



Cross-scale chronological analysis of Southeast Asia's seed regulations and emerging challenges for seed commons

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ABSTRACT

Seed regulatory frameworks paradoxically often attempt to increase farmers' access to quality seed via restrictions on their production and exchange. Efforts to balance regulatory objectives lead to tensions between the legal situation of 'informal' and 'formal' seed systems. This is especially true for vegetatively propagated crops with decentralized, farmer-dominated seed systems. In Southeast Asia, cassava (*Manihot esculenta*) exemplifies an economically important crop with a seed system that seemingly operationalizes elements of a farmer-led transboundary seed commons. By compiling 137 seed-related regulations and organizational memberships of five countries of Southeast Asia's Greater Mekong Subregion, we document the emergence of increasingly complex multi-scalar seed regimes. International influences, especially related to seed property rights, produce layered, intersecting regulatory commitments and inconsistent recognition or support for farmer-managed systems. Intergovernmental cooperation emphasizes regulatory harmonization, but risks eroding local seed governance structures. Returning to cassava, we exemplify a clash between emerging regulatory regimes and commons-oriented governance.

1. Introduction

Appropriate seed policy and law are imperative for increasing agricultural production through varietal turnover (Spielman and Kennedy, 2016), adapting to environmental stressors including climate change (Hampton et al., 2016; Otieno et al., 2021), and managing agrobiodiversity (van Dooren, 2009; Thomas et al., 2011). Balancing these goals, 'seed systems' of actors, institutions, and processes shaping the production, exchange, and use of seed are shaped through geography, economy, and biocultural interactions between each crop and its cultivators, leading to a plurality of seed management and governance structures. Seed management can be conceptualized as the actions and decisions constituting the practical handling of seed, while governance includes the strategic and policy aspects of seed system administration.

Seed regulations are changing rapidly in Southeast Asia's Greater Mekong Subregion (GMS). Bounded by the Indochinese peninsula, the

GMS includes Myanmar, Thailand, Cambodia, Vietnam, and Lao PDR (we omit the Southern Chinese provinces of Yunnan and Guangxi). GMS member states' differing levels of economic development, social stability, and political orientation (Krongkaew, 2004) result in variable responses to emerging global issues (Rasiah et al., 2014). Agriculture is a priority area of GMS cooperation, supported by a strongly smallholder-dominated workforce (Tubtim, 2019), to date largely resisting farmland consolidation trends typical in other developing economies (Lowder et al., 2016; Rigg et al., 2016). Sharing borders, agroecozones, natural resources, and infrastructures, GMS collaboration entails a major economic corridor (Turner, 2013), cooperation strategies and agreements across domains (Duval, 2008), and numerous transboundary environmental and resource commons (Hirsch, 2020). While the governance of plant genetic resources is frequently viewed as a commons problem (Beumer et al., 2021; Girard et al., 2023), it is unclear whether GMS seed regulatory approaches endorse such an approach, and to what extent their emerging structures match the realities of

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Acronyms

ASEAN	Association of Southeast Asian Nations
ATIGA	ASEAN Trade in Goods Agreement
CBD	Convention on Biological Diversity
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
EAPVP	East Asian Plant Variety Protection Forum
FAO	Food and Agriculture Organization of the United Nations
GMS	Greater Mekong subregion
IP	Intellectual Property
IPPC	International Plant Protection Convention
ITPGRFA	International Treaty for Plant Genetic Resources for Food and Agriculture
NEM	New Economic Mechanism
PBR	Plant Breeders' Rights
PGRFA	Plant Genetic Resources for Food and Agriculture
PVP	Plant Variety Protection
RCEP	Regional Comprehensive Economic Partnership
SCO	Shanghai Cooperation Organization
SEA	Southeast Asia
SPS	Sanitary and Phytosanitary measures
UNTAC	United Nations Transitional Authority in Cambodia
UPOV	International Union for the Protection of New Varieties of Plants

existing seed systems.

A particularly relevant and consequential division in crop seed biology is that between sexual and vegetative 'seed', defined here to include any living materials used to propagate plants (CABI, 2014; Jaffee and Srivastava, 1994). Differences between sexual and vegetative seed impact modes of crop production, exchange, decentralization, and regulation. Widely grown and critical to smallholder economies and global food security alike (Thiele et al., 2022), vegetatively propagated crops (VPCs) have clonal seeds facilitating varietal maintenance and farm level multiplication. They also face storage and exchange challenges due to large seed size, weight, high moisture content and physiological activity, pest and disease accumulation over successive generations, and limited involvement of formal or commercial seed system actors (Almekinders et al., 2019; Andrade-Piedra et al., 2022). VPC seed systems are often highly decentralized and polycentric, reflecting the characteristics of the crops themselves (Scott, 2017). This makes such VPC seed systems particularly instructive case studies of the suitability of seed policy and regulations.

We review the evolution and status of seed regulations in the sub-regional bloc of the GMS to describe emerging seed regulatory regimes, employing a multi-scale perspective to evaluate elements supporting or restricting the functioning of diverse, polycentric seed governance systems. We ask: what are the major stages in the evolution of regulatory approaches through the 20th and 21st centuries, what are the structures of the current seed regimes in force, and do these allow space for commons-oriented seed governance? To illustrate, we draw on cassava (*Manihot esculenta* Crantz), a VPC with a well-developed commercial industry but public seed systems, as a practical example embodying key challenges and tensions in the regulation of farmer-led, transboundary seed commons.

2. Conceptual framework

2.1. Plant genetic resources and the commons

At its simplest, a commons can be defined by a shared resource, a

community, and an associated set of social governance protocols resulting in pooled resource management (Bollier, 2014). Commons theory has been applied to many shared resource problems (Ostrom et al., 1999; van Laerhoven and Ostrom, 2007), highlighting diverse governance approaches (Velicu and García-López, 2018). Commons governance represents a third, user-oriented alternative to traditional approaches of strong government administration over access and use of resources, or enforcement of sets of rules directing their systematic private appropriation and exploitation. Decades of work have shown commons-based means of sustainable resource management to be commonplace (Ostrom, 2009), challenging top-down administration of privatization as the *de facto* solution for regulating resource use (Ostrom, 1999; Wynberg et al., 2021).

With increasingly globalized trade and genetic interdependence (Khouri et al., 2014, 2016), debates often present plant genetic resources for food and agriculture (PGRFA) as 'global commons' (Halewood, 2013). PGRFA are both ecologically-derived and human-directed, connecting local farmer networks to international genetic resource pools through interactions with gene banks and germ-plasm exchange mechanisms (Halewood et al., 2021). PGRFA have been conceptualized as a special 'new commons'; an evolving resource pool with layered structures invoking the participation of actors at scales from individuals to global agreements (Dedeurwaerdere, 2012; Halewood, 2013), usually emerging in response to new threats of enclosure (Hess, 2008).

Increases in privatization and commodification of PGRFA in market economies (Howard, 2009) have attracted criticism as examples of enclosure via overly stringent regulations controlling their use and exchange (Kloppenburger, 2014; Frison, 2018; Scharper and Cunningham, 2006). Critics highlight examples of the exclusion of farmers from seed production processes through an emphasis on patentable hybrid grains exhibiting heterosis (Matuschke and Qaim, 2008; ter Steeg et al., 2022), or the frustration of would-be crop improvement projects by well-intentioned regulations leading to diffuse, conflicting levels of PGRFA ownership (Safrin, 2004).

2.2. Seed regimes and regime complexes

As the primary tangible unit of exchange (and thus regulation) of PGRFA, seed is subject to rules of inclusion, exclusion, and enclosure (Montenegro de Wit, 2019; Sievers-Glotzbach et al., 2020). Seed's multidimensionality is derived from its botanical, ecological, economic, and socio-cultural dimensions (Sievers-Glotzbach and Christinck, 2021), invoking roles as a vehicle for genetic conservation and evolution (van Dooren, 2009), technology transfer (Louwaars, 2002; Pickett et al., 2014), an economic commodity and means of production (Kloppenburger, 2010), and a vector for dispersal of plant microbiomes (Hill et al., 2021; Song et al., 2024), pests (Jacobsen et al., 2019; Kumar et al., 2021), and pathogens (Buddenhagen et al., 2017; Delètre et al., 2021). Seed governance strategies thus include consideration of collective goods, and their counterparts, 'collective bads' (Damtew et al., 2020; Cieslik et al., 2021). Policymakers balance these tensions via regulatory approaches serving the oft contradictory interests of multiple stakeholder types and policy goals.

Seed regimes are composed of the assemblages of semi-coherent sets of rules, norms, and principles related to seed use (Kuyek, 2007; Tschersich, 2021). To provide analytical structure to seed regimes, the multi-level perspective (MLP) employs an innovation-oriented framework for decomposing institutional change into nesting layers including the implementation niche, the regime, and the contextual landscape (Li et al., 2013). The core notion of the MLP is that transitions come about through interactions between processes at different levels (Schot and Geels, 2008). In our approach, based on analysis of legal and policy documents, we build on this perspective to focus on the formal regulatory elements of regimes at different scales in the GMS. To do so, we employ the concept of regime complexes, systems of overlapping,

non-hierarchical regulatory regimes introducing legal inconsistencies and confusion (Raustiala and Victor, 2004). Adapting the multi-scalar approach of Cash et al. (2006), we conceptualize a multi-scalar seed regime complex implicating different jurisdictional and spatial scales (Fig. 1), with national laws and regulations occupying a critical position for translating higher-scale regulations into lower-scales aligned with customary farmer exchange activities (Girard et al., 2023). While this view draws from the MLP's niche – regime – landscape hierarchy, it is adapted to focus on granularity at regulatory regime level, integrating both jurisdictional and spatial scales in the concept of regime complexes. We focus on national and international scales of seed regulation and their roles in shaping the seed regime complexes of the GMS. Examples of potential entanglements between scales include tensions between national seed security policies and trade agreements supporting open market access, informal or traditional seed sharing practices running afoul of emerging testing and quarantine regulations, and contradictory mandates between local, provincial, and national regulatory bodies within an increasingly integrated GMS.

2.3. Seed policy and law at scale

Policy and law are interrelated components of the regulatory environment. Applied to seed, policy has been described as “a statement of principles that guides government action and explains the roles of relevant stakeholders in the coordination, structure, functioning and development of the seed system comprising both formal and informal sectors” (FAO, 2015, p. 3). Laws and subervient regulations and enforcement mechanisms form the legal framework for operationalizing and implementing policy in practice (Louwaars, 2002), and have been described as instruments to “protect the farmer by establishing a legal obligation for the seller to guarantee the quality of seed by means of standardized inspection and testing procedures” (FAO, 2015, p. 8), although they undoubtedly also serve to protect the interests of commercial seed actors and provide avenues for the success of their business models (Langyintuo et al., 2010). Seed laws are operationalized in practice via engagement with one or more of the dimensions of seed. Mapped to a seed value chain framework (Delaquis et al., 2024a), elements of seed policy and law align with common regulatory targets

(Fig. 2).

Pursuit of these multiple objectives is further complicated by interactions between scales (local, national, international), generating complicated regulatory landscapes (Louwaars, 2002). At intergovernmental scale, regulations include multiple treaties for PGRFA, most notably the International Treaty for Plant Genetic Resources for Food and Agriculture (ITPGRFA), the International Union for the Protection of New Varieties of Plants (UPOV), and the World Trade Organization Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs). Even when not necessarily contradictory, agreements pursue different ambitions and purposes, creating ambiguity (Bass, 2015), which can be exploited by actors with the political and economic resources to navigate the regime complex (Mark, 2016). Major international agreements are further complemented by increasingly numerous regionalized agreements and treaties, whose legal implementation mechanisms remain a matter of some debate (Tvedt, 2021). Amidst this confusion, national regulators strive for practically implementable solutions through policies, laws, and regulations.

Attempts by institutions to respond to seed demand through breeding and supply from public (inter)national programs have resulted in calls for more pluralistic approaches to seed system development, both in the global North and South (Louwaars et al., 2013; Montenegro de Wit, 2019; Mulesa et al., 2021). These include challenging assumptions of market centrality in processes of diffusion of agricultural innovations, based on evidence indicating that despite large private and public investments, informal actors remain the dominant seed suppliers in most contexts (Almekinders et al., 1994; de Boef et al., 2010; Sperling et al., 2020).

Despite the thriving informal sector, proposed regulatory solutions are often loosely and implicitly assumed to be economic or commercial in nature (Sievers-Glotzbach and Christinck, 2021). However, experiences emphasizing the scale and biocultural character of seed commons suggest advantages of interventions based on or involving social capital (Galarza-Villamar et al., 2024). This may be especially true for VPCs, where formal seed systems have often had considerable difficulty establishing themselves (Almekinders et al., 2019; McEwan et al., 2021).

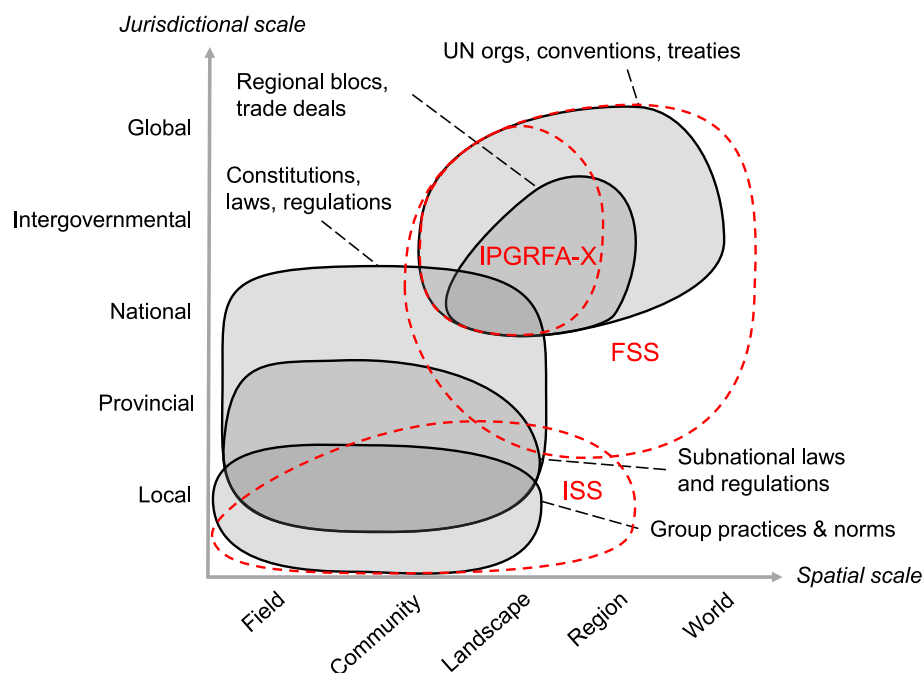


Fig. 1. A schematic diagram of a multi-scalar seed regime complex across spatial, jurisdictional, and institutional scales. Dashed lines bound the functional spaces occupied by informal seed systems (ISS), formal seed systems (FSS), and the exchange of international plant genetic resources for food and agriculture (IPGRFA-X).

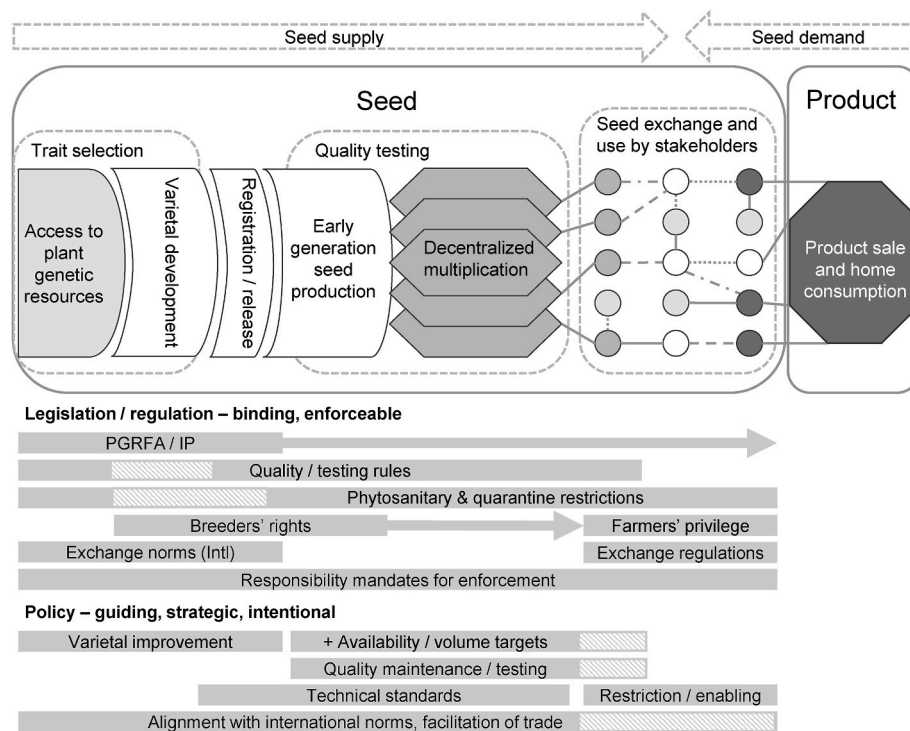


Fig. 2. A process-based value chain model of a generic seed system. Varying line patterns linking seed stakeholders represent different seed economies between stakeholder types, each of whom may also participate in other processes in the value chain (suggested by matching shades). Note that the value chain is not strictly linear, can be entered at multiple stages, and stages are frequently omitted. Thematic coverage of major elements of seed law and policy are indicated by bars below the relevant stages of the value chain.

2.4. Vegetative seed and cassava

Seed regulations often default to the adoption of structures developed for highly commercialized grain staples such as rice, wheat, and maize (Louwaars et al., 2013). Rice is so deeply ingrained in GMS food systems that authors have framed the social and agroecological organization around it as the “paddy-state” (Scott, 2009, p. 74). The deep regional emphasis on rice as the *de facto* staple crop has strongly shaped GMS seed regulation, including via special laws, exemptions, and cooperation mechanisms such as the ASEAN Plus Three Emergency Rice Reserves, itself a regional commons administered between member states (Belesky, 2014). The dominance of rice in regional food security discourse belies that a majority of the most widely grown and productive crops in the GMS are VPCs (Table 1). Grain-focused stipulations for packing and labeling, seed count by weight, moisture content, and other parameters are not equally appropriate for a truckload of cassava planting stems or banana suckers. VPC seed systems are often highly decentralized, requiring flexible management and instigating calls for special consideration in policymaking (Almekinders et al., 2019;

McEwan et al., 2021).

Despite its Amazonian origin (Olsen, 2004), cassava has become one of the most widely grown cash crops in Southeast Asia, and one of five priority crop commodities in the 2020–2025 regional food security strategy (ASEAN, 2020). The GMS currently produces a third of the global cassava supply, accounting for >95% of internationally traded products (Cramb et al., 2017) and an increasing share of global starch markets (Newby et al., 2020). The crop is so dominant it has inspired (unsuccessful) intergovernmental proposals for a price-setting cartel (Arunmas, 2018), and investments in the sector are cited as having higher benefit-cost ratios and poverty reduction potentials than livestock, food industry, or tourism (Haque Khonder, 2019).

The existing cassava seed system involves numerous aspects perhaps best viewed as commons governance problems at multiple scales. An introduced neotropical crop, GMS cassava landrace diversity is comparatively low (Fu et al., 2014; Ocampo et al., 2022), and the crop's genetic improvement relies on international introductions of foreign germplasm via public breeding programs (Delaquis et al., 2024b; Garrett et al., 2017). Collected prior to the ratification of the Convention on Biological Diversity (CBD), the In Trust Agreements (ITAs) on acquisition and distribution of germplasm by institutes of CGIAR and their later inclusion in the Plant Treaty framework safeguard public access to the most globally significant cassava germplasm collection, subject to the terms of the Multilateral System (Byerlee and Dubin, 2009; Marden et al., 2023). Collaboration between CGIAR and public breeding programs in Thailand and Vietnam led to a series of national releases contributing to a near doubling of yields from 1996 to 2016 (Kongsil et al., 2024; Malik et al., 2020). There are no fully private breeding programs in the region.

Low multiplication ratios and large size, weight, and transport cost of cassava's vegetative planting stems make seed production challenging to centralize. Farmer seed exchange is frequent and self-organized at local scales, along with long-distance interprovincial transboundary exchanges mediated by specialized, self-organized informal trade

Table 1

Reliance on vegetatively propagated crops and cassava area and production levels in the countries of the Greater Mekong subregion in 2024 (FAO, 2026).

Country	Vegetative seed (%) ^a	Cassava area (ha)	Cassava area rank ^b	Cassava production (tons)	Cassava production rank ^b
Cambodia	60	598,220	2	14,261,306	1
Lao PDR	70	295,000	2	7,402,000	1
Myanmar	40	20,394	30	252,188	18
Thailand	80	1,419,766	4	28,624,312	3
Vietnam	70	516,694	6	10,533,957	4

^a Share of the top 10 crops ranked by production volume that are entirely or usually vegetatively propagated in practice.

^b Ranked position relative to all other crops reported nationally.

networks (Delaquis et al., 2018), who also participate in the movement of harvested roots supplying cross-border value chains (Mahanty, 2019). Seed exchange is highly regionalized among GMS nations, but involves no private seed companies, emphasizing informal networks linking public institutions, NGOs, farmers, and traders (Delaquis et al., 2024b).

Recent outbreaks of stem-borne pests and diseases including cassava mealybug (Wyckhuys et al., 2018), cassava mosaic disease (Minato et al., 2019), and cassava witches' broom disease (Pardo et al., 2023) highlight seed management as a sustainability concern requiring collective action, for which traditional knowledge has proven insufficient (Upadhyay et al., 2018), and whose sources of disease resistance genes lie outside the region (Garrett et al., 2017). Due to the landscape-scale of pest and disease transmission via farmer seed networks, and the importance of proximity to infected fields of one's neighbors, these phytosanitary issues are an example of a collective bad problem (Galarza-Villamar et al., 2024).

Cassava seed systems in the GMS thus exemplify an effective, but highly informal VPC seed system, with elements of commons governance in the strongly self-organized nature of seed production and exchange, public ownership and widespread sharing of genetic resources at multiple scales, and transboundary exchanges ignoring administrative boundaries in favor of a regional community of growers shaping seed supply and demand. Whether regulatory changes support or hinder the evolution, structure, and functioning of commons governance of this resource impacts the primary livelihood activity of several million GMS smallholders and an agri-food value chain of global importance.

3. Methods and sources

Focused database searches were conducted to compile the major reported legal documents pertaining to seed in GMS countries. Our search strategy and terms focused on identifying seed regulations relevant to farmer and trader seed use and exchange. As a general source of seed law we consulted FAOLEX, the repository of legal agricultural documents submitted to FAO by member states, containing 92,898 documents in the Agriculture Dataset. For plant variety protection (PVP) regulations, we included the WIPOLEX database maintained by the World Intellectual Property Organization (WIPO). For phytosanitary regulations, two databases were consulted: the ASEAN Trade in Goods Agreement (ATIGA) list of sanitary and phytosanitary (SPS) measures (Annex 9), and the regulations for each country deposited with the International Plant Protection Convention (IPPC) as per member national reporting obligations (Table 2). The Access and Benefit-sharing Clearing-House of the Nagoya protocol was also consulted for participating countries. A detailed list of all sources and dates of access is provided in Supplementary Materials (Table S1).

Records were manually screened for relevance and discarded if not directly concerned with legal, policy, varietal registration, management, or phytosanitary aspects of seed. Records discarded included province-level strategy documents (especially in Vietnam), and those not primarily seed oriented, including greenhouse gas mitigation strategies, crop production targets, disaster preparedness policies, and regulations for fertilizer, pesticide, and other non-seed agricultural inputs. A summary of the queries for each search and the results returned and retained is presented in Table 2. Records were classified as representing laws, regulations (implementing rules, circulars, notifications, or specifications), or policies.

Global membership status lists were compiled for major international treaties, trade blocs, and international organizations relevant to seed regulation and exchange in the GMS using databases on the official websites of each body or national announcements. Lists of sources consulted, their objectives, and their relevance to seed are summarized in Tables 3 and 4.

Key elements of the major national seed laws currently in force for each country related to variety registration and release, seed production and commercialization, seed quality and testing, special measures

Table 2
Database search results of seed policy and law in the five GMS countries. Repositories and databases were searched following the listed queries and retained based on relevance.

Theme	Source	Query	Results	Retained
Agriculture (general)	Food and Agriculture Organization of the United Nations - FAOLEX	Termless search (inclusive) of categories: 'planting material/seeds', 'plant variety', 'breeders' rights', 'farmers' rights', 'plant protection' Filtered by 'cultivated plants'	124	72
Variety rights and Intellectual Property	World Intellectual Property Organization - WIPOLEX	Termless search (inclusive) of 'plant variety protection' category	18	18
Phytosanitary	ASEAN Trade in Goods Agreement - ATIGA	ATIGA Annex 9 SPS measures submitted by national governments	46	23 (unique)
Phytosanitary	International Plant Protection Convention – IPPC member reporting	Items submitted to IPPC web portal following National Reporting Obligations – not a searchable database; country pages manually consulted	Evaluated on per country basis	6 (unique)
Various	Additional manual searches	-		18

related to vegetatively propagated crops, and penalties for violation were manually extracted and analyzed. Detailed tables of the referenced passages for each country are available in Supplementary Materials (Table S2–Table S6).

Institutional memberships were mapped using R 4.0.3 (R Core Team, 2020) and the package tmap (Tennekes, 2018), while records returned from legal databases were used to construct chronological timelines. We did not attempt to comprehensively compile bilateral trade treaties of GMS countries, but mention specific examples where appropriate. Our methods are therefore limited to the evolving content of formal regulations, and do not attempt to explicitly engage with the status of their implementation, or to imply stakeholders' awareness or endorsement of their content.

Through these methods, we illustrate the emergence of ever-more complex and restrictive seed regimes from a multi-scale perspective, finding few examples of regulatory structures promoting commons-centered approaches to seed governance. Through cassava, a major regional cash crop, we highlight incongruities between policy and practice. Our analysis makes key contributions to the scholarship on seed governance by systematically approaching the GMS as a regional bloc within a multi-scale system, illustrating seed regime complex transition in a dynamically developing region. In the following sections, we provide a regional chronology of GMS seed regulation, summarize current national seed regulation frameworks and intergovernmental memberships, and, vis-à-vis cassava, discuss the suitability of legal frameworks for crops with vegetative reproduction, and commons-oriented, farmer-managed seed systems.

Table 3
Select political and economic institutions present in the GMS and their relevance to seed.

Full Name	ASEAN ^{a,b}		SCO ^c		RECP ^d		CPTPP ^e	
	Association of Southeast Asian Nations	Shanghai Cooperation Organization	Regional Comprehensive Economic Partnership Agreement		Comprehensive and Progressive Agreement for Trans-Pacific Partnership		Partnership	
GMS members	Cambodia, Lao PDR, Myanmar, Thailand, Vietnam	ASEAN (guest attendee), Cambodia (dialogue partner), Myanmar (dialogue partner – 2022)	Cambodia, Lao PDR, Myanmar, Thailand, Vietnam		Vietnam		Vietnam	
Type	Regional political and economic union (including free trade area)	Political, economic, and security alliance	Trade agreement		Trade agreement		Trade agreement	
Agreement objectives	To accelerate economic growth, social progress, cultural development, and promote peace	Security and defense, economic cooperation, cultural exchange	Economic partnership and integration; trade facilitation; “participation in regional and global supply chains”		Maintenance of open global markets, increase global trade, accelerate trade liberalization and investment		Maintenance of open global markets, increase global trade, accelerate trade liberalization and investment	
Seed implications	ASEAN Trade in Goods Agreement contains provisions on seed trade and SPS measures. 2020-2025 ASEAN Integrated Food Security Framework “Output 1.2. Sustainability of the food supply chain with enhancement to the seed industry”	Member state cooperation in “selection, seed production, and breeding ... exchange of legislative information and standards related to biological quality and biological security ... plant protection, quarantine ... exchange of seed and planting material”	Listed treaty products include “Seeds, fruit and spores, of a kind used for sowing” (Chapter 12 (09)), as well as many other crop-specific provisions		Chapter 18, art. 18 (7) requires all Parties to ratify or accede to by date of entry into force		Chapter 18, art. 18 (7) requires all Parties to ratify or accede to by date of entry into force	

^a <https://asean.org/wp-content/uploads/images/2012/Economic/AFTA/annex/Annex9.pdf>.

^b <https://asean.org/wp-content/uploads/2020/11/42-AIFS-Framework-SPAFS-Final-13-July-2020.pdf>.

^c <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC174060>.

^d <https://investmentpolicy.unctad.org/international-investment-agreements/treaty-files/6032/download>.

^e <https://www.international.gc.ca/trade-commerce/trade-agreements-accords-commerciaux/agr-acc/tpp-ptp/text-texte/18.aspx?lang=eng>.

4. A chronology of GMS seed regulation

A total of 137 seed-related laws, regulations, and policies in the GMS were identified (Table 5). A limitation of extant databases is that many arose from large modern trade and cooperation agreements, and thus focus on recent legislation. We make no pretense of surveying legal traditions predating these sources, and our focus is on contemporary trends and regime transitions.

Periods of seed regime transition vary by country, with differing styles of implementation embedded in regional, national, and colonial history (Fig. 3) – the shifting ‘landscape’ of the MLP theory. The post-WWII period was punctuated by the Geneva conference and partition of colonial French Indochina into the kingdoms of Laos and Cambodia, and the North and South states of what would later become a unified Vietnam. To the west, Myanmar gained its independence from Britain in 1948, while Thailand alone avoided complete colonization by European powers.

Rapid, episodic legislation aligns with national development transitions, for example following Vietnam’s ‘Đổi Mới’ economic reforms, or during Myanmar’s period of civil government. National histories were punctuated by periods of political upheaval, transitioning towards increased economic integration. Most GMS seed regulations date from the late 1990s onwards, coinciding with interactions with international organizations and treaties, sparking intervals of intense legislative activity.

The modern political geography of the GMS is characterized by global forces vying for influence. The Bandung conference in 1955 established all GMS countries as eventual members of the Non-Aligned Movement, as exemplified clearly in Article 1 of Cambodia’s constitution, declaring the country ‘permanently non-aligned’. In this context, GMS agriculture had already been strongly shaped by the colonial and post-colonial introduction of new cash crops, frequently of neotropical origin, for export-oriented cultivation (Booth, 2007, p. 27). Several distinct eras of GMS seed policy and legal development are apparent.

4.1. 1950s – 1980s: phytosanitary concerns

The first major membership for all countries was entry into the FAO. Other early national regulations were primarily phytosanitary in nature, including Thailand, Lao PDR, and Cambodia engaging with the IPPC, and Thailand’s *Plant Quarantine Act* (1964). Early national regulations from Cambodia (1983) and Vietnam (1989) also focused on quarantine and import/export phytosanitary regulations. With plant genetic resources still largely considered as common goods of humanity and the Green Revolution underway, seed legislation focused on protecting national agricultural industries from plant health epidemics through quarantines and phytosanitary screening. This first engagement with international organizations, in emphasizing formal restrictive approaches, would set precedent for future regulation of both seed health and varietal identity. Meanwhile, postcolonial conflicts and social upheavals gave way to sweeping reforms, including political revolutions enacting policies of land redistribution by collectivization in Cambodia, Vietnam, and Laos, followed by de-collectivization beginning at the end of the 1970s (Rigg et al., 2016). Succeeding the nationalization of land in 1948, Myanmar also elaborated land law during the military government beginning in the 1960s (Mark, 2016). GMS countries invested heavily in agriculture, began processes of economic decentralization, and in 1986 undertook major liberalizing economic reforms in Lao PDR (the New Economic Mechanism) and Vietnam (Đổi Mới, or ‘renovation’), part of a major shift from command economies towards market orientation (St John, 1997). Proponents of these policies were also strongly influential in Cambodia through reconstruction advisors of the Vietnamese occupying force.

Table 4

Select international treaty organizations present in the GMS and their relevance to seed.

	IPPC ^a	CBD ^b	ITPGRFA ^c	UPOV ^d	WTO (via TRIPs) ^e
Full name	International Plant Protection Convention	Convention for Biodiversity	International treaty for plant genetic resources for food and agriculture	International Union for the Protection of New Varieties of Plants	World Trade Organization
GMS members	All	All	Cambodia, Lao PDR	Vietnam	All
Type	Multilateral treaty	Multilateral treaty	International treaty (harmonized with CBD)	Treaty body	Intergovernmental Organization
Agreement objectives	International cooperation against the introduction and spread of plant pests, preserve food security, biodiversity, and facilitate trade.	Conservation of biological diversity, affirm states' rights over their biological resources, recognize the role of indigenous and local communities, promote cooperation.	Prioritizing farmers' rights and multilateral agreements; provide normalized rules and mechanisms for exchange.	Provide and promote an effective system of plant variety protection, encourage development of new plant varieties. "Each Contracting Party shall grant and protect breeders' rights" (art. 2)	WTO: formulate, enforce, and promote international trade rules. TRIPs: reduce trade distortions and barriers, ensure methods to enforce intellectual property rights.
Seed implications	Induces member Parties to create a national plant protection organization, assign it a normalized list of responsibilities and mechanisms, report changes in structure and regulations to IPPC secretariat (art. IV)	Multiple, including in-situ and ex-situ monitoring, use, and exchange, subject to all areas in which sovereign states maintain jurisdiction	Affirm farmers' rights to save, use, exchange seed, establish mechanisms and provisions for fair, equitable sharing of benefits from their use, promote farmers' rights at national and international levels (Preamble)	Protect breeders' rights, but allows for Parties to exempt for farmers' privileged use "for propagating purposes, on their own holdings, the product of the harvest which they have obtained by planting, on their own holdings" (art. 15 (2))	"... Members shall provide for the protection of plant varieties either by patents or by an effective sui generis system or by any combination thereof." (art. 27 (3) (b))

^a https://assets.ippc.int/static/media/files/publication/en/2019/02/1329129099_ippc_2011-12-01_reformatted.pdf.^b <https://www.cbd.int/convention/text/>.^c <http://www.fao.org/3/i0510e/i0510e.pdf>.^d https://www.upov.int/edocs/pubdocs/en/upov_pub_221.pdf.^e https://www.wto.org/english/docs_e/legal_e/27-trips_01_e.htm.**Table 5**

Legislation, regulations, and policies identified and retained through the database search process, presented by country.

Country	Legislation	Regulation	Policy	Country total
Cambodia	1	9	1	11
Lao PDR	5	12	1	18
Myanmar	6	2	5	13
Thailand	9	11	0	20
Vietnam	7	68	0	75
Category total	28	102	7	137

4.2. 1990s: access to PGRFA and stabilizing, liberalizing economies

The 1980s saw increasing regional stability giving way to open the previously closed economies of Lao PDR, Vietnam, and Cambodia. GMS countries continued to pursue domestic reforms, with new national constitutions in Lao PDR (1991), Vietnam (1992), and Cambodia (1993). With the basis for revised legal systems in place and investment rising in East Asia, GMS countries increased participation in international mechanisms and agreements. By the end of the decade, all GMS countries had joined ASEAN, all but Thailand had signed the CBD, and both Thailand and Myanmar were members of the WTO. This period was punctuated by the 1997 Asian financial crisis, strongly impacting GMS economies pursuing agricultural modernization as a national development strategy (Rasiah et al., 2014).

4.3. 2000s: globalization, complexity, IP legal development, and seed as commodity

Accelerated by plans for economic recovery from the financial crisis, the 2000s saw increasing seed legislation and membership in international organizations. This coincided with pressure to better align laws with new international commitments, introducing significant complexity into regulatory systems. Amid increasing constraint of domestic policy by the forces of globalization (Cerny, 1995), intergovernmental scale seed regulations promoted rapid development of PVP

laws.

In this period, the influence of UPOV on seed regulation grew, including through bilateral treaties with the United States obligating both Cambodia and Lao PDR to become UPOV members (Jefferson, 2021) – although despite this both countries currently retain observer status. The first *East Asian Plant Variety Protection Forum* in 2007 was a collaboration landmark for 'ASEAN Plus Three' (China, Japan, and South Korea), seeking further UPOV-based harmonization of PVP laws, prompting the promulgation or revision of members' domestic regulations. Several countries also moved to develop specific 'seed laws', among them Vietnam's *Seed Ordinance* (2004), Cambodia's *Law on seed management and plant breeders' rights* (2009), and Myanmar's *Seed Law* (2011), all of which strongly promote private sector participation in seed production and marketing.

4.4. 2010s – 2020s: seed laws, navigating the regime complex, seed industry development, and policy

By this period, all GMS countries had joined the WTO, and hence TRIPs, requiring member states to have functional mechanisms for IP protection of plant varieties. Entry occurred as early as 1995 (Thailand and Myanmar) and as late as 2013 (Lao PDR). In addition, all policies included in the database (n = 7) date from this period, perhaps reflecting growing acknowledgment of the importance of strategic long-term planning in attracting investment.

Clarity of regulations and implementing infrastructure strongly influenced domestic seed production in this period, with Lao PDR, Cambodia, and Myanmar remaining public sector oriented, Vietnam remaining heavily dependent on imported seed, and Thailand developing an advanced private seed sector (Access to Seeds Index, 2020).

When the Nagoya protocol came into force in October 2014, Lao PDR, Myanmar, and Vietnam became party to the agreement, Cambodia ratified it the following year, and Thailand did not join. Vietnam proceeded to assert State ownership over genetic resources inside the country through *Decree No. 59/2017/ND-CP*, providing rules for access and benefit sharing (ABS) under the 2018 *Biodiversity Law*. Lao PDR

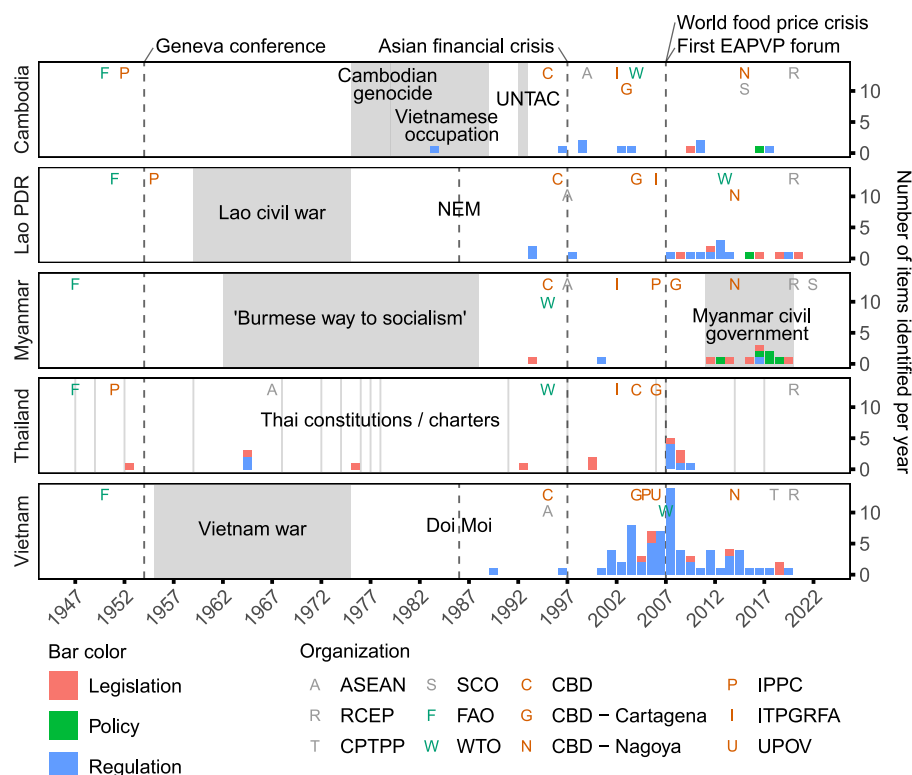


Fig. 3. Chronology of seed legislation and policy in the Greater Mekong Subregion. Countries and number of published regulations are presented on the vertical axes. In-panel letters indicate organizational membership dates (excluding observer status, but otherwise without distinguishing mode of membership). Organizations are grouped by color: grey indicates regional trade or political groups, green indicates intergovernmental organizations, and orange indicates intergovernmental treaties or agreements. NEM - New Economic Mechanism, UNTAC - United Nations Transitional Authority in Cambodia, EAPVP - East Asian Plant Variety Protection Forum. For organizational acronyms and description see [Tables 3 and 4](#)

applied the *Lao National Framework on the Access to Genetic Resources and the Fair and Equitable Sharing of Benefit Arising from their Utilization* (2013) and the *Biotechnology Safety Law* (2014), concerned with genetically modified organisms. Neither Myanmar nor Cambodia had deposited any laws, administrative, or policy documents with the ABS clearing house of the CBD at the time of our analysis.

With a strong economy and experience engaging in global markets, Thailand's relative selectivity in participation in intergovernmental agreements may partly reflect the country's status as one of East Asia's earliest and most prolific pursuers of bilateral trade agreements, dating to the 1966 *Treaty of Amity and Economic Relations with the United States* (Booth, 2007, p. 174; Postigo, 2013, p. 22). Strong presence in international markets may have likewise reduced Thailand's dependence on

later emerging multilateral trade agreements. By contrast, the economies of Vietnam, Lao PDR, and Cambodia remained largely closed prior to market liberalization in the 1990s.

5. Summary of national seed laws

The chronology of development of GMS legal systems is a result not only of historical forces, but also of diverse governance systems and legal frameworks (Table 6). We proceed with a review of key seed laws in each of the five GMS countries, and a brief discussion of selected elements of each case, using conventions for Articles (Art.) and Sections (§).

Table 6
Descriptive attributes of the national legal systems of GMS countries.

	Cambodia	Lao PDR	Myanmar	Thailand	Vietnam
Governance system	Constitutional monarchy, statute-based	Socialist one-party, Marxist-Leninist	Parliamentary democratic republic	Constitutional monarchy	Socialist, one-party, Marxist-Leninist, 'Democratic centralism principle'
Major legal influences	Angkorian customary, French civil law, Vietnamese contract law, UNTAC common law	French civil law, Vietnamese legal tradition, Thai law	Customary law, English common law, Indian penal code	Statutory law, legal code of Rama I, French civil law, common law	Confucian tradition, French civil law, Soviet Marxist-Leninist legal ideology
Constitutions	1947, 1972, 1981, 1993 (amended eight times, latest 2018). From 1975 to 1979, rule of law suspended	1945, 1947, 1991 (amended 2015). From 1975 to 1991, no written constitution or penal code	1948, 1974, 2008	Periodic coups, 20 constitutions since ending absolute monarchy in 1932, latest 2017	1946, 1959, 1980, 1992 (amended 2013)
Legal repository	Royal Gazette	Lao PDR Official Gazette	Gazette of the Republic of the Union of Myanmar	Royal Thai Government Gazette	State Official Gazette (Cong Bao)
Customary law recognized	Integrated, but not explicitly	No	Yes, notably in personal law	Yes, in some cases	No, with rare exceptions

Table 7

Elements of the current legal framework for seed in Cambodia (see Supplementary Materials [Table S2](#) for detailed summary).

Major laws consulted	* Law on seed management and plant breeders' rights (2009) † Instructive circular No. 345 implementing sub-decree No. 96 ANK-BK on standards and management of agricultural materials (2002) ‡ Sub-decree No. 15 on phytosanitary inspection (2003)	
Variety registration and release		
Managed by	General Directorate of Agriculture - evaluation/testing Ministry of Industry, Science, Technology, and Innovation (formerly Ministry of Industry and Handicrafts)	Sub-decree 118 (2017); Law of establishment of MISTI (2020)
DUS/VCU/Other	Novelty, Distinct, Uniform, Stable	Art. 6 *
Status of landraces or farmer varieties	Can be registered	Arts. 3, 40 *
Status of PBR	Laws aligned with UPOV (Cambodia currently observer); exception for experimental, non-commercial, breeding use	Preface, Art. 16 *
Seed production and commercialization		
Seed categories	Breeder, foundation, registered, and certified; full list awaiting updated implementing regulations	§ 4 *; Art. V (3) (2) †
Can farmers save?	On their own holding	Art. 16 *
Can farmers exchange?	An exemption from PBR for "Acts done privately and for non-commercial purposes"	Art. 16 *
Can farmers sell?	Use including "offering for sale, selling or other marketing" requires breeder authorization	Art. 15 *
Role of traders	Trading requires a license and certificate of seed quality	Arts. 42, 79 *
Seed quality and testing		
What seed is tested	All seed to be traded must be tested, additional tests for import/export	Art. 45 *; Art. 4(q) †
Testing regime/ authority	Managed by the Ministry of Agriculture, Forestry and Fisheries, General Directorate of Agriculture; phytosanitary and quarantine inspections by the Plant Protection and Phytosanitary Inspection Office	Art. 46 *; Art. 4(u) † Sub-decree 118 (2017)
Testing rules	Variety quality certificate required for anyone selling seed	Art. 41 *
Fake or counterfeit seed	Misrepresentation of quality, faked packaging, untrue claims all illegal	Arts. 44, 71, 80 *
VPC recognition	No special recognition beyond definition	
Penalties		
Violation of PVP	5M - 20M Riel fine, 1 to 5 years imprisonment	Arts. 72, 78 *
Unlicensed trading	Fine double the value of the goods	Art. 79 *

5.1. Cambodia

Systematic dismantling of the legal system during the Khmer Rouge period (1975 – 1979) and subsequent occupation left Cambodia to rebuild a system of legal administration and jurisprudence from the ground up ([Hor et al., 2012](#)), creating ongoing challenges in many areas of Cambodian law ([Table 7](#)).

The [World Bank's 2019 Enabling the business of agriculture](#) report for Cambodia notes a lack of clarity in published procedural materials, awarding a 'supplying seed index' score of 3.7 out of 100, among the lowest globally ([World Bank, 2019](#)). Despite privileged status in Cambodian agriculture, even rice remains 90% supplied through farmer/informal seed systems, with the majority of formal seeds being imported, and a near-total absence of enforcement of seed certification regulations ([Asian Development Bank, 2021](#); [Martin et al., 2017, 2021](#); [World Bank, 2011](#)).

The 2009 *Law on seed management and plant breeders' rights* offers a strict interpretation of PBR; while the law reserves the privilege for

Table 8

Elements of the current legal framework for seed in Lao PDR (see Supplementary Materials [Table S3](#) for detailed summary).

Major laws consulted	* Law No. 01/NA on Intellectual Property (Amended) (2011) † Decree on Plant Varieties (No. 238/GOV) (2020) ‡ Law on plant protection and quarantine (amended version) No. 13/NA (2016)	
Variety registration and release		
Managed by	Department of Agriculture, Ministry of Agriculture and Forestry	Arts. 19, 20 †
DUS/VCU/Other	New, Distinct, Uniform, Stable, following UPOV, 2019	Art. 68 *
Status of landraces or farmer varieties	‘Improvement’ or ‘development’ required; ‘promoted’ variety (without DUS or PBR)	Art. 10 * Art. 22 †
Status of PBR	PBR via IP law; Lao in contact with UPOV (observer status)	Art. 3 (24) *
Seed production and commercialization		
Seed categories	Seed classes not defined in the legislation examined, although several varietal categories are described	Arts. 3, 8 †; Art. 51 ‡
Can farmers save?	"for propagating purposes, on his or her own holdings"	Art. 82 (2) *
Can farmers exchange?	Exemption from PVP for “acts done privately and for non-commercial purposes”	Art. 82 *
Can farmers sell?	“production or reproduction”, “offering for sale” and “sale and marketing” only by variety owner	Art. 78 *
Role of traders	Not mentioned; distribution requires seed business license	Art. 42 †
Seed quality and testing		
What seed is tested	Commercial seed must be tested. “Production, import or distribution of plant seeds” requires registration and certification. Movement of plant materials domestically subject to approval	Arts. 22(5), 47 (4) †; Art. 59 ‡
Testing regime/ authority	Ministry of Agriculture and Forestry licenses seed businesses, regulates testing laboratories, issues quality certificates. Department of Agriculture conducts sampling and quality testing	Arts. 31, 32, 40, 42 †
Testing rules	Plant seed quality assurance certification required; provisions to be defined: “purity, density, germination, and pest infection”	Art. 28 †
Fake or counterfeit seed	"Fake seed", misrepresentation of varietal identity, exaggeration of qualities, are all prohibited	Art. 118 *, Arts. 3, 47, 48 †
VPC recognition	No special recognition beyond definition	
Penalties		
Violation of PVP	Range from extrajudicial reconciliation and mediation to administrative and criminal penalties, up to three months imprisonment and 10M LAK fine	Arts. 123, 137, 159-162 *; Arts. 61–65 †
Unlicensed trading	Included in the above	

farmers to re-use seed on their own holdings, it does not permit sharing or sale without inspection and certification. Commercial exchanges between unlicensed farmers are prohibited, and traders must obtain variety and quality certifications ([Asian Development Bank, 2021](#)). The regulatory framework is aligned with [UPOV, 2019](#), with more than half of the space in the seed law devoted to PVP ([Sarom, 2014](#)). For most purposes, the provisions in Cambodia's 2009 law remain largely unimplemented due to a lack of subsequent regulations for their operationalization and enforcement ([World Bank, 2011](#); [Asian Development Bank, 2021](#)).

With an aim to address gaps in implementation, a draft seed policy was developed in 2016 in consultation with USAID and UPOV. Proposed measures included a seed management unit in the General Directorate of Agriculture, a national seed council to direct research and sectorial development, and a national variety release committee. Responsibility for PVP/PBR was assigned to the newly created Ministry of Industry,

Table 9

Elements of the current legal framework for seed in Myanmar (see Supplementary Materials [Table S4](#) for detailed summary).

Major laws consulted	* The New Plant Variety Protection Law (Pyidaungsu Hluttaw Law No. 29, 2019); [†] The Law of Protection of the Farmer Rights and Enhancement of their Benefits (2013); [‡] Seed Law (2011); [§] Seed Law Regulations (2016)	
Variety registration and release		
Managed by	National New Plant Variety Protection Central Committee	Art. 4 [‡]
DUS/VCU/Other	Novel/new; Distinct, Uniform, Stable; VCU to be evaluated	Arts. 10–13 *; Art. 10(a) [‡]
Status of landraces or farmer varieties	Not treated explicitly, but prescriptions in the New Plant Variety Law do not prohibit their registration	Art. 2(c), Ch. V *
Status of PBR	Protected. Laws approved by UPOV council; procedure for accession to UPOV, 2019 initiated	Arts. 3(a), 12, 13(b) *
Seed production and commercialization		
Seed categories	Breeder, foundation, registered, certified, hybrid. Additional category “Pure Seed”	Art. 2 [†] , Art. 2 (c) [‡]
Can farmers save?	Exemption for farmers only for their own consumption on their own land holdings	Art. 27(b) *
Can farmers exchange?	Distribution and sale allowed of seed produced by any peasant to another peasant	Art. 31 [‡] ; Art. 2(d) (V) [†]
Can farmers sell?	Only to another peasant - definitions not provided	Art. 31 [‡]
Role of traders	Traders are not specifically mentioned or defined	
Seed quality and testing		
What seed is tested	All varieties produced for commercial purposes require a recognition certificate and seed quality testing	Arts. 2, 24 [‡] ; Art. 27 [†]
Testing regime/ authority	National Seed Committee assign testing to a Seed Quality Inspection Body, can certify testing laboratories	Art. 7, 23 [†] , Art. 13, Ch. VII [‡]
Testing rules	Genetic purity, seed purity, germination, moisture content, pest and disease. Import/export subject to additional regulation	Arts. 17, 31 [†]
Fake/counterfeit	No mention of counterfeit seed; only of misrepresentation during the registration process and failure to meet quality standards	
VPC recognition	No special recognition beyond definition	
Penalties		
Violation of PVP	Imprisonment of 6 months - 3 years and/ or fine	Art. 38 *
Unlicensed trading	Imprisonment up to 6 months and/or fine, confiscation	Art. 28 [‡]

Science, Technology and Innovation in 2020, while the General Directorate of Agriculture remained responsible for testing and evaluation of applications, as well as phytosanitary matters. The ratification of the policy and remaining reforms appear to be at various stages of progress and awaiting deposition in regulatory databases.

In 2015, Cambodia became the first GMS country to join the Shanghai Cooperation Organization (SCO) as a dialogue partner.

5.2. Lao PDR

The Lao seed regulatory environment ([Table 8](#)) is restrictive, and the ability for smallholders, traders, or farmer-based organizations to exchange and sell seed is limited under the 2020 Decree on Plant Varieties. Like Cambodia, Lao PDR is one of the lowest ranked countries on the World Bank seed supply index ([World Bank, 2019](#)).

The *Intellectual Property Law* (2011) enshrined plant breeders' rights and PVP, with the Ministry of Agriculture and Forestry as the primary institution responsible for implementation under the *Decree on Plant Varieties* (2020, Art. 66). The *Law on Plant Protection and Quarantine* (2016) aims to stimulate “commercial production, increasing quantitatively and qualitatively” (Art. 1). The Lao State officially endorses and

encourages plant breeding activities (*Decree on Plant Varieties*, Art. 4), but most is currently conducted by state organs themselves, limited to a few important crops, and only a single private company produces seed domestically ([Access to Seeds Index, 2020](#)). To promote such activities, Article 60 of the *Decree on Plant Varieties* (2020) prescribes commending and incentivizing “Outstanding Achievers”.

At time of writing, the *Decree on Plant Varieties* (2020) lacked an official English version and was yet to be deposited in FAOLEX or other international databases. The full implications are thus not clear, but the text contains little information regarding farmers' privilege, traders, or small-scale exchange or sale between producers. For registration of a ‘promoted variety’, large-scale trials are required, and a testing certificate is required from provincial authorities (*Decree on Plant Varieties*, Art. 22). Article 22 also provides some exemptions from PVP registration, including ‘gifts’, but it is not clear whether this refers only to imported materials or includes domestic exchange. The provisions for ‘promoted varieties’ have been interpreted as an alternative variety release system, although limited in scope and scale ([De Jonge et al., 2021](#)). This new mechanism operates through state identification of ‘promotion varieties’ to be commercialized in particular provinces, not subject to DUS requirements, and not protected by PBR.

As in Vietnam, Lao IP law allows the State to circumvent PBR “where it is necessary to meet an urgent public need and to ensure food supply or to prevent commercial monopolies, the government can issue notifications allowing the exploitation of a protected variety without the authorization of the right owner” (Art. 87), although it is unclear if this has ever occurred.

5.3. Myanmar

Myanmar's civil government period (2011–2020) coincided with rapid legal reform across all sectors by the State Peace and Development Council ([Table 9](#)). This was buoyed by international support in seed law development, most notably by the Integrated Seed Sector Development Myanmar Programme (2017–2020).

The 2011 *Seed Law* exempts regulation for “distribution and sale of seed produced by any peasant by himself to another peasant” (Art. 31) and does not require seed producer's licenses for researchers and peasants producing seed in cooperation with the ministry (Art. 32). The volume of seed relevant to be considered as a ‘commercial exchange’ is to be set by the National Seed Committee (Art. 5(b)), a grey area similar to the exclusion of ‘large farms’ from farmers' privilege exemptions in the explanatory notes of UPOV Article 15 (2). However, the seed law's explicit objective is supporting development of the agricultural sector through commercial seed businesses (Art. 3).

Myanmar's 2013 *The Law of Protection of the Farmer Rights and Enhancement of their Benefits* acknowledges seed production (and sale) as essential defining actions of farmers, but does not comment on rights associated with production and exchange. Instead, Article 20(a) enables the Leading Body to promote private seed research and production, seemingly implicitly asserting that this best serves farmers' interests. The law also establishes the rights of farmers to “select and cultivate crops they desire freely on their farm land [sic] without injuring paddy cultivation” (Art. 8) and establishes the Leading Body to (somewhat ambiguously) aid farmers in acquiring inputs and enforcing seed standards.

Protecting the rights of farmers and encouraging integrated seed sector development are not among the objectives of the 2019 *New plant variety protection law*, which superseded the 2016 law with more stringent regulation of PBR affirmed by the UPOV council as aligned with [UPOV, 2019](#), formally opening a pathway for national membership ([UPOV, 2019](#)).

Recent studies suggest a generally low demand for quality seed in Myanmar, but do not assess vegetatively propagated crops ([Boughton et al., 2020](#)). Nevertheless, Myanmar's agricultural policy includes plans to “Review and amend Seed Law, with emphasis on protection of seed

Table 10

Elements of the current legal framework for seed in Thailand (see Supplementary Materials Table S5 for detailed summary).

Major laws consulted	* Plant Quarantine Act (1964; amended 1999, 2008) † Plant Varieties Protection Act (1999) ‡ Plants Act (1975; amended 1992, 2007)	
Variety registration and release		
Managed by	Application - Minister of Agriculture and Cooperatives; Appeals - Plant Variety Commission	§ 6, 25–27 †
DUS/VCU/Other	Distinctness, Uniformity, Stability (except wild plant varieties). Distinctness via “feature beneficial to the cultivation, consumption, pharmacy, production or transformation”	§ 11–12 †
Status of landraces or farmer varieties	Varietal categories include “local domestic” for specific localities and “general domestic” for commonly exploited varieties. Community registration can be held by a “local government organization, farmers’ group or co-operative”	§ 3, 45, 47 †
Status of PBR	Applies to ‘new varieties’; alignment to UPOV controversial (see text)	§ 33, 37, Ch. III †
Seed production and commercialization		
Seed categories	Includes controlled, certified, and deteriorated	§ 3, 34, 36 ‡
Can farmers save?	Yes, whether of a ‘new variety’ or a ‘domestic variety’	§ 33, 47 †
Can farmers exchange?	Exemptions for non-commercial purposes for both local and new protected plant varieties, restrictions for promoted varieties	§ 33(5), 47(3), 47(4) †
Can farmers sell?	Commercial activities are not exempted, but blanket exceptions for acts “committed in good faith”	§ 14 ‡
Role of traders	Defined commercially; trade in seed requires a license	§ 14, 16 ‡
Seed quality and testing		
What seed is tested	All seed produced commercially. A list of species and varieties of ‘controlled seed’ is determined by the Minister	§ 12 ‡
Testing regime/authority	Minister of Agriculture and Cooperatives administers the Plants Act, in addition to a ‘Plants Committee’; Plant Quarantine Committee	§ 5–6, 13 ‡; § 5 bis, 6 bis, 15 *
Testing rules	Exports and imports subject to phytosanitary regulations; packaging in controlled sites by licensees must include informative labels; inspectors can visit, collect samples, evaluate seed, confiscate prohibited items	§ 39, 21–24, and 39 ‡; § 6 bis, 6 ter, 9, 11, 12 *
Fake or counterfeit seed	Includes misleading, forged, or incomplete labels, false statements during registration, adulterated or otherwise falsified seed, exaggerated statements about quality	§ 67–68 †; § 35, 38 ‡
VPC recognition	No special recognition beyond definition	
Penalties		
Violation of PVP	Include fines & damages, confiscation, imprisonment up to 2 years and/or fine up to 400,000 Baht	§ 62, 64 †
Unlicensed trading	Imprisonment up to one month and/or a fine up to 20,000 Baht	§ 65 †

farmers, and facilitate public participation on the drafting of implementing regulations and procedures for the Amended Seed Law”, additional measures for promotion of seed production by cooperatives as well as private actors, and the establishment of an information system for seed demand and supply [Myanmar Agriculture Development Strategy and Investment Plan (2018–2023), p. 60–61]. Following the 2020 coup d’état, Myanmar entered a new period of conflict, drawing rebukes from ASEAN, and the status of legal development for the future

is uncertain.

5.4. Thailand

Thailand retains strong public and civil society representation in the seed regulatory system (Table 10). Treaty accession requires National Assembly endorsement, often including public consultation (2017 constitution, Chapter VII, § 156; Chapter VIII, § 178). During the formulation of the *Plant Variety Protection Act* (1999), this five-year process included NGOs, farmers, academics, plant breeders, and private sector actors engaged in vigorous debate and opposition, ultimately resulting in a compromise version (Kanniah, 2005). As a result, the act includes the creation of a Plant Variety Protection Commission with diverse representation among stakeholders in breeding and seed propagation, including representatives from 10 Thai government organizations and departments and 12 members appointed by the Council of Ministers, including six farmers, one plant breeding/variety academic, one academic from natural resource conservation, two from NGOs, and two from associations conducting breeding/propagation. The commission has the power to hear appeals and overturn registration decisions made by the Director General. Despite this outcome, the high degree of concentration of political and economic power has often given transnational entities and corporate domestic elites strong lobbying power and representation in such decisions (Chiengkul, 2018; Tubtim, 2019). Thailand’s *Plant Variety Protection Act* has been highlighted as an example of compromise between multiple policy goals including promoting commercial breeding and seed systems through PVP, retaining elements of commons access through resistance to enclosure, and promoting widespread access to PGRFA (Kanniah, 2005; Louwaars, 2002).

Section 36 of the *PVPA* enables the government to prohibit “production, sale, distribution in any manner, importation or exportation of new plant varieties”, or ultimately even the certificate of varietal registration itself, in the public interest, specifically mentioning disease prevention, public welfare, conservation of the environment and biological diversity, promotion of nutrition, and prevention of monopoly formation. This may be exercised by the Minister with approval of the Commission. The law also provides the Director General (again with the approval of the Commission), the ability to authorize the use of plant variety rights in cases in which the owner has failed to provide sufficient volumes of propagating materials, or charged what is deemed to be an “exorbitant price” (§ 37).

This approach is further supported by the provisions under § 48, stipulating that collection of local domestic plant varieties for commercial interests, whether variety development or research, must be accompanied by a benefit-sharing agreement with approval of the Commission.

Section 49 prescribes the profit share: 20% to the developer or conservator, 20% to the local government organization, farmers’ group, or cooperative, and 60% to the community itself. Being the earliest country in the region to adopt post-TRIPs seed laws, Thailand has periodically revised the *Plant Act* and *Plant Quarantine Act* (three times each to date), supplemented with frequent updates to criteria, notifications and specifications targeting specific crops and issues. These notifications can be numerous: a 2010 update by the Thai national focal point under IPPC reporting obligations listed 32 items supplementing the *Plant Quarantine Act* between 2007 and 2010 alone (https://assets.ippc.int/static/media/files/publications/1310181906_25a_Thailand.pdf). These may include the addition of specific crops to restriction lists, for example Notification G/SPS/N/THA/152/Rev. 1 (2007) prohibits the entry of ‘any part’ of cassava into Thailand unless accompanied by specified inspections and phytosanitary measures. Criteria and specifications not rising to the level of major laws or notifications did not appear in the databases consulted.

In an example of regulatory permissiveness, Thailand does not require rice producers to obtain certification, instead reserving the right for authorized inspectors to conduct random inspections to assure that

Table 11

Elements of the current legal framework for seed in Vietnam (see Supplementary Materials Table S6 for detailed summary).

Major laws consulted	* Law No. 31/2018/QH14 Law on Crop Production (2018) † Decree No. 94/2019/ND-CP ‡ Law No. 50/2005/QH11 of November 29, 2005, on Intellectual Property ¹ Law No. 41/2013/QH13 on Plant Protection and Quarantine (2013)	
Variety registration and release		
Managed by	Ministry of Agriculture and Rural Development	Art. 196 ‡
DUS/VCU/Other	Novel, Distinct, Uniform, Stable; VCU; genome sequencing risk assessments required for GMOs	Art. 15 (b-c), 18–19 *; Arts. 158–163 ‡
Status of landraces or farmer varieties	Article 6 of MARD Decision 35/2008/QD-BNN allows “farm households” to register varieties	Art. 6, 35/2008/QD-BNN
Status of PBR	Full UPOV member since 2006; PBR regulations in operational compliance	UPOV
Seed production and commercialization		
Seed categories	Varietal grades specified in national standards by species groups; classes include open-pollinated, breeder, pre-basic, basic, and certified; Decree 31/2016, Article 14 (2d) further describes parental & hybrid seeds	Arts. 25(3a), 25 (3b) *
Can farmers save?	Exemption for “personal and non-commercial purposes”; use “for self-propagation and cultivation in the next season on their own land areas”	Art. 190 ‡
Can farmers exchange?	Non-commercial exchanges of farmer varieties protected within their administrative district; “planting materials of industrial crops and perennial fruit trees using vegetative propagation should use mother stocks or stock nursery”	Art. 8, 35/2008/QD-BNN
Can farmers sell?	Sale of seed by unlicensed persons is prohibited	Art. 8 ¹; Art. 12
Role of traders	Legally recognized; must register and conform to quality, traceability requirements; responsible for assuring seed quality and compensating losses	Arts. 22, 35, 42 *
Seed quality and testing		
What seed is tested	All main crops, and all plant varieties	Arts. 9(3), 13(5) *
Testing regime/ authority	Ministry of Agriculture and Rural Development, or testing organizations licensed by them	Arts. 25–26, 34 *
Testing rules	Producers must be registered businesses and provide seed traceability; importing requires a phytosanitary certificate	Art. 22 *; Art. 26 ¹
Fake or counterfeit seed	Highly regulated and restricted, defined several ways by misrepresentation, exaggeration, adulteration, mislabeling	Arts. 9(4), 27(3), 1 (3) *
VPC recognition	Regulations for traceability and age of propagation materials; Application processes for perennial fruit and industrial crops; breeders' rights extended to cassava, taro, pineapple, tulip	Arts. 8–9 †; 11/2013/TT-BNNPTNT
Penalties		
Violation of PVP	Fines up to 50M VND	31/2016/ND-CP Art. 12 (2)
Unlicensed trading	Includes civil, administrative, criminal; Decree 31/2016/ND-CP details levels of fines and imprisonment	Art. 199 ‡

rice seed sold meets quality criteria, including from community rice centers through inspections by the Rice Department (Napasintuwong, 2018).

Although Thailand's major seed laws have yet to be tested in the supreme court, selective enforcement does occur, for example the 2022 arrest of an individual carrying durian seedlings across the Thai-Lao border (Vongphachanh, 2022). The individual, reportedly unaware his

actions were illegal, was charged under the *Plant Variety Protection Act*. Thailand is also notable for having by far the largest private seed sector in the subregion, with strong industry associations and reported export values of over 30 M USD quarterly (APSA, 2022).

5.5. Vietnam

After joining the WTO and the lifting of post-war sanctions, Vietnam rapidly joined international agreements to regularize trade and access global markets, with contemporaneous development of the regulatory framework (Table 11). Huong and Thuy (2021) describe several major legislative challenges of adapting Vietnam's Confucian-inspired, Marxist-Leninist system to a global market context. The result is a hierarchical system of normative legal documents in which decrees, circulars, and decisions issued by multiple parallel executive branches play prominent roles in interpreting and implementing laws, often introducing inconsistencies (Huong, 2020; Huong and Thuy, 2021). Regulatory flexibility introduced via these means may be subject to unclear resolution and prioritization mechanisms. Civil society organizations are closely monitored in Vietnam, and public participation in lawmaking processes is primarily via the ‘collective leadership’ model of central government.

Observers have suggested that *MARD Decision 35/2008/QD-BNN* represents some official recognition of farmer seed systems (Tin et al., 2011), or even a basis for legal recognition of the informal seed sector (Kuhlmann and Dey, 2021). The decision contains provisions for legal recognition of “farm households, cooperative teams, cooperatives, and clubs,” protecting non-commercial exchange within district boundaries. This example, linking exchange rights specifically to district administrative scales, is discussed in detail by Nguyen and Nguyen (2016). However, others have suggested a more cautionary interpretation, arguing that the decree rather represents integration of seed clubs and cooperatives under formal sector rules, aligned with UPOV, 2019; Thomas and Boisvert (2015).

Vietnam declined to enter the ITPGRFA, while joining UPOV 1991, a strategy interpreted by some authors as promoting a commodity-oriented approach aiming first to develop and commercialize domestic PGRFA resources through formal seed sector development (Nguyen and Weckström Lindroos, 2021). Vietnamese State policies have encouraged dissemination and adoption of hybrid maize and rice seed, mobilizing national and local extension services in a top-down model of influence (Kyeyune and Turner, 2016).

Many measures of the *Ordinance on Plant Varieties* (2004) are being replaced by the *Law on Crop Production* (2018, entry into force January 1, 2020) as the development of associated implementing rules and regulations continues. *Decree No. 94/2019/ND-CP* expanded the *Law on Crop Production*, including specification of procedures and forms used for application for variety protection, elaborating eligibility of the production and sale of plant varieties, genetic conservation policies, and banning export of varieties of specific species.

Part four of the *Law on Intellectual Property* (2005) is concerned exclusively with PVP. Article 190 describes limitations to the rights of PVP certificate holders, following UPOV, 2019 in including exclusion for ‘using plant varieties for personal and non-commercial purposes’ and for research. From 2005 to 2007 Vietnam passed in rapid succession several Vietnam Standard TCVNs following IPPC's adopted International Standards for Phytosanitary Measures (ISPMs).

Similarly to Thailand, the Vietnamese State reserves the right to force licensing of a variety without the permission of the PVP certificate holder in priority cases including “... in service of national defense, security, food security and nutrition for the people or to meet other urgent social needs” [Art. 195 (1) of the 2005 *Law on Intellectual Property*]. To date no cases have been identified testing the limits of exemptions under farmers' privilege through Vietnamese courts (Nguyen and Weckström Lindroos, 2021).

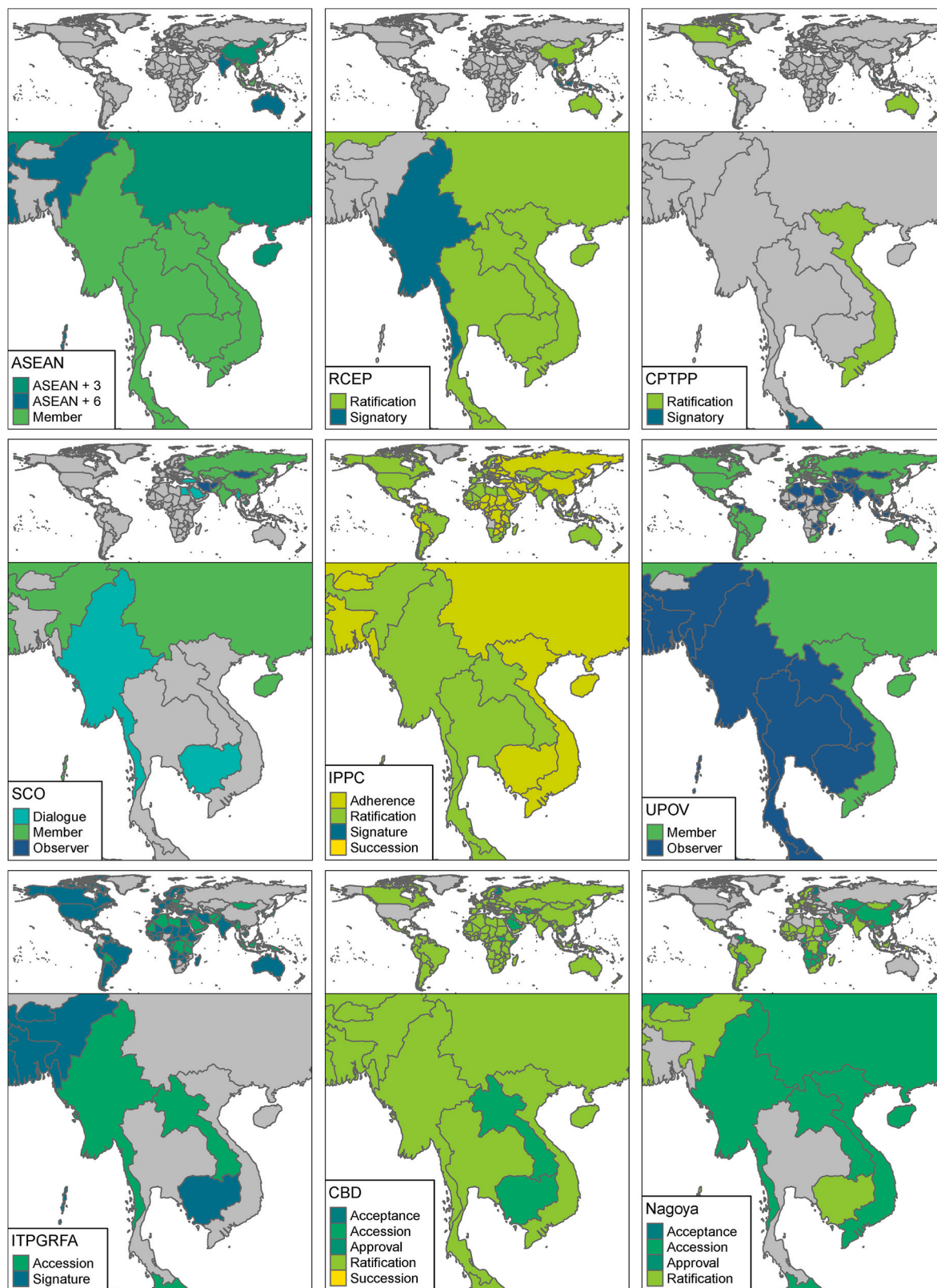


Fig. 4. Country participation in select international treaties, agreements, and trade or political areas active in the Greater Mekong Subregion (circa January 2022, see Supplementary Materials [Table S1](#) for details of source data).

6. The intergovernmental regime complex

Viewed as a region, the high variability in GMS membership or participation status in intergovernmental organizations is evident (Fig. 4). Treaty organizations such as the IPPC or CBD involve extensive global communities, while Vietnam's participation in CPTPP, or Cambodia's and Myanmar's admission as dialogue partners in the Shanghai Cooperation Organization (SCO), are regionalized and exclusive.

Increasing participation of GMS economies in global markets since the late 1990s accompanied a focus shift towards commercially enforceable PVP, most notably through UPOV, exerting pressure for nation states to adhere in several ways. UPOV offers assistance in formulation and review of national laws, and UPOV boilerplate appears often in legislation (e.g., the intellectual property laws of Vietnam and Lao PDR), often with little adaptation to local context. For example, the 'farmer's privilege' element of UPOV in Art. 15 (2) contains reference to the exclusion of 'large farms'; an unclear, contextual term for smallholder-dominated GMS countries which has been accompanied by little supporting clarification in national laws. Though only Vietnam is a full UPOV member, all other GMS countries have observer status, and Cambodia, Lao PDR, and Myanmar all received UPOV approval for drafts of their PVP laws. Indeed, both Cambodia and Lao PDR implicitly agreed to become UPOV, 2019 members via bilateral trade agreements with the United States in 2006 and 2003, respectively – although this has yet to materialize. Myanmar's civil government laws were formally reviewed by UPOV in 2017 and declared compliant with UPOV 91 (UPOV, 2017).

Treaties and free trade areas often require UPOV membership (CPTPP), or at least a degree of alignment (RCEP), as prerequisites for participation. Through ASEAN Plus Three, the EAPVP builds on this influence with a stated objective of regulatory harmonization, and has introduced UPOV-harmonized guidelines for DUS testing of cassava (East Asia Plant Variety Protection Forum, 2013). The Asia Pacific Seed Association (APSA), ostensibly the world's largest seed association, including 23 members from Thailand, five from Vietnam, three from Myanmar, and none from Cambodia or Lao PDR (FAO, 2020), has itself also been granted observer status in UPOV. This confluence has led some authors to conclude that adherence to UPOV rules is inevitable for most Asian countries, regardless of membership status (Jefferson, 2021).

The negotiation phase of RCEP entailed controversy when leaked documents highlighted a push from wealthier liberalized economies in South Korea and Japan to strengthen TRIPs regulations, including mandatory participation in UPOV felt by some observers to erode smallholder access to seed (Townsend, 2021). This led to a strong reaction from international NGOs (GRAIN, 2016) and national representative groups in negotiating parties, including India (La Via Campesina, 2019), who would ultimately withdraw from RCEP. However, these stricter provisions were absent in the unsealed version of the agreement ultimately signed.

Similarly, during initial negotiations of the CPTPP, the Thai House of Representatives Subcommittee on Agriculture revealed that Thailand was already listed on the official UPOV website as an observer, signaling intended membership (Prachatai, 2020). Thailand's dualist legal system requires a cabinet resolution by the National Assembly for membership of any status in international agreements, and the perceived lack of this procedure earned strong reprimands from House Committee members, triggering official requests for clarification to UPOV. Thai farmer organizations had previously participated in public hearings on the agreement, raising concerns about limitation of farmers' seed management practices by new IP laws (Arunmas, 2018). Thailand's announced intention to join CPTPP again caused controversy (Bangkok Post, 2021), but economic disruption in the wake of the economic impacts of the COVID-19 pandemic heightened pressure to commit (Chalermpalanupap, 2020). In many other countries of the GMS, illiberal governance structures complicate and limit civil society's potential for productive engagement with policymakers (Simpson and Smits, 2018; Yanyue, 2014).

7. Seed regimes between policy and practice

7.1. Seed use by farmers and traders

The regulatory environment of the five GMS countries described in this study constitutes a radical departure from previous decades. A farmer of average age in Asia – 53 as per Rigg et al. (2020) – would have started farming prior to all seed laws in our aggregated database for every country except Thailand. Rapid change has led to patchy, complex, frequently overlapping regulations restricting the conditions for seed saving, exchange, varietal registration, and phytosanitary requirements. Recent attempts to assess the legal landscape highlight this emerging complexity. A survey on the status of PVP law by the Asia & Pacific Seed Association (2020) garnered no responses from Cambodia, Myanmar, or Lao PDR, while an FAO report on the status of seed laws in Asia & Pacific Seed Association (2020) yielded no responses from Lao PDR and a single public sector respondent from the remaining GMS countries.

Meeting strict and onerous regulations may be particularly challenging for landraces developed in restricted agroecologies (Batten et al., 2021). One example is the Mekong Rice Clubs of Vietnam, whose use of MARD Decision 35/2008/QĐ-BNN for registration of varieties by farm households has met with the reality of expensive and lengthy registration processes, paired with strict geographical restriction of sale. Mechanisms to address inequities, even well-intentioned, often in practice serve to articulate farmers more closely to the market system (Kloppenborg, 2010) through implicit assumptions that the market economy, rather than existing alternative economies, is 'the solution' (Gibson-Graham and Dombroski, 2020).

Often farmers themselves, informal traders perform essential roles in facilitating smallholder access to seed (Sperling et al., 2020). The national laws examined emphasized top-down regulation of trading activities, state sanctioned licensing, variety, and quality certificates, in some cases making traders liable for seed quality and responsible for compensating losses (e.g., Vietnam). In other cases (Lao PDR and Cambodia) traders are largely absent, presumably included as 'seed businesses'. In all cases, traders were poorly defined, although commerce and scale of activities were relevant factors. However, even by the most permissible readings, seed movement by unregistered actors of non-certified seed across international boundaries was overtly criminalized, and phytosanitary regulations generally provided authorities sweeping powers to enforce quarantine measures as necessary both for import/export and domestically.

None of the policies examined made direct reference to alternative quality assurance methods more integrated into local governance, such as 'quality declared' (QDS) or 'participatory guarantee' (PGS) systems, in which upstream sources of regulated germplasm supply multiplication efforts by local actors leveraging community scale processes and social dynamics as alternatives to certification (Fajardo et al., 2010). Examples from Thailand (Napasintuwong, 2018) or Vietnam (Tin et al., 2011), typically arose from special conditions, notably for rice production as the dominant seed regulatory model in public discourse. In most such cases, exception, ambiguity, or direct participation of government bodies were used to legitimize exemptions. The approach of *de facto* criminalization of informal sector activities subject to inconsistent enforcement may have utility for administrators in practice (allowing the country to conform to international conventions, pursue offenders when politically expedient, and habitually exempt the peasantry), but hampers the development of commons-oriented approaches by limiting the legal space in which institutions can operate and foster innovation (Mosse, 2004).

There is little recognition of the unique characteristics of VPCs evident in the seed regulations evaluated. Where distinction is made, it is typically affirmation that the laws and standards apply. Myanmar, Lao PDR, and Cambodia all show signs of moving to develop specific seed laws, while Vietnam and Thailand continue to rely on subsections of

general crop production laws, supplemented by decrees, ordinances, or other regulations to specify their application to VPCs.

With no alternate system currently available or proposed to meet the scale of VPC seed supply, strict application of existing seed laws would fracture the linkages underpinning current cassava seed systems, effectively halting the current mechanisms of dissemination and uptake of newly released varieties supporting millions of households' livelihoods.

7.2. Multi-scale regime complexes

The emergence of commons design principles from small, local case studies has been a major criticism of their utility for globalized, market integrated contexts (Cox et al., 2010). This seems to introduce a complication for local or niche practices to meaningfully influence the 'legitimated' regulatory elements of seed regimes. While defining system boundaries that match underlying socio-ecologies is a critical step in classical commons governance (Hanna and Munasinghe, 1995), adapting to unclear boundaries in 'new' genetic commons is complicated (Halewood, 2013). Seed regime complexes, spanning local, regional, and international scales, present a pernicious regulatory challenge. National law occupies a critical space for translating international obligations to local scale and introducing context-specific adaptations, but in many cases remains seemingly at odds with local practice and norms. Excessive framing of the commons at intergovernmental scales risks introducing incongruence with local scale communities implicated in the resource's daily management (Hirsch, 2020), who often have limited influence in higher-scale decision-making processes, reducing their ability to address cross-scale problems in governance (Cash et al., 2003, 2006).

Attempts at GMS-wide common resource governance through intergovernmental boundary organizations have drawn similar criticisms in a region where smallholder influence is often blunted by concentration of power, monopolistic tendencies, and excessive regulation (Gulati et al., 2007). Mekong River Commission, a boundary organization established for managing shared water resources, has been critiqued for insufficient representation of local scale actors, over-emphasizing intergovernmental or subregional agendas, and thereby concentrating decision-making power with central state agencies (Hirsch, 2020; Lebel et al., 2005).

Omission of local scale actors is particularly conspicuous in seed given the high reliance on informal networks and local actors in the resource's governance. In our cassava example, seed exchange (Delaquis et al., 2018), new varieties (Malik et al., 2020; Ocampo et al., 2022), and pest and disease issues (Graziosi et al., 2016) all represent trans-boundary public goods or bads overwhelmingly managed by smallholder communities. Despite this, commons perspectives were primarily limited to governing genetic resources via intergovernmental scale agreements facilitating the introgression of public PGRFA into national breeding programs. We found limited provisions for similar perspectives in national regulations, which tended to adopt administrative perspectives developed to restrict self-organized exchange.

Thailand and Myanmar's regulatory systems involved mechanisms for public and farmer representation in seed councils or committees forming the bodies implementing PVP, seed quality, and quarantine regulations. In Thailand this was taken to the highest level of diversity in participation, with PVP regulation by a 'Plant Variety Protection Commission' (including representatives from ten Thai government organizations and departments and twelve additional members appointed by the Council of Ministers, including six farmers, one plant breeding/variety academic, one academic from natural resource conservation, two NGO representatives, and two breeding/propagation representatives), a 'Plants Committee' for seed quality and certification (consisting of high ranking representatives from five government departments or agencies, no more than nine experts appointed by the Minister, and the Director of the Office of Agricultural Regulatory), and a 'Plant Quarantine Committee' (including representatives from 13 government departments or

institutes and appointed experts, led by the Department of Agriculture). By contrast, Cambodia, Lao PDR, and Vietnam regulate the multiple aspects of seed primarily through direct governance via government organs issuing legislation and regulations, or by their oversight of third-party licensing to conduct inspections and tests.

7.3. Integration, harmonization, and coherence across scales

In addition to divergent legal structures, distinguishing laws from policy can be challenging in cross-cultural settings, and either can be deterministic expressions of intent, or more aspirational expressions of goal setting. Conceptions, definitions, and interpretations of the role of policy in lawmaking differ widely among contexts and cultures (Low, 2003). In Lao PDR, ethnographic work has identified diverging definitions for 'nanyobai', the common Lao language translation of 'policy', including strategic directions, binding laws, and short term responses to emerging problems (Smith et al., 2022). During the development of Vietnam's *Regulation on Production Management of Farm Households' Plant Varieties*, stakeholders also debated the application of the word 'policy' to their cultural and legislative context (Nguyen and Nguyen, 2016).

While in a minority of cases official, approved English-language regulations have been published (e.g., Cambodia's *Seed Management and Plant Breeder's Rights*, developed with support from UPOV), in many others this task is left to the remit of law offices or foreign translation services. While original local language versions prevail in case of conflict, a lack of standard versions in UN languages complicates external assessment. Unclear terminology is also a persistent problem at higher levels. During 2019's seventeenth regular session, the FAO Commission on Genetic Resources for Food and Agriculture requested FAO to clarify the terms "farmers' seed systems", "informal seed systems", "formal seed systems", and "integrated seed systems", taking into account submissions by members and observers (FAO, 2019, para. 67), including their definitions in the notes of the eighteenth regular session (FAO, 2021).

New seed quality challenges are also on the horizon for legislators. In addition to unregistered seed, 'fake seed' is identified as a problem by regulators (FAO, 2020), with GMS seed laws including different definitions, variously invoking misrepresentation during registration processes, misleading advertising, exaggeration of qualities, or false labeling.

Regional seed law harmonization is commonly recommended to encourage integration and lower non-tariff barriers for seed companies, with examples in Latin America, Asia, and West, East, and Southern Africa (De Jonge et al., 2020; Langyintuo et al., 2010; Rohrbach et al., 2003; Tripp and Rohrbach, 2001). Seed regulatory harmonization is a recognized goal for ASEAN, with the initiation of a seed council in 2013, a second meeting held in 2017, and an ASEAN Integrated Food Security Framework focused intently on the commercial seed sector. For example, Output 1.2.7 of the plan deals exclusively with the 'seed industry system' (ASEAN, 2020, p. 16). Some authors have described the ASEAN style of high-level, closed door negotiation and consensus-forming as 'elite-centric regional socialization' (Acharya, 2003), while the advent of bodies such as the ASEAN Seed Council, EAPVP, and memberships in international treaties and trade blocs all push GMS states towards harmonization and integration (Jefferson, 2021).

7.4. Seeking compromise

As empirical evidence grows for the continued dominance of farmer seed systems in national seed supply (Gill et al., 2013; McGuire and Sperling, 2016; Zimmerer et al., 2023), policy recommendations usually suggest striking a balance between totally 'formal' administrative enforcement and 'informal' local commons approaches. These compromises have been variously formulated as 'hybrid solutions' emphasizing farmer agency and commercial access (Kyeyune and Turner, 2016), a

‘middle-of-the-road’ approach between informal/formal seed systems (Gatto et al., 2020), the promotion of ‘pluralistic’ and ‘intermediate’ seed systems (Mulesa et al., 2021), the application of ‘regulatory flexibility’ (Kuhlmann and Dey, 2021), and ‘compliance with resistance’ to UPOV 91 derived PVP regimes (Jefferson, 2021).

Such options promote legislative flexibility to allow space for poly-centric seed governance structures to emerge and engage with regulatory structures on more even footing. However overly ambiguous or contradictory regulations risk enabling the dominance of larger actors with economic or political resources, at their extreme resulting in ‘seed regulatory capture’ (Van Dycke et al., 2023) or ‘hyperownership’ (Safrin, 2004). Similar results have been observed in the GMS as a result of “stacked laws” in Myanmar’s land tenure (Mark, 2016), and “overlapping property arrangements” in Lao PDR land use plans and policies (Broegaard et al., 2017).

The special nature of seed as a new commons – multi-scalar, (re) generative, evolving, highly responsive to technological advances, and central to livelihoods and food security – ensure that its regulation will continue to be a source of debate and contention. For regulatory regimes to adequately match the systems they aim to regulate, commons-centered approaches are critical, yet currently mostly attract measures to restrict, rather than promote, their emergence. The GMS cassava seed system provides a particularly clear example of this dissonance.

8. Conclusions

Employing a regional approach and historical perspective, we highlight the variability of seed policy and regulatory development in the GMS in response to both national development trajectories and regime transitions, and evolving regional and global influences. Moves towards regional regime-level harmonization could reduce heterogeneity to better match the self-organized, transboundary nature of seed governance, but risk ignoring farmer-led management structures adapted to specific crop x locality combinations.

Trends we observe in contemporary GMS seed regulation development echo those of authors across numerous other developing country contexts, including an increase in number, complexity, and stringency of regulations, with little tacit support for commons or farmer-based governance systems (Herpers et al., 2017; Tschersich, 2021; Vernooij et al., 2023). The smallholder-led nature of GMS agriculture was poorly reflected in most cases of legislative and regulatory evolution, with higher-scale decision-making often omitting farmers’ roles as managers of the seed commons, despite the dominance of informal seed actors. Revisiting the multi-level perspective framework, the levels of the GMS seed regulatory hierarchy show weak functional interactions, with niche-level innovations rarely propagating into higher-level regulatory changes, representing mostly a top-down flow of power. Spaces of innovation at the local level need to be identified by regime level actors (i.e. governments and their legislative bodies) or created by empowered local level actors (farmers and their advocates/allies).

We identified diminishing provisions for commons-centered seed governance, in favor of increasing restriction by higher scale administrative regulation. This is abundantly clear in the case of vegetatively propagated crops, often subject to rules designed for seeds more easily standardized, packaged, stored, and regulated.

Contrasting existing regulatory frameworks identified with cassava, a major vegetatively propagated crop with public breeding programs, informal seed production and dissemination systems, and regional, transboundary exchange networks and value chains, we highlight informal management at several scales despite an increasingly restrictive regulatory landscape. Given this disparity, future research should build on our findings to evaluate how changing regulatory landscapes are experienced (or not) by farmers and other stakeholders, including mechanisms of adherence and resistance to emerging seed regimes. Regional cooperation must not be limited to increasing restrictions, but should embrace the strengths of existing self-organized networks, and

emphasize the creation of spaces for innovation within local niches and mechanisms for translation to higher scales, starting with renewed efforts to understand the structures of existing seed commons and the undervalued functions they provide.

CRedit authorship contribution statement

Erik Delaquis: Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Michael Halewood:** Writing – review & editing, Conceptualization. **Cheyenne Gerlach:** Writing – review & editing, Investigation, Data curation, Conceptualization. **Conny J.M. Almekinders:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Conceptualization. **Paul C. Struik:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization.

Declaration of competing interest

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Appendix A. Supplementary data

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Data availability

Data will be made available on request.

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