributions toward a deeper understanding of how climate and environmental changes shape and are shaped by the rural world. We call for placing sustainability at the core of future analyses of ongoing agrarian transitions to strengthen more systematic investigations of their relationship with broader social and climate changes. The new focus on sustainability—both to investigate causes and assess outcomes—will fundamentally influence how agrarian studies scholarship seeks to understand the relationship of climate change with agrarian transformations. Through an assessment of three examples of agrarian transitions, driven by state, non-government organizations, and capital-intensive development projects, we highlight the “wicked” sustainability challenges threatening the wellbeing of rural populations and of ecosystems that sustain rural livelihoods. We conclude that incorporating a sustainability governance framework into critical agrarian studies facilitates understanding and action toward sustainable transformations in the rural world.

Keywords Agrarian change · Climate change · Development projects · Sustainability governance

Introduction

Effective responses to climate change and ecosystem threats are gathering greater urgency as global assessments document its calamitous nature (IPBES 2019; IPCC 2021; UNFCCC 2016). The disastrous consequences of climate change are attributable to the grossly unequal emissions of the rich and the poor. Tragically, the worst consequences of catastrophic climate shifts will be borne by vulnerable populations, especially in poorer countries and by their disadvantaged social groups in the rural world (Borras and Franco 2018; Newell 2022). Conceptual frameworks for

understanding these outcomes borrow from social theory, political ecology, and environmental justice writings to focus on distributive and justice dimensions of climate change outcomes (Martinez-Alier et al. 2016; Robinson and Shine 2018; Sovacool et al. 2023; Walker 2011).

Relatedly, critical agrarian studies have shed light on agrarian change and struggle in the rural world by situating them in the broader historical context (Akram-Lodhi et al. 2021). Due to the persistence of unequal relations between the core and periphery since the colonial period, there has been entrenched unequal distribution of socio-economic and environmental costs and benefits across space, time, and social groups (Foster and Holleman 2014; Skillington 2019). However, the state and other development agencies often justify such socio-economic and environmental inequalities by broader development goals and agendas, in the names of crop yield improvement, zero emission commitments, low-carbon transitions, waste-to-energy projects, and conservation enclosures (Borras and Franco 2012; Deakin et al. 2016; Homewood 2017; Johnson et al. 2018; Neumann 2004; Sovacool 2021). Such exploitations can be manifested at different scales. Globally, unequal relations between the Global North and South result in the establishment of institutions that favor the former at

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the expense of the latter (Givens et al. 2019). Within a country, unequal relations between more economically developed regions and less developed regions also lead to different forms of extraction (Luo et al. 2020). Even within the same geographic region, people of different demographic backgrounds and social statuses are subject to different privileges and benefits (Hammer 2019).

In the rural context, the differential impacts of climate change and its market and state responses have given rise to an emerging literature on agrarian transitions in a changing climate. These writings highlight the necessity to situate contemporary agrarian struggles and the legacies of colonial history and inequality within the wider context of climate change (Borras et al. 2022b). It is also urgent to integrate these two domains of research to explore potential sustainable agrarian transition, as different climate models reveal converging predictions on the growing impact of climate change (IPCC 2021), which will have more adverse effects on more people's livelihoods than ever, with particularly catastrophic effects on the vulnerable rural poor.

Building on the emerging scholarship on agrarian transitions in a changing climate, we suggest that future development interventions in the rural world must be directed toward sustainability and informed by insights from writings on sustainability transitions (Chaigneau et al. 2022; Kates and Parris 2003). Sustainability, itself, is broadly understood to rest on three pillars: social, economic, and environmental. While climate change poses new and urgent challenges to agrarian systems, governance for sustainability remains a contested space, shaped by multiple actors and drivers. To understand and address the complex challenges of ongoing agrarian transitions, we highlight the importance of sustainability governance for a more sustainable and just rural world (Agrawal et al. 2022).

In this research, we focus on the complex dynamics of agrarian transitions influenced by three pivotal external drivers—state policies, non-governmental organizations (NGO) and their actions, and capital investments and market actors. While the impact of state policies on agricultural transformations has traditionally received ample scholarly attention, the heightened challenges posed by climate change necessitate a fresh evaluation of the state's evolving role in sustainability governance. Similarly, despite NGOs' burgeoning influence in this arena, few studies have rigorously examined their impact, particularly as active drivers of agrarian transformations in the context of climate change. Additionally, we aim to expand upon existing research concerning market forces by delving into how capital investments directly and indirectly drive shifts in agriculture. Specifically, we assess the sustainability implications for each across different contexts. By doing so, we aim to connect scholarship on sustainability governance with core issues of climate change and agrarian struggles so that the tradeoffs and co-benefits

of development interventions in social, economic, and environmental dimensions can be articulated more effectively.

In the rest of the paper, we first introduce the sustainability governance framework in the context of agrarian change. Then we analyze three distinct external drivers of agrarian transitions, which are a targeted poverty alleviation program in China (representing state-led development within its border), a collection of NGO interventions in Ethiopia (representing international NGOs operating in a foreign country), and the global land rush (representing a polycentric global food regime with participation by hundreds of countries as investors and hosts). Indeed, state, NGO, and capital are not mutually exclusive in determining the trajectories of agrarian transition. As shown below, in state-driven transition, capital can be involved in infrastructure construction and management. In NGO-driven transition, the development intervention programs are typically endorsed by host-country governments. In capital-driven transition, state also plays a crucial role to facilitate land tenure change for large-scale agricultural development. By adopting the sustainability governance analytical framework, we show why an integrated approach is needed to examine the ongoing agrarian change for sustainable outcomes.

Sustainability governance framework for agrarian change

In the past decades, the literature on agrarian change has been primarily driven by the logic and arguments around structural transformation, and that focus has mainly highlighted the importance of the economy and growth (Lin and Wang 2017; Mensah et al. 2016). The issue of agrarian change has been more socially and economically framed in the literature. As identified by Djurfeldt et al. (2018), structural transformation primarily affects three processes of agrarian change, which are (1) intensification of agriculture for higher crop yield, (2) commercial diversification of agricultural production, and (3) diversification into non-agricultural sectors. Accordingly, scholars have advocated for policy actions to enhance agricultural productivity and stimulate reforms in both agriculture sector and non-agricultural economy in rural settings (Barrett et al. 2017; Lin 1992). Critical scholars of agrarian change have taken this focus to task, and their work highlights the importance of equity and social goals, as well as the uneven nature of transformation in the agrarian societies (Hall et al. 2017; Martiniello 2019; Sunam and McCarthy 2016).

However, much of the current work insufficiently brings the social and economic dimensions together. Consequently, there is a lack of a well-developed theory of when agrarian change or structural transformation happens. Debates continue regarding whether external interventions

should focus on smallholder farmers or commercial producers, or whether the state should prioritize large- or small-scale farms, or whether state, capital, or civil society play greater roles in shaping social and economic outcomes in the rural world. Nor do we have an adequate understanding of when and what kinds of structural transformation for agrarian change lead to more rather than less equitable outcomes. Therefore, even as the focus has been on the social or the economic domains, the linkages need to be understood and elaborated more clearly.

Additionally, in a world of climate change, scholarship on agrarian change, which has generally focused far more on its social and economic dimensions, needs greater articulation with its environmental dimensions. The environmental dimension of agriculture has always been important; however, the environmental struggle tends to be sidelined in favor of the goal of taming nature as justified by the state and other development agents (Borras et al. 2022a; Lu and Schönweger 2019). Unfortunately, many dire predictions of climate change have been realized over the past decades (Steffen et al. 2015). The growing frequency and intensity of catastrophes provoke challenges about how to ensure both human and environmental well-being given climate change. Therefore, addressing these issues through the lens of agrarian transition and structural transformation is insufficient at best, and may lead to poor identification and application of solutions.

We argue that it is necessary to confront the reality that the ongoing challenges are not agrarian issues alone in the cause, process, and outcomes. They are sustainability challenges in the rural world that require coordination across the social, economic, and environmental dimensions (Liao et al. 2023). The agrarian change issue stands beyond an independent domain and intersects with the socio-economic transformations that shape climate and environmental changes and adaptation practices. Without integration between the socio-economic processes and biophysical changes, analyzing adaptation practices might miss the goal of facilitating agrarian change toward more desirable outcomes.

We adopt the sustainability governance framework to analyze the role of state, capital, and NGO in the process of agrarian transition (Agrawal et al. 2022). In contrast to focusing on either structural transformation or climate change adaptation in the rural world, attention to sustainability governance would situate the broader goal of sustainability at the core of the ongoing agrarian transition. Such a shift calls for an adjustment of analytical attention to understanding the synergies and tradeoffs across the social, economic, and environmental dimensions in the rural settings affected by the three distinct external drivers—state, NGOs, and capital (Fig. 1).



Fig. 1 Social, economic, and environmental dimensions of sustainability governance under external drivers

A refocused examination of sustainability governance for agrarian change under different external drivers exhibits two aspects of novelty. On the one hand, it considers the social, economic, and environmental dimensions of agrarian change linked to different types of development projects in the era facing prominent climate turbulences and disasters. In this context, the state's role in shaping policy, NGOs' influence in community-driven development, and capital investments from market actors become particularly salient. Understanding the synergies and tradeoffs across different outcome dimensions become crucial in assessing the varying impacts of interventions by the state, NGO, and market forces in rural settings. On the other hand, emphasizing the governance aspect of these development projects sheds light on how different interventions can potentially bring about institutional transformations for more inclusive and sustainable outcomes. Such a focus would be crucial for improving future rural development interventions so as to promote sustainability in their target communities in the context of climate change.

State-driven agrarian change

Since the 1950s, the state has been central to rural development throughout the Global South (Bernstein and Byres 2001). Despite decades of deregulation of financial markets, adoption of new agricultural production technologies, expansion of agribusiness capital, and ascendancy of neoliberalism (Bernstein 2012), state remains to be a major player in the process of agrarian change in many contexts (Cabral and Amanor 2022). As argued by Bates (1984), because of state efforts to secure control over the rural world and its inhabitants, it largely defines the distinctive features of agrarian societies, as well as their transition trajectories and outcomes. Through structural adjustment programs, economic liberalization, and various development interventions, many rural areas are imposed with different reform agendas by the government (Mensah et al. 2016).

In this article, we use the recent case of Targeted Poverty Alleviation in China to discuss how state-led development

has shaped agrarian change within its border. The state justified its unprecedented scale of rural poverty reduction interventions as addressing the widening disparity between rural and urban household income. The remarkable economic boom since its market reforms in 1978 boosted household income in both rural (from 134 to 11,422 RMB between 1978 and 2015) and urban areas (from 343 to 31,195), but the gap increased over the past decades, resulting in a Gini coefficient over 0.5 that indicates a high level of inequality (Xie and Zhou 2014). Such a gap would be greater if differences in social welfare are considered. Consequently, reducing such a widening gap between urban and rural areas has been identified by the Chinese government as a top priority (People's Daily 2017). To address these challenges, in 2014, the government initiated the Targeted Poverty Alleviation Program that emphasizes both precision targeting and capacity enhancement. The government planned to allocate subsidies and assistance according to the official records of poverty at the household and village levels. In the long term, the poor households are expected to become self-sustaining through the enhancement of productive capacities in both agricultural and industrial sectors (Liu et al. 2017).

In addition to addressing the widening economic gap, the poverty alleviation effort in China's rural areas is also expected to contribute to climate change mitigation in the broader state agenda. The sparsely populated rural areas in western China are considered as ideal locations to promote the share of renewable energy in the country's energy portfolio (Geall et al. 2018). Accordingly, the energy sector is mobilized to build photovoltaic (PV) infrastructure under the overarching poverty alleviation program (Fig. 2). Indeed, such efforts are closely aligned with China's recent commitment to a carbon peak before 2030 and carbon neutrality by 2060 (Liu et al. 2022).

Recent studies have shown that the targeted poverty alleviation program has transformed the rural landscape in

China (Davie et al. 2021). To illustrate this point, consider Qinghai Province in western China. In 2017, the province had a population of 5.98 million, with rural residents making up 3.44 million of this total. Furthermore, the per capita disposable income of farmers and herders in Qinghai was only 9460 yuan—just 70.4% of the national average (Jiang et al. 2020a). Interventions in the energy sector for poverty alleviation demonstrate the synergy between renewable energy development and the enhancement of rural agrarian livelihoods. The revenues generated from solar farms serve as an example. These funds have been funneled into creating welfare positions via a cash-for-labor scheme tailored to benefit local communities. Additionally, the income from solar energy projects has been strategically invested in upgrading health and education infrastructure and supporting the local collective economy. Together, these efforts significantly contribute to improving agrarian livelihoods in rural areas (Lo 2021).

While the program has achieved noteworthy success, it has also generated other unintended consequences in the socio-economic and environmental dimensions. Most strikingly, it has inadvertently exacerbated local inequality. By concentrating resources on officially designated 'poor' households and villages, the program boosts their wellbeing but marginalizes neighboring households and villages not included in the official poverty alleviation framework. This selective allocation of resources not only perpetuates inequality but also heightens the likelihood of intra- and inter-village tensions and contentious mobilizations in rural China (Liao et al. 2021a).

The second unintended consequence is the exacerbation of regional inequality. Although the solar farms are built in rural areas of western China, the clean energy they produce is largely exported to other parts of the country via ultra-high voltage transmission lines. The development of large-scale solar farms in the 'underutilized' land of western

Fig. 2 Solar farm built for poverty alleviation in Qinghai, China



China fulfills the broader agenda of boosting the share of renewable in China's energy portfolio and catering to the demands of consumers in coastal areas. However, it neglects the pressing need to enhance clean energy consumption within the very rural communities where these farms are located. In addition, the PV manufacturers responsible for constructing this massive infrastructure are predominantly based in eastern China and, as such, reap a significant share of the revenue generated. This lopsided distribution of benefits perpetuates and intensifies geographical disparities in development across China (Liao et al. 2021a).

While PV infrastructure certainly contributes to increasing the share of renewable energy in China, the goal of facilitating local energy consumption behavior change is barely achieved. The share of biomass and fossil fuels (such as cattle dung, firewood, and coal) in the energy portfolio of rural households in Qinghai remains to be dominant (Jiang et al. 2020b). For example, in the Tibetan villages, local households still rely predominantly on fossil and biomass energy. Transitions in energy consumption behavior requires the alignment of technologies, institutions, market, and consumer practices (Geels et al. 2017). But in rural Qinghai, the pastoral and agropastoral communities are yet to develop a set of cultural practices that primarily rely on electricity as the major energy source (Geall et al. 2018). Consequently, the poverty alleviation program's ambitious goal of facilitating energy transition in these communities remains largely unfulfilled, despite the considerable clean energy infrastructure developed in the region. Moreover, the environmental impacts and conflicts arising along the commodity chain of the PV products are often masked or shaded by the green and renewable discourses (Hu 2023; Sovacool 2021).

NGO-driven agrarian change

Non-governmental organizations play a crucial role in facilitating agrarian change and adaptation to climate change. Their role is highly prominent in countries or regions where state capacity and resources remain limited (Werker and Ahmed 2008). In certain parts of the world, NGOs have become more impactful than the state in determining the development agenda and trajectories (Bernal and Grewal 2014; Bratton 1989). Existing research has revealed that NGOs can generate significant effects on improving the livelihoods of the rural population (Alvi and Senbeta 2012) and enhancing their capacity to adapt to various socio-economic and environmental shocks (Brockhaus et al. 2013; Funder and Mweemba 2019). However, NGOs are criticized for lack of accountability for the rural poor whose livelihoods they aimed to improve (Bebbington 2005). Existing research findings reveal that individual NGO intervention projects might be poorly aligned with the development goals of the

state or community (Andrews 2014). Another criticism of NGOs that merits discussion is the issue of project longevity; specifically, many NGOs operate on a typical 4 to 5-year funding cycle and often exit communities without leaving a sustainable plan for continued development (Liao and Fei 2017). Therefore, the question of how NGO interventions can contribute to desirable agrarian change and adaptation to climate change necessitates further scrutiny.

In this paper, we use the case of NGOs operating in the Borana Zone of southern Ethiopia to understand how cross-border development interventions shape agrarian change in the pastoralist communities. Given the arid environmental condition of Borana, pastoralism is the major livelihood strategy (Coppock 1994). The region has received massive NGO interventions over the past decades, due to a mix of factors including poor infrastructure, frequent natural disasters (i.e., drought), and natural resource-use conflict (McCarthy et al. 2000). Instead of focusing on one NGO or its project, we analyze a collection of NGO projects in Borana, including cash-for-labor to clear the encroaching bushes, water facility construction, and rangeland fencing (see examples in Fig. 3), and examine how NGO interventions generate viable opportunities for adaptation to climate change in the arid and semi-arid context, and their implications for agrarian transitions in the dryland context.

Under the influence of various NGOs, pastoralists have been diversifying livelihood strategies to adapt to climate change (Anbacha and Kjosavik 2021). In their efforts to alleviate the impact of frequent drought, NGO interventions encourage some adaptation strategies by pastoralists but discourage others. Due to water facility construction, pastoralists are getting more sedentarized. Meanwhile, they enclose more open rangelands for dry season herding, cultivate more croplands, and become more engaged in cash-for-labor projects (such as bush clearing and water facility construction). Although mobility is compromised to a large extent, pastoralists increase diversification and market exchange as alternative adaptation strategists to climate change (Liao and Fei 2017).

However, due to the pressure to show immediate impacts on the target communities to their donors, NGOs' intervention projects may not be fully accountable to the broader social-ecological systems that support pastoralist livelihoods. Despite providing the necessary assistance to pastoralists, these interventions can reinforce dependence on external aid, and compromise indigenous institutions for self-organization in natural resources management (Watson 2003). Such unintended consequences of NGO development interventions are likely to compromise the long-term sustainability of the pastoral systems in the drylands.

In addition, due to a collection of intervention projects (water facility construction in particular), traditional mobile pastoralism is being replaced by herding near permanent



Fig. 3 Boards showing completed projects by different NGOs in Borana, Ethiopia

settlement areas, which leads to greater recursive use of rangelands (Liao and Clark 2018). Alongside with the resource-use pattern change is the weakening of indigenous institutions on natural resources management and conflict resolution, which can further compromise pastoralists' capacity to adapt to the changing environment.

Capital-driven agrarian change

Since the colonial period, capital has been a major driver of agrarian change in the global rural world, which primarily aims to boost agricultural production (Green 2022). The Enclosure Movement in England in the eighteenth century was one of the earliest examples of large-scale capital-driven development in the rural world (Jones 1990). Following that, western agribusiness capital expanded to different parts of the world to seek land and other natural resources that propelled colonial exploration and reinforced the core-periphery divide between the Global North and South (Wolford 2021).

In the past three decades, however, the classical division of roles within the global agrifood system has been altered due to increasing capital engagement by emerging market investors (Watts 2012). The recent wave of agrarian change can be illustrated by the Global Land Rush for agricultural development in the past two decades (White et al. 2012), which is also known as land grabbing or large-scale land acquisitions (LSLAs). Existing global estimates of the scope of land grabs since the early 2000s suggest that the range lies somewhere between 45 and 227 million

hectares (Nolte et al. 2016; Zagma 2011). In the context of climate change and associated increase of natural disasters, food production is projected to decline in many parts of the world, which motivates agribusiness investors to seek land overseas for food production (Franco and Borrás 2019). Host country governments are also keen to pursue capital-driven agricultural development. In addition to the economic benefits of enhanced crop yield, they also expect less clearance of naturally vegetated landscapes and less carbon emissions as a result of agricultural intensification. Aligned interests between investors and host-country governments resulted in a restructured global food regime because the associated agricultural production and geopolitical relations became more polycentric (McMichael 2012, 2020).

While LSLAs for agricultural production generally falls under the umbrella of the Global Land Rush, they are highly diverse. According to Land Matrix (Nolte et al. 2016), LSLAs are distributed in 123 host countries, pursued by investors from 103 countries. Both domestic and transnational capitals are involved in the Global Land Rush. They are also subject to different contract arrangements (i.e., leases, concessions, or ownership transfers). Some transacted lands are located in the naturally vegetated landscapes, such as forests and rangelands, while others exist on existing crop fields, either used by smallholder farmers or managed as state farms. With the size of land acquisitions ranging from 12 to 860,000 ha, they are also intended for different types of crop production, including both food and non-food crops.

Different characteristics of land acquisitions are likely to generate divergent outcomes across the social, economic, and environment dimensions, resulting in vastly different trajectories of agrarian change and struggle. The divergent economic, social, and environmental outcomes depend on the scale of investment, technologies of production, labor relations, and histories of land settlement and ownership (Hall 2011; McCarthy 2010). Emerging evidence suggests that land acquisitions do not always result in intended level of crop yield (Ali et al. 2019). Reasons that can explain the mismatch between expectation and reality include poor infrastructure in rural areas, underestimation of production challenges, displacement of nearby smallholder farmers, and speculative land-based investment behavior (Clapp and Isakson 2018; Isakson 2014).

In rural areas, LSLAs concern the broader social-ecological systems, with tenure changes having the potential for generating unintended outcomes on the entire agro-ecological system and smallholder livelihoods (Meyfroidt et al. 2013). On the one hand, changed land tenure and land-use patterns may contribute to macro-level economic growth in recipient countries, and have the potential to enhance smallholder livelihoods through out-grower schemes (Herrmann 2016) or spillover effects of new agricultural production technologies (Deininger and Xia 2016). On the other hand, land tenure change risks the appropriation of land and other natural resources from the rural households whose livelihoods depend on these assets (Hajjar et al. 2020). Therefore, critical scholars have raised significant concerns on social equity and justice (Vermeulen and Cotula 2010).

Concurrently with the shifting agrarian society is the working landscape in the rural world. As transacted ‘idle lands’ are implemented for agricultural production, large swathes of naturally vegetated landscapes are converted into crop fields (see Fig. 4 as example). Consequently,

deforestation and loss of ecosystem services are commonly reported at the land conversion stage (Liao et al. 2024; Shete et al. 2016). Associated with deforestation are carbon emissions. According to recent quantification, the total amount of potential carbon loss from land clearing is estimated at 2.3 gigaton, an amount equivalent to global carbon emission estimates from land-cover change in 2017 alone (Liao et al. 2021b). Critically, the dynamics of LSLAs often exhibit a marked North–South divide, where wealthier countries or corporations based in the Global North acquire lands in the Global South. This not only exacerbates local vulnerability but also raises significant environmental justice issues. These acquisitions can displace local communities, stripping them of their rights to natural resources and exacerbating social inequities, all under the guise of development. Thus, critical agrarian scholars also call for moving beyond land acquisitions to investigating the broader issue of natural resources governance and socio-environmental justice in the rural world (Oliveira et al. 2021).

Discussion

Given the complexity and interlinked nature of social, economic, and environmental processes that underpin the ongoing agrarian change and struggle, we argue that framing them merely as agrarian issues or environmental problems is inadequate and misleading. While general systems thinking offers a wide lens to view complex adaptive systems (Levin et al. 2013), our sustainability governance framework serves as a more targeted instrument for understanding governance issues tied to agrarian transformations in a climate-sensitive context. Although the concept of social-ecological systems also accounts for the multifaceted nature of rural agrarian

Fig. 4 Recently cleared woodlands to grow soybeans in western Ethiopia



livelihoods (Ostrom 2009), our approach offers unique distinctions.

First, our framework explicitly engages in the socio-ecological system analysis approach that breaks down the social, economic, and environmental components, scrutinizing the mechanisms that link them. This targeted approach allows us to emphasize the governance structures directing these interactions, setting our framework apart from more generalized systems thinking. Second, we expand the scholarship beyond simply acknowledging feedback loops and system nonlinearity. Instead, our framework offers actionable insights for designing or modifying governance mechanisms that can handle these complex features, particularly in the context of climate change uncertainties. Lastly, while general systems thinking often addresses the interconnectedness of socio-ecological systems, our framework does so while also concentrating on the role of various external drivers—such as state policies, NGOs, and capital investments—in shaping these connections. This results in a nuanced view of governance, which is frequently glossed over in broader systems approaches.

Our analyses of state, NGO, and capital-driven development in different contexts reveal the wicked nature of agrarian transition and rural development (Waddock et al. 2015). Without sufficient consideration of climate change and attention to a sustainability framing, it is likely that research tends to focus on the primary goal of each type of development intervention while sidelining the other dimensions (Table 1). For state-driven projects, attention primarily focuses on the goal of reducing poverty and inequality (Liu et al. 2017). For capital-driven development, the primary goal is to increase crop yield and boost economic development in the rural world (Deininger and Byerlee 2011), while critical scholars have questioned the unequal outcomes across different social groups (Moreda 2015). In contrast, the suite of NGO projects analyzed in this paper have diverse goals, but each has its focal dimension (Bebbington 2005; Liao and Fei 2017).

With a sustainability framing, our analysis suggests that development projects driven by different agents can lead to various unintended consequences beyond its focal dimension. Additionally, climate change, along with its institutionalized responses and justification, further accelerates the pace of social differentiation and exclusion across different agrarian settings. Therefore, our analyses highlight the critical role of sustainability governance framing in

understanding the wicked nature of agrarian transition driven by the state, NGO, and capital.

In the case of state-driven poverty alleviation in rural China, massive fiscal input and human resources indeed improve rural livelihoods for those identified as ‘poor’, but it also exacerbates existing agrarian struggles. Unequal distribution of resources creates new local inequality between the ‘aided’ and ‘unaided’ households and villages in rural China. Meanwhile, renewable energy development in rural China further reinforces exclusion justified by climate change mitigation. On the one hand, the rural poor were barely involved in the energy transition process as their energy portfolio remains dominated by biomass and fossil fuels. On the other hand, the revenue of PV infrastructure construction primarily flows to PV manufacturers and contractors based in eastern China, while PV-generated electricity is transmitted to distant consumers (Zhao et al. 2022).

In the case of NGO-driven development and adaptation to climate change in rural Ethiopia, we reveal that these external interventions also created various unintended consequences. While rural livelihoods in the drylands primarily rely on mobile subsistence livestock herding traditionally, NGO interventions have diverted local livelihoods toward more diversified sources. While better-off households can effectively transit into livelihoods that are less subject to the impact of climate change, crop farming and sedentarization dismantle indigenous institutions and practices that were designed to make the entire dryland system resilient in the face of extreme climate events (Liao and Fei 2017; Watson 2003).

In the case of capital-driven agricultural development in the Global South, both investors and host-country governments are preoccupied with the goal of boosting crop yield, while using climate change as a justification to develop more ‘efficient’ agricultural systems as an adaptation. While some investments resulted in better development outcomes than others, the livelihoods and well-being of neighboring smallholders are typically the last on the agenda of agribusiness investors. Therefore, rural struggles continue to exist, as demonstrated by various sabotage, protests, and violent confrontations between the rural communities and the agricultural investors (Li 2018; Martiniello 2021; Moreda 2015).

Table 1 Primary goal of state-, capital-, and NGO-driven projects

Type	Social	Economic	Environmental
State	Explicit in reducing poverty and promoting equity	Implicit	Implicit
Capital	Implicit	Explicit in boosting agricultural yield	Implicit
NGO	Each NGO project has its own specific focus but is implicit on outcomes beyond its focus		

Conclusion

As the world grapples with escalating challenges of climate change and agrarian struggles, the vulnerabilities of marginalized communities, particularly the rural poor, have become increasingly exposed. In this context, it is imperative to adopt the sustainability governance framework for understanding the social, economic, and environmental dynamics of agrarian change. Such a framework is essential for crafting policies and interventions that are both sustainable and inclusive. Regardless of whether these agrarian transitions are driven by state policies, capital investments, or NGO initiatives, adopting a sustainability lens provides critical insights into managing the multi-dimensional challenges that these changes present.

Future research on agrarian transition needs to integrate the social, economic, and environmental dimensions and examine the full array of outcomes from interventions by the state, capital, and NGOs. Understanding such joint outcomes requires carefully designed research that is usually transdisciplinary, and reliable data on human and environmental wellbeing in the rural world would be essential to constitute a comprehensive understanding of the complexity of agrarian change. Collection of a range of indicators across the social, economic, and environmental dimensions will be crucial because the trajectory of agrarian transition is often complex and multifaceted. Thus, research protocols must incorporate regular and repeated monitoring of rural wellbeing and the ecosystems that sustain their livelihoods, and track the evolution of agrarian societies affected by various development interventions.

We envision future policy-making to center on enhancing the capacity and agency of rural populations to facilitate agrarian transitions for sustainable and just outcomes. It is crucial to recognize that in the context of climate change, rural development interventions must be able to mitigate risks without compromising the wellbeing of people and the environment. Future development interventions should contribute to local institutions and build on local people's motivations to make a difference. Attention to sustainability in the process of agrarian transition can help facilitate a shift toward transformations that are more equitable, just, and flourishing.

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