Global Environmental Change 80 (2023) 102651

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Beyond the boom-bust cycle: An interdisciplinary framework for analysing crop booms

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ARTICLE INFO

Keywords:
Crop boom cycles
Governance
Nested scales
Variegated pathways
Conceptual framework
Mekong Region

ABSTRACT

The expansion of commercial agriculture is one of the primary drivers of livelihood and land-use changes in the world. Globalisation and other factors have intensified this expansion to the point where booms in single cash crops overtake entire regions before going bust, a pattern that is particularly pervasive in resource frontiers. Using case studies across the Mekong Region, a place which serves as a harbinger for crop booms globally, we propose a new analytical framework for understanding and governing crop booms. We combine multiple theoretical approaches to study crop booms and draw on insights from case study work conducted across temporal and spatial scales. The framework consists of three components: 1) the nested nature of crop boom-bust trajectories, 2) the cyclical spatial and temporal patterns of crop booms, and 3) the variegated pathways and impacts of agrarian change. The framework presents new insights into the processes of agricultural intensification in frontier spaces. As such, it facilitates a better understanding of the drivers, characteristics and impacts of crop booms for researchers and decision-makers alike with the intention of supporting efforts to develop more sustainable pathways in the region and beyond.

1. Introduction

The expansion of intensive agriculture has taken on unprecedented forms over the last two decades. It is a primary driver of land conflict, landscape transformation, and related biodiversity loss globally (IPBES, 2019). While intensive agriculture is hardly new, a growing body of scholarship examines the rise of 'crop booms' – a term still inconsistently defined but used to mark an extreme iteration of agricultural expansion. Crop booms scholars argue that the globalisation of agricultural capital and value chains, reductions in regulatory barriers to foreign investment in land, and increasing porousness of borders (among a long list of other factors) have all driven the proliferation of crop booms around the world in the past two decades (Castella et al., 2016; Münster, 2015). With this proliferation have come concerns for their environmental (Fehlenberg et al., 2017; Hurni et al., 2017; Tenneson et al., 2021; Gasparri et al., 2016) and socioeconomic impacts (Zuo et al., 2021; Hua et al., 2021; Nghiem et al., 2020; Gatto et al., 2015), along with calls for improved governance (Andreotti et al., 2022).

Crop booms pose serious challenges to research and land governance. The drivers of booms – both in terms of the political, economic

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https://doi.org/10.1016/j.gloenvcha.2023.102651
Received 12 May 2022; Received in revised form 5 February 2023; Accepted 7 February 2023
Available online 16 March 2023
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and biophysical factors, and the multiple actors involved – increasingly span national borders, making them difficult to trace and govern. Their complex temporal and spatial dynamics obscure their impacts across scales. Smallholder farmers play a varied role both as actors driving booms and as a group most directly affected by their social and environmental costs (Fox and Castella 2013; Hall et al., 2011). The tendency for cash crops to be introduced in rapid boom and bust patterns has left rural communities, national policymakers, and development planners struggling to manage and mitigate their impacts. The described challenges, compounded by the speed and scale at which booms occur, leave decision-makers among each of these groups resorting to reactive instead of proactive planning. Due to the complexity of their drivers, their dynamic speed and spatial reach, and their implications across scales and actors, researching crop booms with a view to informing more effective governance requires new interdisciplinary and integrative frameworks.

For our purposes and to differentiate and bound the concept, we define crop booms as the rapid and extensive establishment of a single cash crop, produced under intensive monoculture and for markets (instead of subsistence and usually but not always for export), which permanently alters the area's land ownership, resource management, and agricultural production structures. Some refer to crop booms as a conjunctural moment (Mahanty and Milne 2016), some a "land system regime shift" (Junquera and Grêt-Regamey, 2019), some relate it to the closing of land frontiers (Li, 2014), but the common emphasis we trace across fields and scholars is this sense that the changes triggered by crop booms are systemic, difficult to reverse, and lock producers into the crop boom (and bust) model.

Crop booms emerge especially rapidly in resource frontiers, or spaces having (or perceived or socially constructed as having) low population density, natural resource abundance and unexploited 'available' land (White et al., 2012). The upland areas and borderlands of the Mekong Region,[1] where all the authors of this paper work, are spaces exemplary of resource frontiers and have been heavily targeted by state and corporate actors alike as apt places to expand commercial agriculture (Sikor et al., 2011; Rudel and Meyfroidt, 2014; Taylor, 2016; Vongvisouk et al., 2016). Similar processes have driven encroachment upon other landscapes, such as coastal mangroves or wetlands (for example: Primavera 2005; de Lacerda et al., 2021; Ilman et al., 2016; Belton et al., 2017a,b; Hall, 2011b), and even boreal regions (Meyfroidt 2021). Frontiers are often understood as sites of rapid landscape change and as sites of capitalist expansion where property and labour systems are fluid and unsettled (Barney, 2009; Tsing, 2005). State policies for attracting foreign direct investments coupled with a view of high-input industrialised agriculture as the preferred development approach (Harwood, 2019), rising financialisation of farming (Genoud, 2018), and infrastructure development have all paved the way for crop booms. In frontier regions shaped by informal land tenure regimes or opaque or insecure property relations, crop booms drive a reorganisation of land relations as various actors seek to control access to increasingly valuable land (Hall et al., 2011).

A global rise since the 2000s in 'land grabs,' or large-scale land acquisitions, by transnational agribusiness investors is linked to trends in crop booms (Borras et al., 2011; Borras et al., 2018; Folke et al., 2019; Messerli et al., 2014). Though neither are new, the rise in large-scale land acquisitions was driven by shifts in the global food system that also catalyse crop booms: by the revival of logics supporting plantation agriculture, by shifts in land governance leading to the sector's financialization and consolidation, and by the reorganisation of capital in the agribusiness sector (McMichael, 2012). And while they overlap somewhat, the concept of crop booms draws our focus to broader constellations of actors driving boom crop production, including smallholders, local entrepreneurs, cross-border traders, state actors, and local and migrant smallholder farmers (Cramb et al., 2017; Li, 2014). Indeed, smallholder engagement in crop booms ranges from incorporation into commercial production through outgrower schemes, contract farming arrangements, leasing land to agricultural investors, and family farms that independently produce and sell crops (Rigg et al., 2016; Zaehringer et al., 2020). While this complex mix of arrangements and actors often facilitates and fuels crop booms, smallholder farmers play pivotal roles in mediating access to land, labour, and resources, as well as entering into contracts to grow cash crops. Simultaneously, smallholder farmers often bear the brunt of environmental degradation, economic insecurity, resource exclusions and increasing socioeconomic differentiation that follows crop booms and busts. Thus, smallholders represent a bridge between global food markets and fertile land, and are at the centre of crop booms and the broader, ongoing agrarian transformations they are part of.

Crop booms are a worldwide phenomenon, but the Mekong Region is an important locus for their study. Governments and development donors have emphasised agricultural sector commercialization and export-led growth development in the region since the 1960s, laying the foundations for the region's dynamic transboundary agricultural value chains (De Koninck and Rousseau, 2012). Policy support, development aid, and favourable land policies have helped smallholder production – in both subsistence and market-oriented forms – remain unusually persistent across Southeast Asia (Rigg, 2020; Rigg et al., 2016). The resolution of (or pause in) military conflicts, the steady opening of borders to trade and of land markets to foreign agribusiness investment, and the close proximity between countries with skyrocketing demand for agricultural imports (China, Vietnam, Thailand) and those seeking markets for a growing export-oriented agricultural sector (Laos, Myanmar, Cambodia) have all shaped strong enabling conditions for crop booms (Hall et al., 2011; Schoenberger et al., 2017). The rise of crop booms has therefore had profound and varied consequences for the millions of smallholder farmers inhabiting frontier landscapes across Southeast Asia. These conditions are not unique to the Mekong Region – the same patterns play out in other contexts with examples in Africa (Kydd, 1988; Woods, 2007; Ross, 2014; Antwi-Bediako and Abubakari, 2019; Llopis et al., 2022), Latin America (Carter et al., 1996; Barbier, 2004; Borras et al., 2013; Gasparri et al., 2016), other parts of Asia (Clough et al., 2009; Gatto et al., 2015; Kelley, 2018; Griffin, 2020; Belton et al., 2017a,b; Andreotti et al., 2022 provide a cross-regional study). Our focus on multiple cases from a single region allows us to demonstrate crop boom patterns linked across scales and country contexts, which individual accounts from different regions do not so easily reveal.

In this paper, we synthesise our collective empirical knowledge to develop an analytical framework to understand crop booms. From research in the Mekong Region over the past 10–15 years, we have observed how crop booms arise, progress, and repeat across the region over time. Our case studies show many similarities in the drivers behind land-use trajectories and local outcomes of crop booms, while also displaying the variegated pathways and differentiated impacts of agrarian change that accompany them. Through a collaborative process of comparing and contrasting our case studies, we aimed to distil the key mechanisms and conditions that underpin crop booms, the patterns through which they unfold, the dynamic processes of crop expansion, and their outcomes in terms of agrarian change. Our research draws on different scholarly traditions, especially land system science, actor and commodity network theories, and agrarian studies and political ecology. This interdisciplinary theoretical background provides a collective strength in establishing a framework to understand crop booms and their diverse and complex interactions between land users, institutions, the biophysical environment, and markets across scales. In developing the framework, we drew on these theoretical perspectives to identify key elements and relationships that characterise the patterns, drivers and impacts of crop booms.

[1] The Mekong Region includes Southern China, Myanmar, Lao PDR, Thailand, Cambodia, and Vietnam.

The crop boom framework we present consists of three components, each of which addresses aspects of crop booms we have found are frequently misunderstood or overlooked: 1) nested crop boom-bust trajectories, 2) movement and cycles of crop booms, and 3) the variegated pathways and impacts of agrarian change. Ultimately, the presented framework aims to facilitate the identification of leverage points to foster more sustainable processes of agrarian change in the region and beyond. In the next section, we present the theoretical lenses that underpin our research and are used to frame the case study comparison, followed by a description of our methodological approach and introduction to our empirical case studies. We then present the components of the framework and, finally, we discuss the analytical relevance of the framework for research and policy on moving beyond crop boom-bust cycles towards sustainable agricultural futures.

2. Theoretical lenses

Crop booms have been studied through multiple theoretical lenses. Each lens seeks to address how crop booms emerge, the trends and patterns through which they progress, and their impacts. However, each focuses on different aspects, approaches crop booms from different analytical starting points and applies different methods. Here, we present key insights from the main bodies of literature that have contributed to crop boom studies and informed our own empirical work (Fig. 1).

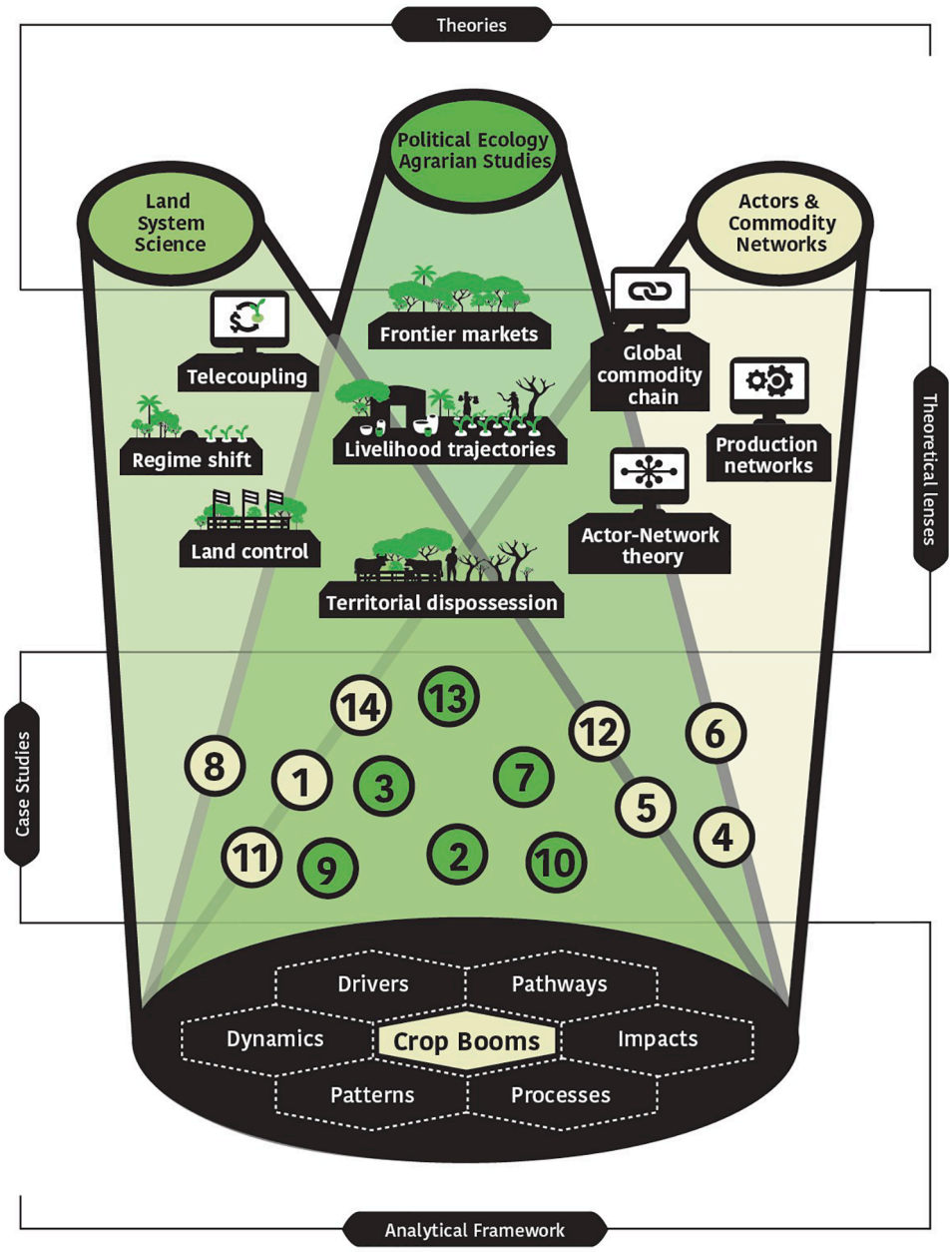

Fig. 1. Multiple theoretical lenses combined with a comparative analysis of case studies inform the analytical framework. Each theoretical lens illuminates aspects of the central themes for studying crop booms, and each case study used in the case comparison is informed by one or more of the theoretical lenses.

2.1. Land system science

Land system science analyses and models the spatial patterns, cross-scalar drivers, decision-making processes, and varied social-ecological outcomes of land-use and land-cover change (Müller and Munroe, 2014; Turner et al., 2007; Verburg et al., 2015). Recent work has examined the increase in commodity crop booms in forest frontier regions and other vulnerable ecosystems (Garrett et al., 2019; le Polain de Waroux et al., 2018; Meyfroidt et al., 2014). One key focus has been on the complex cross-scalar drivers and causal mechanisms, also referred to as telecouplings, that tie crop booms to distant demands for agricultural products and drive social-ecological change through land-use displacement and cascade effects (Friis and Nielsen, 2019; Lambin and Meyfroidt, 2011; Meyfroidt et al., 2013). The concept of land use regime shifts also provides a useful theoretical lens for characterising and analysing the abrupt and transformative nature of crop booms (Ramankutty and Coomes, 2016). Indeed, several authors have associated crop booms as catalysts for large, persistent, and usually unexpected changes in social-ecological systems with major impacts on ecosystem services, and consequently, on human well-being, which can be seen as constituting full regime shifts (Biggs et al., 2018; Müller et al., 2014).

Land system science uses a broad range of modelling approaches, including spatial land-use models, agent-based models, gaming approaches, and Bayesian models. In relation to crop booms, these tools have been used to model the location and spatial patterns of crop booms (Ornetsmüller et al., 2019), as well as smallholder land-use decision-making on multiple spatial and temporal scales (Junquera et al., 2020; Ornetsmüller et al., 2018). A central aim for land system science has been to use large-scale modelling studies, remote sensing analysis, and meta-analyses to generalise pathways and trajectories of change for specific land-use changes (Meyfroidt et al., 2018). Increasingly, land system science scholars have focused on various governance tools and mechanisms for addressing the unsustainable outcomes of land-use change embedded in global market dynamics and commodification of agriculture, including supply chain interventions and other tools directed at or developed by corporate actors driving commodity crop expansion (Meyfroidt et al., 2020; Lambin et al., 2020; Munroe et al., 2019). Land system science offers perspectives for analysing dynamics of crop booms, pathways and trajectories, as well as the drivers of land-use changes behind them. This lens especially informs cases by Bruun, Castella, Friis, Junquera and Ornetsmüller in Section 3 (Table 1).

2.2. Critical agrarian studies and political ecology

Critical agrarian studies and political ecology both examine rural resource use and socioeconomic differentiation processes, highlighting how unequal power relations can drive economic and environmental change. Both fields of research, for example, pay particular attention to questions of how land and resource access, control, and tenure shape crop booms and their uneven outcomes (Hall et al., 2011). Political ecology furthermore shares with land system science a view that society and environment are intertwined, and that land is foundational for understanding various aspects of agrarian environmental change (Turner and Robbins, 2008).

Agrarian studies is focused on how capitalist production systems expand into rural spaces and restructure social relations (Akram-Lodhi and Kay, 2010; Kautsky, 1988; Edelman and Wolford 2017). The field has uncovered how market integration inherently creates agricultural classes (Bernstein, 2010; Lenin, 2004), which experience differentiated livelihood trajectories and wealth inequality (Marschke and Vandergeest, 2016; Rigg and Vandergeest, 2012; Schoenberger et al., 2017). The field has examined how these processes intersect with social reproduction (McMichael, 2008; Naidu and Ossome, 2016), and often lead to land dispossession (Levien, 2018). The friction between smallholders, industrial agriculture, and the boom in transnational land investments in the past two decades has been another major focus of this field (Borras and Franco, 2012; White et al., 2012). Also prominent are discussions of elite facilitation of frontier markets (Gellert, 2015; Ong, 2012), the mechanisms through which territorial exclusions occur (Hall et al., 2011) and the heightened vulnerabilities wrought by these developments (Li, 2010; Sassen, 2014).

Political ecology overlaps with agrarian studies in its emphasis on the political economy of rural development and agrarian transformation, while bringing a sharper emphasis on nature-society relations. It contributes to our study of crop booms an understanding of their socio-material dimensions (e.g. biophysical characteristics of crops, ecological dimensions of production systems) (Peluso and Vandergeest, 2020) and a commitment to countering apolitical and ahistorical framings of environmental issues in order to advance equitable and just social-ecological change (Robbins, 2019). Political ecologists understand crop booms as produced through the intersecting interests of politically and economically powerful actors, enabled by frontier land and labour configurations (Hall, 2011a; Li, 2014; Mahanty and Milne, 2016). Moreover, the social and political dimensions of a given crop's production, which differ under plantation estate versus smallholder systems, shape the dynamics of a crop boom and explain their uneven outcomes across actors involved (Bissonnette and De Koninck, 2017; Byerlee, 2014; Cramb et al., 2017). Agrarian studies and political ecology bring theoretical grounding to understanding the social, political and economic structures that enable the development of crop booms, as well as the processes that govern their development and their variegated outcomes. They form the basis of analysis for cases by Kenney-Lazar, Lu, Mahanty and Friis in Section 3 (Table 1).

2.3. Commodity chains and production networks

As agricultural systems have become increasingly embedded in globalised markets, methods examining actors and drivers as interconnected, instead of individual or place-based, complement approaches like land system science. Commodity and value chain analysis, global production networks, and actor-network theory, all aim to describe, map and explain the spatially dispersed and complex connections through which specific products are produced, distributed, and consumed. These approaches particularly inform cases by Cole, Mahanty and Vagneron in Section 2.2.

Given the significance of global markets to localised crop booms, some of the research underpinning this paper uses global commodity and value chain analyses to contextualise interrelated asymmetrical global structures of labour, production, consumption, and revenue capture by corporate actors and others (Bernstein and Campling, 2006; Gereffi et al., 1994; Ponte et al., 2019). Value chain analysis adds insights on how actors can improve their position in the chain to gain higher returns or reduce their exposure to risks, for example by producing high-value export crops (Bolwig et al., 2010; Dolan and Humphrey, 2000). Some value chain studies also address the social and environmental risks faced by smallholder farmers who produce relatively low-value commodities of the type studied in this paper, such as maize, cassava, rubber (Kaplinsky, 2000; Riisgaard et al., 2010). Global production networks analysis adds attention to how firm strategies and complex power relations underpin spatially dispersed production and uneven developmental outcomes that are both embedded within and also reshape the territories where they operate (Coe and Yeung, 2015; Henderson et al., 2002; Hess, 2004). In relation to crop booms, commodity or value chain and production network approaches trace connections across multiple territories, extending analysis beyond direct actors (such as farmers and traders in the context of crop booms) to incorporate indirect actors such as local officials who mediate access to land (Neimark et al., 2016) or transnational firms that operate at arm's length from producers via networks of intermediaries.

Finally, as noted earlier, analysis of social and material networks can provide important insights on how farmers are 'enrolled' (Callon, 1984) into the production of new commodity crops. This has been a focus in

Table 1
Comparison of drivers and impacts across author case studies. See supplementary material Table S1 for the full details on site location, theoretical lenses and methods used in each study.

Study	Land-use change	Drivers of crop booms	Socioeconomic impacts	Environmental impacts
Hepp et al., 2019 (1) 2 villages **Maize** **Laos**	From shifting cultivation to maize mono-cropping	Improved market access (infrastructure development).	Increase of average wealth. Increase of indebtedness (fluctuating prices of maize). Increase of inequality among village households. Perceived increase of food security.	Loss of tree cover as fallow lands were turned into permanent fields; Erosion associated with development of feeder roads; No reports of declining yields.
Ornetsmüller et al., 2018 (2) 9 villages **Maize** **Laos**	All stages of the maize boom from shifting cultivation to maize mono-cropping and to crop diversification away from maize	High demand for maize by neighbouring countries. Improved market access (network of intermediaries providing inputs and collecting harvest). Land use policies incentivizing cash cropping and penalising shifting cultivation. Poverty and the desire to escape from it.	Increase of average wealth. Increase of inequality among village households. Increase of indebtedness. Reduction of food sovereignty and security. Partly selling of land and outmigration.	Soil erosion Loss of biodiversity. Land concentration. Simplification of landscape mosaics. Deforestation (fallows turned to permanently cultivated fields).
Castella and Phaipasith, 2021 (3) 5 villages **Maize** **Laos**	Expansion of maize cultivation through construction of feeder roads	High demand from Vietnam due to expanding livestock industry. Improved market access (infrastructure development). Incentive policy from district governor who invited Vietnamese traders to introduce maize.	Improved livelihoods (e.g., number of assets, children schooling, housing quality). Increased indebtedness (input costs, construction of feeder roads). Upland rice fields moved to the periphery of the village territory increases drudgery for the poorest. Increased off-farm activities.	Deforestation and land degradation. Soil erosion Loss of soil fertility Decline in yields partially compensated by the use of chemical fertilisers and expansion of feeder roads to claim additional land from former upland rice fallows.
Vagneron and Kousonsavath, 2015 (4); Yadav et al., 2021 (5) 10 villages in Laos **Maize** **Laos, Vietnam**	Expansion of maize cultivation through cross-border trade between Laos and Vietnam	High demand from Vietnam (animal feed and ethanol production). Declining productivity of monocropping in Northwest Vietnam pushing traders to source from Laos. Agricultural commercialization policies in Laos. Strong cross-border relations between Lao and Vietnamese villages.	Income improvements. Farmers locked into unfair agreements with traders over long periods of time (feeder roads and provision of inputs, cash credit). Increased indebtedness (input costs, construction of feeder roads). Vicious circle of maize dependency: lower yields lead farmers to plant even more maize.	Soil erosion (mono-cropping) Loss of soil fertility. Decline in yields Increased pollution (herbicides) Deforestation (building of feeder roads to access new maize fields).
Cole, 2022; Cole and Rigg, 2019 (6) 2 villages in Laos **Maize** **Laos, Vietnam**	Expansion of maize cultivation in Lao-Vietnamese borderlands influenced by feed/livestock production in Vietnam	High demand from Vietnam for animal feed. Declining productivity of monocropping in Northwest Vietnam pushing traders to source from Laos. Agricultural commercialization policies in Laos Anti-opium campaign (early 2000s) eradicates poppy but fails to provide alternative, traders step in to fill vacuum. Farmers receptive to new commercial opportunities.	Income improvements, asset purchases. Improved accessibility of nearest district towns. Extension of schooling among children and youth. Reduction in household labour force, later affects household ability to keep producing maize and rice to support themselves. Increased payments for inputs, falling profits and evidence of indebtedness.	Land degradation. Decline of fallow rotation for upland rice production. Soil erosion. Landslides in rainy season damaging paddy land of lower villages. Chemical runoff.
Kong et al., 2021, 2019; Kong and Castella, 2021 (7) 10 villages **Maize, cassava** **Cambodia**	From shifting cultivation (fallows) to hybrid maize, cassava and fruit trees.	High demand from Vietnam for animal feed. High prices Expansion of road networks and migration from populated lowlands to upland areas Market expansion (local traders and intermediaries), emerging land tenure system in land frontiers, mechanisation, massive use of chemical inputs and new hybrid cultivars.	Income improvements Asset purchases. Increase of inequality among village households, depending on migration period, labor and capital available at installation Increase of indebtedness. Poor households engaged in outmigration, off-farm activities, and landlessness.	Large-scale deforestation and forest degradation. Landscape simplification. Erosion of biodiversity; Land use intensification Increased pollution (herbicides).
Bruun et al., 2017 (8) 2 villages **Maize** **Thailand**	From shifting cultivation of upland rice to monocropping of maize.	High demand for maize (for feed) leading to favourable prices Land use policies (pledging schemes, introduction of micro-loans) supporting maize cultivation. Enforcement of ban on shifting cultivation with frequent inspections and severe penalties forced farmers into continuous cropping systems.	Increase of average wealth. Increase of indebtedness; Increase of inequality among village households. Out migration. Health problems due to the use of agrochemicals for maize cultivation.	Expansion of area under cultivation and intensification of shifting cultivation system towards continuous cropping leading to tree cover loss, but not deforestation of areas that were not already a part of the shifting cultivation system. Landscape simplification. Declining soil fertility and surface crusting leading to erosion on fields on steep slopes.
Pin Pravalprukskul, *on-going* (9) 10 villages	From maize to rubber	Lower labour availability from farmer ageing and out-migration of household members. High input requirements and costs due	Remaining indebtedness from maize cultivation. Differentiation in rubber adoption	Tree cover gain after a period of tree cover loss during the maize boom.

(*continued on next page*)

Table 1 (*continued*)

Study	Land-use change	Drivers of crop booms	Socioeconomic impacts	Environmental impacts
Maize, rubber **Thailand**		to declining maize yields and increasing prices. Rubber market expansion.	based on resources and financial need.	
Mahanty, 2022, 2019; Mahanty and Milne, 2016 (10) 8 villages **Cassava, rubber, cashew, pepper** **Cambodia**	From cassava and maize to rubber, cashew, pepper.	High demand from starch, biofuel and other processing industries in Vietnam and China. Migration and land-claiming spatially expanded market production. Crucial role of traders in knowledge and cultivar sharing, and as guaranteed buyers.	Land concentrated among elites and early smallholder land claimants. Subsequent migration provided labour for crop booms. Increased incomes in early stages of boom for middle to higher socioeconomic status households. Then indebtedness as farmers borrow for labour and crop inputs, and to transition to more capital-intensive crops e.g. rubber, pepper. Those without land staying in labouring roles; crucial to boom process. Onward migration emerging due to debt-related land loss.	Deforestation. Soil degradation. Cassava disease.
Junquera et al., 2020; Junquera and Grêt-Regamey, 2020, 2019 (11) 11 villages **Rubber** **Laos**	From shifting cultivation (fallows) and old-growth forest to rubber plantations.	High demand from China. Rising rubber prices after 2002. Opium Replacement Program in 2004 promoting cash crops for exports. Land-use regulations restricting shifting cultivation. Cross-border relations between Lao and Chinese villages, sharing information about lucrative rubber plantations in China.	Increase in average household income. Improved livelihoods (brick houses, acquisition of imported consumer goods such as motorcycles). Many communal areas (e.g., Village Use Forests) converted to privately owned rubber plots. Disappearance or reduction of shifting cultivation fallows and associated reduction in access to non-timber forest products. Cash crop production increased average income, but also income variability.	Loss of biodiversity. Increase in soil erosion from conversion of forest or shifting cultivation fallows to rubber. Increased pollution of soil and water due to intensive rubber management practices.
Kenney-Lazar, 2009 (12) 68 villages **Rubber** **Laos**	Shifting cultivation fields and fallows (older growth forest less often) to monoculture rubber plantations.	Cross-border relations between villagers in Laos and China of the same ethnicity. Increased prices (until 2011). Chinese policies (e.g. opium replacement) and investment. Lao government promotion: low-interest loans, facilitating connections between companies and villagers, restricting swidden cultivation and encouraging rubber as a permanent crop. Increasing availability of materials at lower prices (seedlings, tools) and spread of technical knowledge.	Differentiated impacts: some villages have better arrangements (growing independently, latex-sharing) that enabled them to significantly improve cash incomes, some are involved in more exploitative arrangements (land-sharing, land concessions) that have limited their cash income and led to a loss of land and resources increasing costs of livelihood maintenance, while others are more balanced making some money from rubber but maintaining other subsistence and cash livelihood options.	Loss of shifting cultivation landscape (especially fallows, young secondary forest). Loss of biodiversity (especially non-timber forest products).
Lu, 2021, 2017; Lu and Schönweger, 2019 (13) 41 villages **Rubber** **Laos**	Shifting cultivation fallow lands and upland fields to monoculture rubber plantations. Large contiguous plantations less common than scattered plots.	State policy in China (development cooperation support for cross-border investments) and Laos (opening to land investment, limits to shifting cultivation); Chinese overcapacity and demand; High global market prices through 2000 s; Closing rubber-suitable land frontier in China & Vietnam.	Rubber brings broad livelihood improvements, but with severe socioeconomic differentiation within villages, particularly across social groups with different strength of land claims, first mover villages (who are typically better resourced or located), and those with alternative livelihoods negotiate better terms with Chinese companies; Villages heavily reliant on rubber subject to company exploitation, dispossession.	Primary driver of deforestation across mainland Southeast Asia; Company preference for monoculture plantations vs smallholder engagement in different degrees of production intensity and crop diversity.
Friis and Nielsen, 2017, 2016 (14) 1 village **Banana** **Laos**	Expansion of banana cultivation on lowland paddy fields and lower foothills. Banana bust with subsequent change to sugarcane production.	High demand from China. Lower banana supply from China and the Philippines due to environmental, climatic and political factors. Investors attracted by cheap and fertile land in Laos. Economic incentives for villagers to lease out land combined with social pressure and threats from investors. Banana bust created by falling prices, disease spread and government regulations.	Income improvements (for households leasing out land). Health impacts for villagers & plantation workers. Reduction in food sovereignty (reduced rice production at village and district level).	Increased pollution of soil and rivers (chemicals). Destruction of traditional field structures & irrigation. Plastic pollution in soils.

Mahanty's work, drawing on Actor-Network Theory to understand how commodity networks form and dissipate, how networks facilitate knowledge production, and the role of non-human "actants" such as specific cultivars (Latour, 2005). Network analytics can illuminate the diverse array of actors involved in crop booms, their power dynamics and how networks contribute to the production and uptake of new knowledge that are central to crop booms. Through this lens, networks are not only formed, but can also fall apart or – in the context of crop booms – "bust," due to the dissonance caused by disease, land degradation, market volatility or debt (Callon, 2010; Mahanty, 2019, 2022).

Combined, the theoretical perspectives discussed here present a strong foundation for illuminating various aspects of crop booms, including their drivers, spatial and temporal characteristics, and impacts. Across the theoretical lenses, there is broad agreement that crop booms are driven by multiple factors, all associated with the entry of market-oriented agricultural production into new spaces. Moreover, while identifying commonalities of boom-to-bust patterns of crop booms, all theoretical lenses recognise the variability in the dynamics and outcomes of crop booms including their differentiated social and environmental impacts from household to landscape level. These complementary and contrasting theoretical lenses offer an interdisciplinary foundation for our empirical comparison of case studies in the next section.

3. Methodology

We developed the framework presented in this paper through a collaborative process synthesising the theoretical lenses presented in Section 2, and comparing and contrasting insights from our empirical case studies of land-use and agrarian change across the Mekong Region (Fig. 1). This process was informed by our work with various actors: development practitioners, state officials, and boom crop farmers themselves. The empirical material used in the case study comparison is based on our combined long-term, in-depth fieldwork in Laos, Thailand, Cambodia and Vietnam (Fig. 2). The criteria for selecting cases differed across our studies; while some were based on studies of specific crops (e.g. Lu's study of rubber and Pin Pravalprukskul's study on maize), others studied particular sites and landscapes that underwent rapid change in response to the introduction of specific market-oriented crops, and where common patterns of crop expansion, i.e. the booms and in some cases busts could be observed. Our case studies engage a range of methods including semi-structured interviews, household surveys, participant observation, mapping and ranking exercises, remote sensing, and serious games (see Supplementary material, Table S1 for full details on site location, theoretical lenses and methods used in each study). Each of the case studies is also informed by one or more of our theoretical lenses and thus contribute with different dimensions to the understanding of crop boom dynamics.

We compared the case studies along four primary dimensions: 1) land-use changes, 2) drivers, 3) socioeconomic impacts and 4) environmental impacts (Table 1). Through this comparison, we sought to identify key relationships and dynamics that emerge across all the study contexts that were then used to develop the components of the framework (Magliocca et al., 2018). This comparison rendered a number of similarities in the drivers, dynamics, processes, patterns, pathways and impacts of crop booms evident (Fig. 1). Looking across the multiple case studies of hybrid maize cultivation in Vietnam, Laos and Thailand, for example, we observe a spatial pattern wherein crop production moves across large geographical areas. In studies of rubber in Laos and cassava in Cambodia, we noted how different local pathways of crop expansion form a distinct boom pattern, which is not immediately apparent when aggregated at larger scales. Across all the case studies, we observed that the socioeconomic and environmental dynamics and outcomes are highly variegated across scales and location.

Fig. 2. Location of study sites in the Mekong region. Dots and numbers represent study villages.

Through iteration between synthesis of theoretical framing and empirical comparison, we then defined three components that form our analytical framework and that we argue are central for research to inform crop boom governance, namely (i) the *nested scales* of crop boom trajectories (Figs. 3 and 4), (ii) the *movement and cycles* of crop booms (Fig. 5), and (iii) the *variegated pathways and impacts* of agrarian change associated with crop booms (Fig. 6). In the next section, we introduce each of these components in turn, and provide examples from our empirical case studies. Fig. 7 shows how the three components articulate to form an integrated framework that we consider as a middle-range theory of crop booms (Meyfroidt et al., 2018). A full analysis of the

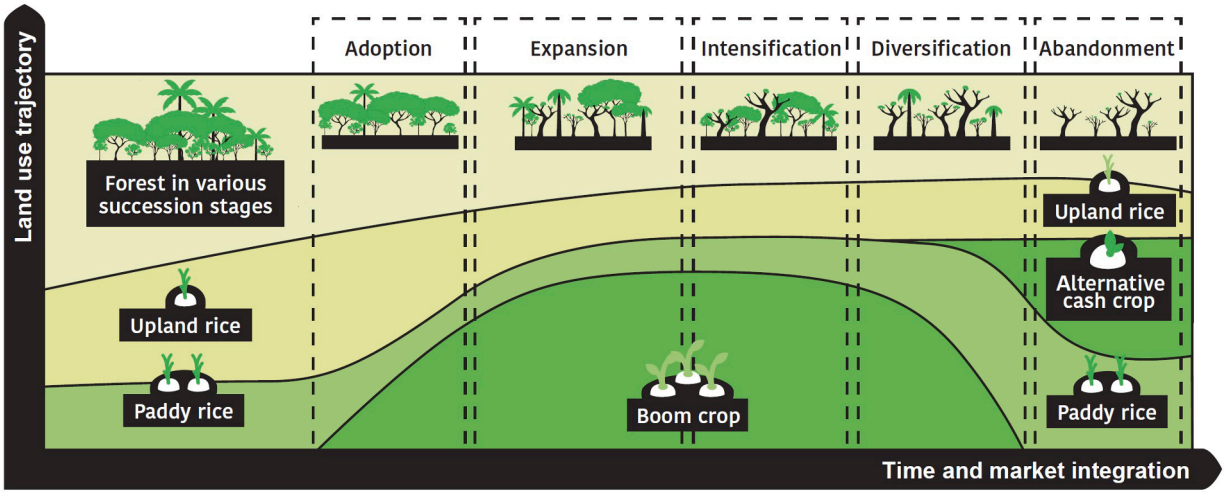

Fig. 3. The five-stages of crop boom-bust land-use trajectories, including the phases of adoption, expansion, intensification, diversification and abandonment. The figure depicts the traditional land use systems combining forests in various stages of regrowth after upland rice cultivation on the slopes and paddy rice in the valley bottoms and hillside terraces. A range of factors including land use intensification (including shortening fallow periods) combined with the expansion of the newly introduced cash crops lead to gradual forest degradation and changing composition of the local landscapes.

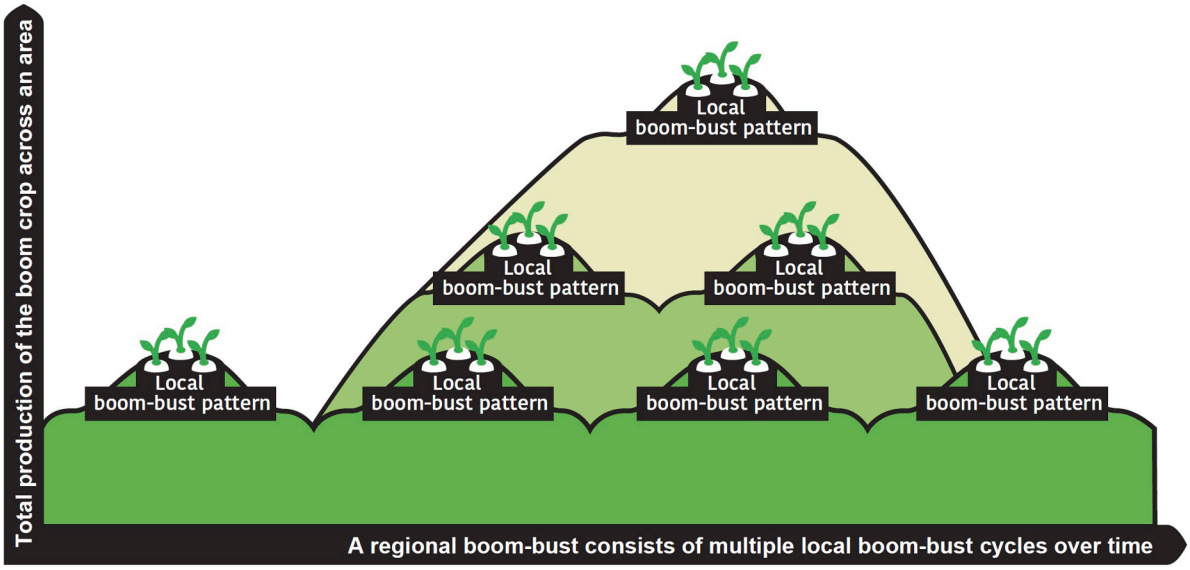

Fig. 4. A nested model of crop boom-bust trajectories from the local to the national or regional landscape level. The figure shows the cumulative effect of local boom-bust trajectories (e.g. at village level) to higher levels booms at e.g. district, province or national level. The production of the crop boom at higher level may increase while the productivity decreases at the local level because the local busts are compensated by the opening of new areas of production elsewhere that are at the initial phase of the boom-bust pattern.

case studies based on the three analytical components of the framework is found in the Supplementary material (Table S2).

4. Crop booms and busts: analytical framework

4.1. Boom-bust trajectories at nested scales

The first component of our analytical framework directs attention to the stages of the boom-bust cycle at a local scale (Fig. 3), and how volatile local boom-concepts and tools from land system science, including the mapping of spatial patterns and an understanding of space as organised in nested scales from local to global, as well as political ecology perspectives on the economic and ecological conditions and the frontier dynamics that fuel booms and busts.

We observe that many cash crops, after being introduced, progress through five stages of boom-bust trajectories in a given place (Fig. 3). Initially, the boom crop is adopted by a few smallholders – often the households with access to capital, suitable land, or with previous relations to mediating actors such as traders. Cultivation then expands and intensifies as other smallholders follow the example of early movers and benefit from the lessons learned and from economies of scale, in some cases through facilitated access to inputs, knowledge, and markets such as in contract farming arrangements or outgrower schemes (Jepsen et al., 2019; Shattuck, 2019). Over time, the intensified production and monoculture conditions lead to soil nutrient exhaustion, new pests, overproduction, competition between producers, as well as rising debt and market vulnerability. In sum, these changes catalysed a crisis in crop production and a shift to diversification of land-use practices or abandonment of the crop (Ornetsmüller et al., 2018). While busts often happen rapidly and lead to dramatic shifts in land-use, especially in frontier spaces where extensive agricultural systems dominate, as in the case of the banana collapse in Luang Namtha Province in Laos and

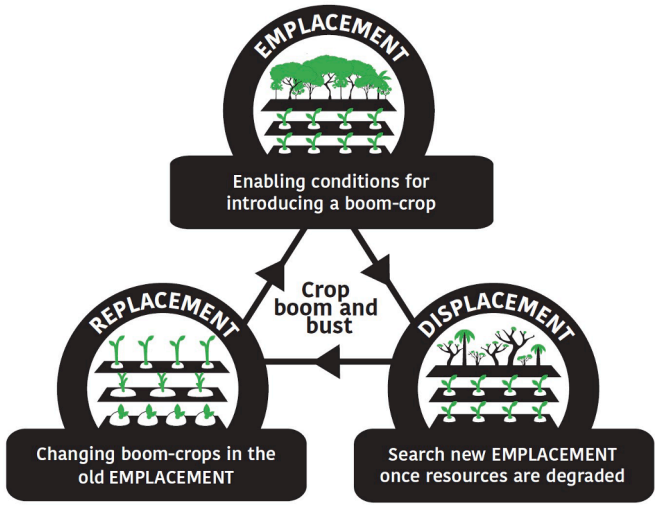

Fig. 5. Three processes that characterise the spatial expansion of crop booms.

subsequent shift to sugarcane, it may also be remarkably drawn out as seen in the case of the maize boom in northeastern Laos.

These rapid and intense changes observed at the local level are, however, often masked or appear as a more steady, incremental rise in crop production at larger scales documented in regional and national statistics (Fig. 4). In other words, the spatial and temporal variability of land-use change is a function of the scale at which it is studied, and as the scale increases, variability declines (Levin, 1992). A focus on higher-level perspectives can thus miss this pattern of crop adoption, expansion, intensification, and diversification or collapse, as well as potential severe socioeconomic and environmental impacts of both boom and bust. This also implies that by the time a crop boom is observed at a larger landscape or regional level, at local scale it might already have collapsed and entered the diversification or abandonment stages. For this reason, governance institutions operating at regional and national scales most often are not attuned to the occurrence of crop booms and their impacts until a boom is well under way or has already passed. For example, the volatility of maize cultivation at the village level was systematically underplayed by actors operating at higher levels and thus who were observing the rise of maize production only at larger scales (Jepsen et al., 2019; Ornetsmüller et al., 2018). Similarly, the bans on rubber and bananas in northern Laos in 2007 and 2012 (rubber) and the mid-2010s (bananas) came at the height of those crop booms but had little to no deterrent on their expansion (Lu, 2021). Rather, in the case of bananas, a combination of pest infestations and market factors, combined to some extent with a national moratorium on new banana plantations in the north, created a bust in banana plantations there - but at the same time pushed the boom south (Tables 1 and S1).

Over time, nested local and regional crop booms might amount to a "mega wave" – where land-use change dynamics sharing common attributes sweep successively over extensive areas (Kronenburg García et al., 2022). Hybrid maize, for example, expanded across the Mekong Region in such fashion – first across Thailand in the 1980s, then across Vietnam in the 1990s, and through Laos, Cambodia and Myanmar in the 2000s. Each area and region underwent all boom stages, from initial conversion of fallows in shifting cultivation systems, to maize monocropping, and finally to crop diversification away from maize (Bruun et al., 2017; Kong et al., 2019; Ornetsmüller et al., 2018).

The notion of boom-bust trajectories at nested scales captures these dynamics, and illustrates the importance of being attuned to the land-use changes associated with boom crops across local, regional, national, and transnational scales, as well as temporal dimensions. This implies a particular focus on local-scale dynamics, including examination of the conditions in specific sites that enable the boom-bust stages to unfold, while connecting and embedding these in the wider context of change at other scales.

4.2. *Movement and cycles of crop booms*

The second component of our framework emphasises the cyclical nature of successive crop booms in time and space. Zooming out from the stages that crop booms go through in a particular locale, we observe that crop booms undergo cycles and move across landscapes through the processes of what we term *emplacement*, *displacement* and *replacement* (Fig. 5). These geographical movements of crop booms are interlinked and often sequential; the boom and bust of a crop in a specific location is connected to the boom and bust of the same crop in other areas, as well as to long-term trajectories of repeating cycles of booms by one crop after another. This component is rooted in studies of the introduction of capitalist agriculture (a central concern in the agrarian change and political ecology literatures, as well as in studies of global value chains and production networks), which emphasise the volatility of transformation dynamics in frontier spaces where market forces are newly introduced, and which suggest that the introduction of capitalist relations of production sets off long-term and irreversible changes (Hall et al., 2011; Li, 2014).

Emplacement describes the conditional factors and actors that enable the initial adoption and expansion of a boom crop in a given area. Across our field sites, these enabling conditions often coincide with frontier settings characterised by extensive land use, subsistence agriculture and high levels of ecological resources. The emplacement process can often be initiated by shifts in access, such as road construction that makes large land reserves or loosely governed resources more accessible. These shifts affect frontier spaces, especially forested areas, informally tenured, or collectively managed landscapes, and borderlands most dramatically (Beban and Gorman, 2017; Eilenberg, 2014). This can, in turn, facilitate in-migration of capital and labour, driving the rapid establishment of boom crops (Kallio et al., 2019; Ornetsmüller et al., 2019). Crop boom emplacement can be also influenced by social factors such as success stories from other locations with adopters imitating successful vanguards in their close vicinity (Cole et al., 2019; Junquera and Grêt-Regamey, 2019; Ornetsmüller et al., 2018). Furthermore, traders often play a key role in the emplacement process by connecting local farmers to new markets (Cole, 2022; Yadav et al., 2021). Traders observe economic trends in key markets and can provide information about new crops, technical knowledge, loans for initial investments, or

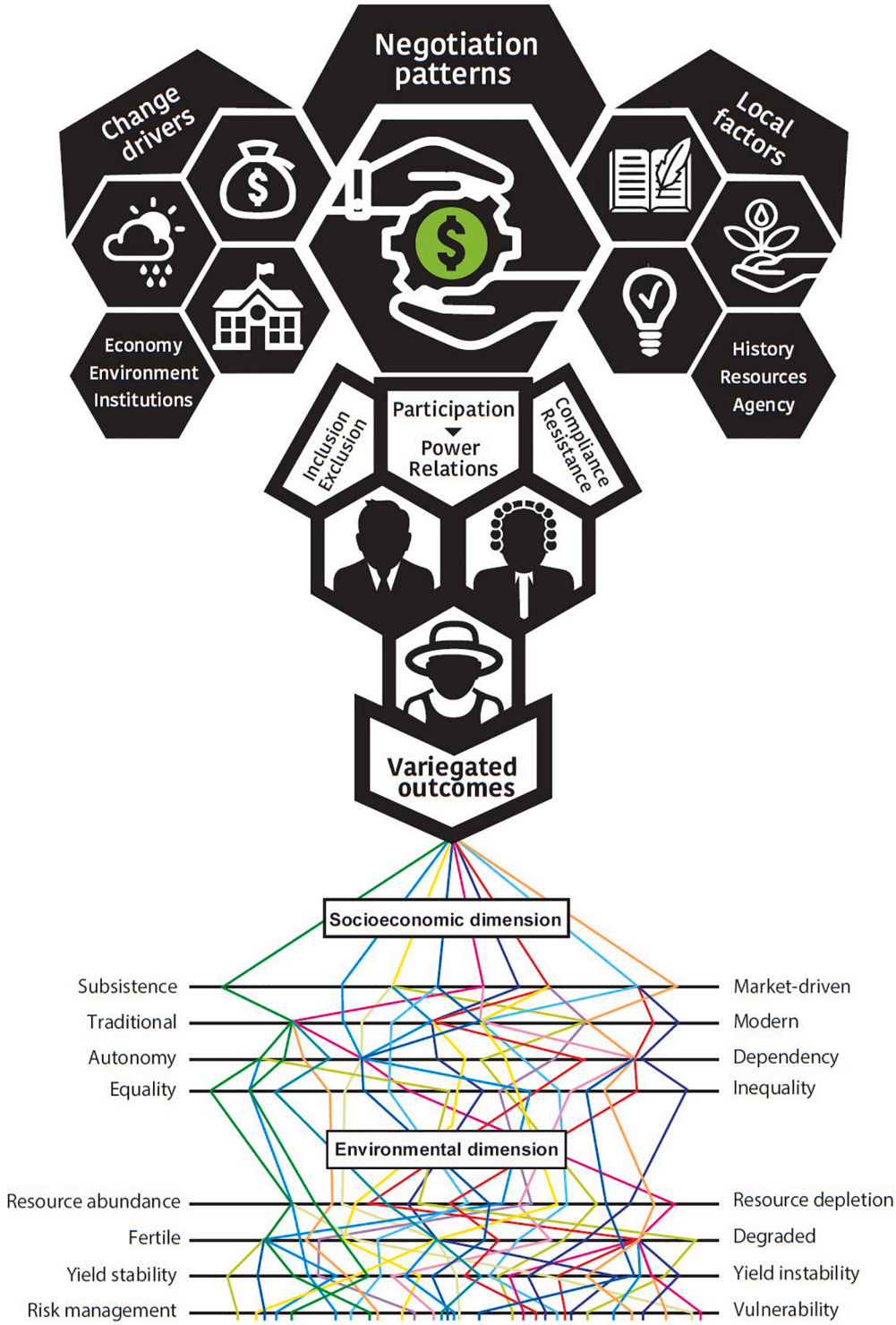

Fig. 6. A model of variegated pathways emerging from local arrangements of production. The figure depicts the crop boom pathways as coloured lines that intersect with the range of variations across relevant environmental and socioeconomic indicators on each horizontal line (corresponding to the range of variation between two extreme values of an indicator) to represent the diversity of contexts. Each variegated pathway is the outcome of locally negotiated arrangements of production.

inputs for establishing the new crop. Across our cases, boom crops often start by replacing fallow areas in shifting cultivation systems or serve as a pioneer crop on newly cleared or enclosed forestlands. Once a boom crop is established, it quickly replaces traditional subsistence crops and complex multi-crop systems, often pushing them towards the periphery of the village, or driving conversion of new areas to maintain subsistence food crops.

Displacement describes the process of adoption of the boom crop in new locations (new sites of emplacement) that feeds the expansion of booms or the relocation of the boom to new areas. As boom crop production intensifies, it sets in motion the factors that eventually lead to abandonment of the crop and replacement by another. As growing engagement of farmers increases competition for land and other factors of production, while increasing environmental degradation reduces their gains from the initial transformation of the land, it drives a push for expansion of the crop to new locations. High rates of frontier migrations,

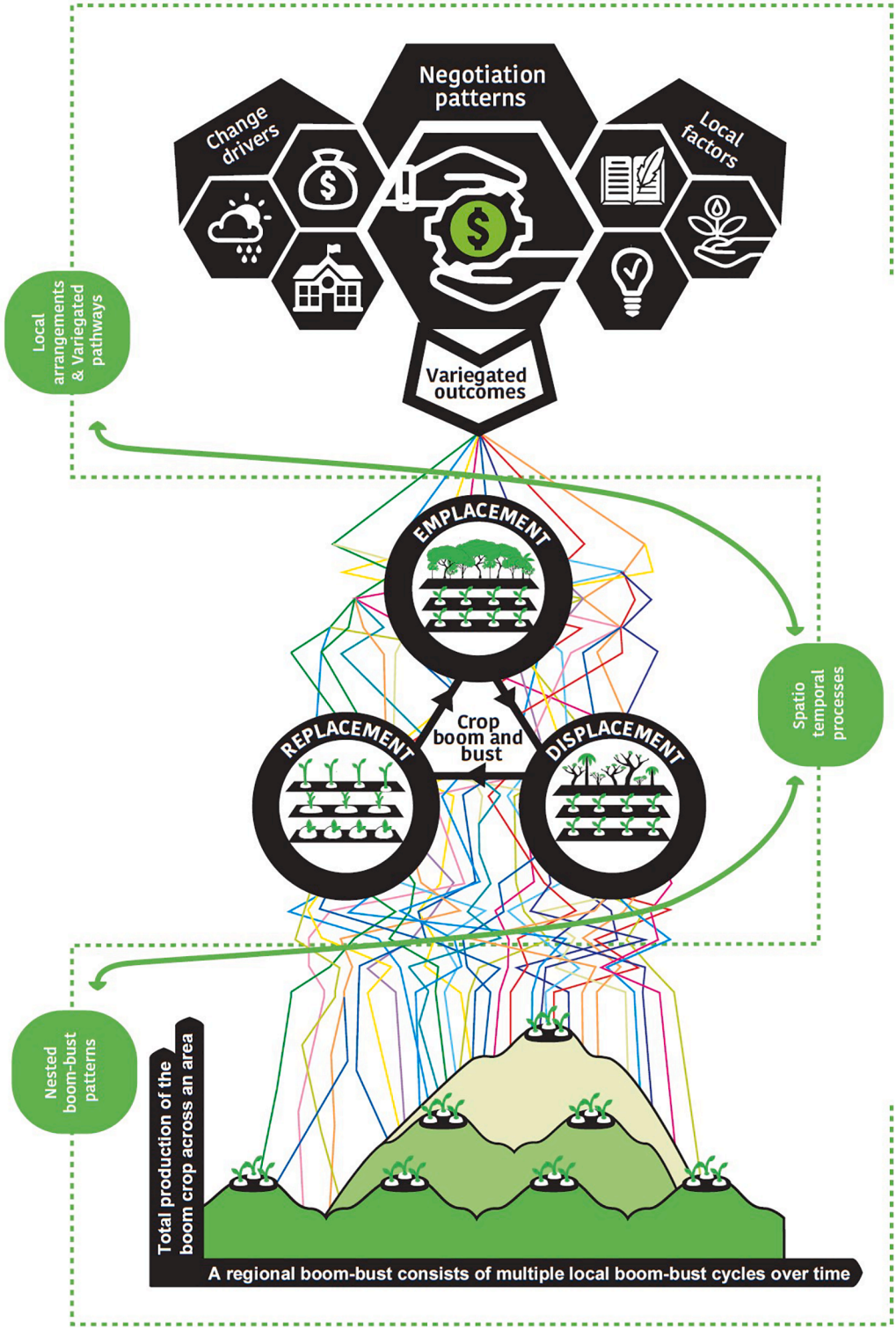

Fig. 7. An integrative framework of crop boom and bust. The green arrows indicate how the three components of the framework combine in describing and explaining crop booms. The variegated pathways resulting from the local arrangements of production and documented in the case studies are placed in the background to illustrate the diversity of crop boom manifestations. They are covered by the overarching patterns that emerged from their comparative analysis, i.e. negotiation patterns among actors (top of the figure), spatiotemporal processes of emplacement, displacement and replacement (centre), and nested boom-bust sequence of land use change (bottom). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

such as in the case of Cambodia, can therefore become a vector for displacement as land pressures increase. Crop booms are often associated with frontiers due to the dependence of some boom crops on a forest rent in the form of soil fertility that is rapidly drawn down when production becomes permanent. Hall terms this the "built-in drive for relocation" associated with crop booms, referring to the fact that crop production can only be sustained or increased, if cultivation constantly shifts from exhausted areas to previously untapped environments (Hall, 2011a: 841). The susceptibility of many crops to pests and diseases (e.g. mosaic virus in cassava, fall armyworm in maize and fusarium wilt in

banana) combined with the inevitable land degradation caused by intensive production results in decreasing returns on a crop in a given plot over time. This in turn encourages the opening up of new areas nearby. This results in what we conceptualise as nested booms that appear at larger scales as "mega waves" that move across large distances and affect large areas (Fig. 4).

Displacement does not necessarily involve the wholesale adoption, abandonment, and substitution of one boom crop for another in the same location at a specific point in time. Before farmers abandon a boom crop, they may explore alternative crops while still engaged in the original boom crop's production or diversify with other livelihood activities. Furthermore, the spatial expansion and adoption of a boom crop need not necessarily follow a continuous path. As the frontier for expansion closes in one area, the boom can "jump" to geographically distant locales. This has been the case, for example, in the banana boom in Luang Namtha, where the boom was ignited by banana investors relocating to Laos after environmental degradation in banana producing regions in China due to intense cultivation and the spread of fusarium wilt. The pattern for displacement repeated in northern Laos, as the boom spread from Luang Namtha to other provinces.

Finally, the *replacement* of one boom crop by another is a prevalent process in many boom-bust cycles. As booms go bust and one boom crop is abandoned, the land and production relations are so altered that farmers can seldom revert to their previous land use and agricultural practice in boom areas. Often they are unable to restore previous growing conditions due to soil fertility loss or field destruction, and the transition from subsistence to market-oriented production alters property systems and increases farmers' dependence on market exchange and monetary income. In some cases, a "boom mentality" can be observed among both farmers and local agricultural extension officers, where at the decline of one boom crop, excitement and anticipation for a new boom crop is seen. In these ways, at the end of a boom-bust cycle farmers are more susceptible to adopting a new boom crop than to restore previous, more extensive farming practices. The social and environmental conditions left by one crop boom becomes a precondition for the next (Ramankutty and Coomes, 2016), while success stories of alternative crops and networks of traders providing links to new markets shape the adoption of new crops. Across our case studies in the Mekong Region, we have observed patterns in the sequences of boom crop replacements. For example, in Thailand and Cambodia, maize and cassava are alternating booms depending on the relative market prices and the level of soil exhaustion until completely abandoned. These annual crops are then commonly replaced by perennial boom crops, such as rubber in Nan Province in Thailand; teak in Xainabouli province, rubber in Luang Prabang province, and plum in Houaphan province in Laos; or mango and longan in Battambang Province, Cambodia. In the wake of the banana bust in Luang Namtha province in Laos, farmers quickly shifted to sugarcane production facilitated by a sugarcane company offering land preparation in return for contract farming arrangements. In some instances, banana plantations themselves had replaced rubber plantations when rubber market prices plummeted, leading some smallholder farmers to cut down rubber plantations and lease their land to banana investors.

Together, the processes of emplacement, displacement and replacement describe the cyclical and expansive nature of boom crops within the context of market expansion in resource frontiers. These cycles, in turn, not only make the connection between different crop booms across space and time explicit, but they also explain the metabolic process by which boom-and-bust cycles are sustained and fuelled, eventually causing spatial patterns of boom-bust trajectories across time and space.

4.3. Variegated pathways and impacts of agrarian change

The third component of our framework sharpens the focus on local agrarian dynamics as variegated pathways of change and outcomes. The concept of variegated pathways refers to the diverse manifestations of a crop boom across a landscape in terms of land use, land access and ownership, access to resources, social relations of production, and livelihoods (Fig. 6). It seeks to capture how logics of capitalism spatially manifest in diverse ways through their articulation with unique local institutions, politics, and social relations (Brennen et al., 2010; Kenney-Lazar and Mark, 2021; Lim, 2014; Peck and Theodore, 2007). The outcomes are also variegated in the sense that the experiences shaping crop boom outcomes are felt differently across individual farms, class groups, villages or landscapes. Our case studies document a common pattern: that crop booms intensify class inequality because wealthy farmers are best positioned to profit from booms and survive their busts, while poor farmers are most vulnerable to falling into debt, forced migration, and wage labour at any stage in the boom-bust cycle. But deviations from this pattern are just as common: many poor households have experienced improvements in their well-being by participating in crop booms. This diversity of outcomes must be dealt with judiciously - not as fluke outliers, nor as proof that certain booms defy this inequality trend, but as parts of a complex but still interconnected process of crop booms and busts. This third component explains how the aggregated outcomes of these local and variegated crop boom pathways lead to a cumulative process of agrarian transition (Beban and Gorman, 2017; Bernstein, 2010; Rigg and Vandergeest, 2012; Rigg, 2020).

The variegated forms of agrarian change result from the multiple possible drivers of commodity expansion (political-economic, policy, or value chain dynamics), the variety of social relations and politics of governance amongst involved government, private, and civil society actors, and the different local characteristics at crop boom sites (agrarian class and social structures, diverse landscape ecologies and topographies). Crop boom pathways, as illustrated by the coloured lines on Fig. 6, intersect in multiple ways with a range of local socioeconomic and environmental conditions to produce variegated outcomes for individuals, households and communities. These conditions set both the context for and represent the outcome of a crop boom, thus representing a new set of contextual conditions for subsequent developments/booms.

Moreover, each variegated pathway is the outcome of diverse and locally negotiated arrangements of production concerning the provision of land access, family or hired labour, market outlet, technical and extension support, and adherence and (non)-alignment with regulations and other state priorities. For example, rubber investors seek permission to sell seedlings, enter into land deals and production arrangements with local authorities and communities, and establish a processing factory with the support of other stakeholder groups (Junquera and Grêt-Regamey, 2019; Lu, 2021; Lu and Schönweger, 2019). In each of these negotiations, power relations differ and histories of engagement and local contextual factors matter. Similarly, people are able to engage very differently with new opportunities presented by incoming investors, new crops or techniques both within and between villages, and they may react very differently faced with various constraints such as price drops, crop failure and low yields, or failures of traders or investors to honour their contracts. Smallholders in Houaphan province in Laos were, for example, more wary of the dependence on chemical fertilisers in maize cultivation than farmers in Xainabouli province (Castella and Phaipasith, 2021).

The case of the cassava in Cambodia illustrates the development of variegated pathways of change and outcomes in crop booms in the context of broader and historical processes of market formation and land commodification in frontier landscapes. Here, the role of diverse actor-networks was central in cassava's uptake and expansion. Traders, farmers with access to land and labour, and new migrants often initiated new crops by sharing seeds and knowledge, which were then taken up by the next wave of farmers (Mahanty, 2022). As the boom unfolded, and both drought and disease seriously affected the quality and quantity of the cassava harvest, the ensuing price drop had highly differentiated consequences for smallholders. Many socially insecure farmers were left with insufficient income to clear the debts from the cost of labour and agricultural inputs. The social and economic inequalities between

farmers further influenced the opportunities for diversification in the wake of the crop boom. Depending on the land and other assets held by households, their level of indebtedness, and their connections to other commodity networks, patterns of social differentiation were consolidated. The wealthier farmers were able to move on to other crops to replace cassava, while some farmers lost their land and had to leave the area to find alternative work, fell into debt, or resorted to wage labour (Mahanty, 2022). Thus, shocks related to price, soil fertility and disease result in dramatic changes to farmers' circumstances, changes which differ within villages (or even families) and also across other scales (e.g. where one district benefits and its neighbouring district struggles to benefit from the same boom crop).

The variegated forms of agrarian change resulting from crop booms show the importance of considering class divisions, differential access to factors of production, and other measures of capacity to engage in or benefit from booms, and weather ensuing busts. Because crop booms are distributed across space, time, crop types, and farm size – that is, because of their variegated nature – individual studies of crop booms are often analysed in isolation. Our interdisciplinary framework captures overarching and interconnected dynamics and patterns across contexts which, in turn, provide important insights for crop boom governance.

Combined, the three components of the framework present an integrative analytical tool to understand and explain crop booms (Fig. 7). Specific constellations of actors, patterns of negotiation and local arrangements of production will invariably intersect to produce variegated outcomes of change within and across sites (top of Fig. 7). Yet, as observed in the various case studies, distinct spatiotemporal processes of emplacement, displacement and replacement form crop boom patterns (centre of Fig. 7) and lead to the nested boom-bust sequence of land-use change associated with crop booms (bottom of Fig. 7). While these processes and patterns represent the general aspects of crop booms leading to massive land-use change and agrarian transition, the multiple, diverse, and variegated pathways of change experienced by individual smallholders run behind the components as a reminder of the necessity to always pay attention to the diverse ways that crop booms manifest locally. We offer this integrative framework as a tool for more comprehensive analysis of crop booms, one that addresses common gaps and limits to single theoretical lenses or cases. Attending to each component can help future crop boom studies create a deeper understanding of the change observed, and facilitate a better identification of leverage points for governance interventions towards more sustainable agricultural futures, as discussed in the next section.

5. Discussion

Crop booms involve long-existing processes of global market integration, but they proceed at new spatial and temporal intensities, catalysed by mechanisms of contemporary globalisation: expanding transport infrastructure, fostering trade, and opening borders. Crop booms bring about a number of intersecting, unsustainable land transformations: from forest to agriculture, from complex and multi-use landscapes to simplified monocultures, from locally controlled and oriented to foreign managed and export-driven agriculture, and from extensive and subsistence to intensified and extractive production. These transformations have become particularly volatile in frontier spaces globally, especially the remote uplands and borderlands of the Mekong Region, that were only recently connected to transnational markets and capital-intensive production systems.

As a result of their fast-changing dynamics and profound social-ecological impacts, crop booms are not only difficult to observe, describe, and analyse, but they also present particularly complex sustainability and governance challenges. The accompanied costs, benefits, risks, and rewards are unevenly distributed across actors, space, and time. Whereas benefits tend to accrue at the start of a boom, costs, both individual and societal, tend to arise later, and can be felt long after the boom has ended. This creates a tendency for policymakers to either glorify individual crops as 'silver bullets' for rural development or, alternatively, to demonise them (Bartlett, 2016) and thus to regulate them on a crop-by-crop basis instead of applying a more systemic approach. Moreover, the volatility of local boom-bust dynamics are often invisible to policymakers at higher levels where such systemic approaches could be best initiated. Moreover, the speed at which crop booms progress means that policy responses are frequently reactive instead of pre-emptive. After a crop has been widely and rapidly established, the worst environmental impacts have already set in, socioeconomic conditions have permanently changed, and policy options are far more limited. The unusual speed and intensity at which boom crops rise and fall in a given locale thus not only explain the negative socioeconomic and environmental impacts of crop booms. They also represent the main challenges that decision-makers, from farmers to government officials, face in managing and mitigating those impacts.

The integrative framework we present in this paper offers a starting point for the type of analysis that is necessary for tackling the challenges presented by crop booms (Fig. 7). It builds on our interdisciplinary collaboration and considers not only the causal relations between drivers of crop booms and their social-ecological impacts, but also how different market, geophysical, and sociopolitical conditions shape and are shaped by complex networks of actors, uneven power relations and diverse interests at hand. By recognizing the cyclical, successive and multi-scalar nature of crop booms, the framework situates the analysis of individual crop booms within the broader structures of agrarian transformation that enable and shape them.

Recognising the *nestedness of local crop boom-bust trajectories* is essential for developing multi-scalar governance interventions that combine the efforts of stakeholders operating at different levels. Local boom-bust cycles feed into and produce higher-level transformations including, for instance, landscape homogenisation, simplification of cropping practices or widespread indebtedness, while often being masked in regional or national statistics. Recognizing this nestedness could allow decision-makers to capture early warning signs of crop boom impacts and better anticipate potential negative social and environmental outcomes. Therefore, policy development at regional to national level needs to be coupled with approaches that are attuned to the patterns of crop boom adoption, expansion, intensification and diversification or collapse at local levels. The crop boom-bust trajectory model also enables the identification of what could be termed "windows of opportunity" – different types of opportunities for intervention corresponding to different stages in crop booms – for policy interventions (Lestrelin and Castella, 2011). While prescribing specific policy interventions is beyond the scope of this paper, we note that approaches that *fail* to recognize the differences of conditions across stages of the boom and the contrasts between how booms present at local and national scales tend to ignore opportunities for diversifying agricultural production systems, empowering smallholder decision-making, and building accountability mechanisms around commercial investments which are widely supported in existing literature and policy research (Lienhard et al., 2020; Rigg, 2020).

While policy responses to adverse impacts of crop booms have generally been reactive, our second framework component focuses attention on the processes of *crop emplacement, displacement and replacement*. This enables an understanding of crop boom dynamics as cyclical and repetitive, thus cautioning against isolating crop boom outcomes in space and time. Rather, the initial emplacement of a boom crop in a given place can be viewed as a "gateway crop" (Mahanty and Milne, 2016) that opens that place and its surrounding area up to expansion of market-driven production systems and intensive agriculture. Various factors, from market volatility to local ecological degradation associated with intensive agricultural production, often result in the displacement of boom crops to new areas and their local replacement by another crop, rather than by diversified agriculture or reduced intensity. Identifying these processes of emplacement, displacement and replacement can help decision-makers anticipate crop boom dynamics,

and ultimately recognise that switching from one boom crop to another will not lead to sustainable agricultural futures, but rather that alternatives are needed to break the adverse impacts of boom crop cycles.

The third framework component acknowledges that governance responses must take into consideration the *variegated pathways* leading to crop boom and their outcomes. Too often boom crops are glorified based on early boom stories or demonised based on bust phase tales. We show that the boom cannot be understood without the bust, that winners and losers, tradeoffs and opportunity costs, and all the variegated ways in which crop booms unfold are related. Crop boom trajectories unfold as a series of negotiations that determine how local arrangements of production are structured: who owns land, invests capital, how crops reach markets, and how the benefits of each of these components are shared across all actors. While new arrangements among stakeholders allow for flexibility, they also create a climate of uncertainty, enable speculation, and increase individual producer vulnerability. Farmers may therefore be protected from the negative consequences of crop booms by research that better addresses the sources of these uncertainties, highlights power imbalances, and reveals biases among the actors involved in the negotiations. It may be possible to steer local trajectories towards more sustainable futures by improving the quality of the negotiations that drive the emergence of local arrangements of production and make up a multitude of location-specific land use trajectories, for example through empowerment of vulnerable stakeholders, information sharing, improved participation, and inclusion of multiple stakeholder groups (Castella et al., 2014). Historically, smallholder farmers have been often portrayed as short-sighted for seemingly ignorant of the costs of monocropping practices, deforestation, and the intensive use of chemical inputs. But many have, quite rationally, chosen short-term profit gains and rapid capital accumulation as a first step in a longer-term transition towards a better standard of living. Such a strategy may involve reinvesting the profits from boom crops in their children's education in the hopes that future livelihoods will be increasingly decoupled from agricultural activities (Cole and Rigg, 2019; Rigg, 2005), or in terracing and irrigating paddy fields to increase yields (Kong et al., 2021; Nghiem et al., 2020; Ornetsmüller et al., 2018). Managing the trade-offs between short term objectives and long term goals is therefore essential for all stakeholder groups. This can be done through multi-actor negotiation platforms that are a key governance instrument in the search for alternatives to crop booms, and which involve an intentional redesign of landscapes and livelihoods (Castella et al., 2022; Duru et al., 2015; Pretty, 2018).

Overall, our framework imparts a common vision of crop booms and their implications. From a *policy perspective*, we suggest that change must be understood, analysed, and governed at multiple levels. When used to bridge national and local perspectives, the framework can help decision-makers and the researchers who support them to anticipate the bust, see beyond single crops' advantages and disadvantages, view the system as a whole, and recognise the differential impacts that booms have across scales, space, and time. The framework aims to raise awareness of the risks of the spatial and temporal imprint of the booms and to help shift governance responses from reactive to proactive. Furthermore, considering the highly variable processes and outcomes of crop booms, empowering actors at the ground level – smallholder farmer households, networks of traders and processors, and the local level state authorities – with resources that build their resilience in the face of change and flexibility to respond at spatial and temporal scales invisible to national decision-makers is essential. In sum, we propose that moving beyond some of the shortcomings in current approaches to crop booms, and thinking about the different windows of opportunity for policy intervention will assist in finding sustainable alternatives to crop boom-bust cycles. That is, rather than trying to respond to booms after they have become established, which tends to exacerbate their severity, policy-makers should understand crop booms as manifestations of cyclical land-use patterns, and therefore anticipate and proactively mitigate their extremes. This requires a sensitivity to and anticipation of the changes and to envision alternative agrarian futures.

From a *research perspective*, we must continue to investigate the policy-related challenges presented above. For example, the role of the state in guiding all stakeholder groups toward a negotiated balance in land use and power relations should be further explored, as well as the role of other stakeholders in this common endeavour. The linkages between boom crops and global markets deserve further attention, as the local and regional patterns described here are influenced by even larger global forces. We should also further investigate the conditions and degree of different actors' agency in negotiating their local and multi-scale production arrangements, for instance, in the context of emerging tensions in food systems, to better understand the impacts of these arrangements on food justice and sovereignty.

There is immense scope to learn from comparing case studies in the Mekong Region to those in other regions, such as South Asia, Latin America or Africa. Through comparison we may better weigh solutions found in other environmental and socioeconomic contexts, such as the variegated role of the civil society in the emergence of alternative movements (e.g. agroecology), that would prevent or buffer crop booms. Such research may show whether and how the patterns identified in this paper resonate beyond our shared study region and may help identify alternatives to the 'wave' of the crop booms-busts in the form of local emergence of subtle 'equilibria' promoted by agroecological research (Duru et al., 2015).

6. Conclusions

Successive failures to reshape crop boom trajectories – to mitigate their impacts, manage their volatility, and move towards more sustainable alternatives – have shown that our current understanding of crop booms is insufficient. We present a novel framework for examining crop booms consisting of three analytical components which recognise 1) the multiscale dynamics and nested nature of crop boom-bust trajectories, 2) the cyclical spatial and temporal patterns of crop booms, and 3) the variegated pathways and impacts of crop booms. Understanding crop booms through this framework can help design more targeted interventions for sustainable agrarian trajectories. The challenges we have observed in our decades of work studying crop booms in the Mekong region are embedded in global contexts of agricultural intensification, marketisation and globalisation. Actors within the changing agrarian system, from government officials and private companies to local smallholders and migrant wage-labourers, are often drawn into the adoption of successive boom crops – into the compulsion to identify the next 'silver bullet' crop. Instead of accepting the costs and chronic volatility of booms, we advocate for creating enabling environments for diversified agrarian systems that avoid incentivizing monoculture, for more stable market relations between farmers and buyers, for greater decision-making autonomy by smallholder producers, and for a view of rural livelihoods and development that prioritises long-term stability over short-term gains. We believe that the proposed framework supports a more holistic approach to studying crop booms, and that this approach will help decision-makers guide processes of agrarian transformation towards more sustainable futures.

CRediT authorship contribution statement

Jean-Christophe Castella: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Juliet Lu:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Cecilie Friis:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Thilde Bech Bruun:** Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing, Visualization. **Robert Cole:** Conceptualization, Methodology,

Formal analysis, Writing – original draft, Writing – review & editing. **Victoria Junquera:** Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing, Visualization. **Miles Kenney-Lazar:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Sango Mahanty:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Christine Ornetsmüller:** Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing, Visualization. **Pin Pravalprukskul:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Isabelle Vagneron:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Cecilie Friis reports financial support was provided by Carlsberg Foundation.

Data availability

Data will be made available on request.

Acknowledgement

The authors are grateful for the two anonymous reviewers and the journal editor who gave us encouraging and very insightful feedback on earlier drafts of this manuscript. We also thank the organisers of the EuroSEAS Conference in 2019 where these ideas first began percolating, as well as other participants and the active audience who attended and exchanged ideas throughout our multi-panel session entitled, "Crop Booms in Borderlands: Perspectives from Southeast Asia." Louise Hedegaard Madsen was a source of great creativity and support in creating the figures included. We also thank Derek Hall for exchanging thoughts on the definition and regional distribution of literature on crop booms and the New Mandala blog hosted by Australia National University for publishing an early essay written by the authors on this topic. CF acknowledges support through the Carlsberg Foundation Reintegration Fellowship grant CF19-0526. RC's research was supported by the Graduate Support Scheme of the Faculty of Arts and Social Sciences, National University of Singapore. IV's research was supported by the Australian Centre for International Agricultural Research (project SMCN/2014/049) and by the NUDP through its Agriculture Policy Development and Capitalization Fund (AgriNet). VJ's research was supported by the Swiss Programme for Research on Global Issues for Development (R4D Programme), funded by the Swiss National Science Foundation (SNSF) and the Swiss Agency for Development and Cooperation (SDC), grant number 400440 152167. PP's research was supported by the European Union's Horizon 2020 research and innovation programme under Marie Skłodowska-Curie grant agreement number 765408.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gloenvcha.2023.102651.

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