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# Understanding the Driving Forces and Actors of Land Change Due to Forestry and Agricultural Practices in Sumatra and Kalimantan: A Systematic Review

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**Abstract:** Indonesia has experienced one of the world's greatest dynamic land changes due to forestry and agricultural practices. Understanding the drivers behind these land changes remains challenging, partly because landscape research is spread across many domains and disciplines. We provide a systematic review of 91 studies that identify the causes and land change actors across Sumatra and Kalimantan. Our review shows that oil palm expansion is the most prominent (65 studies) among multiple direct causes of land change. We determined that property rights are the most prominent issue (31 studies) among the multiple underlying causes of land change. Distinct combinations of mainly economic, institutional, political, and social underlying drivers determine land change, rather than single key drivers. Our review also shows that central and district governments as decision-making actors are prominent (69 studies) among multiple land change actors. Our systematic review indicates knowledge gaps that can be filled by clarifying the identification and role of actors in land change.

**Keywords:** direct causes; PRISMA diagram; tropical deforestation; underlying causes



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## 1. Introduction

Changes in land cover (biophysical attributes of the earth's surface) and land use (human purpose or intent applied to these attributes) are so pervasive that, when aggregated globally, they significantly affect crucial aspects of the earth system functioning [1]. Tropical lowland regions in many parts of the world have experienced large land-use changes, leading to a decline in forest areas, while the area used for agricultural production has increased [2]. Land changes in the tropics significantly affect food security [3]. The loss of natural forests has resulted in the decline of values from several ecosystem services [4].

Indonesia is a tropical country with the world's highest $CO_2$ emissions from the processes of land change [5]. Agricultural expansion and forest exploitation have played an essential role in intensive land use management throughout Indonesia over the past few decades [6,7]. Understanding land-change causes and actors is one of the prime goals of global change research [3,8,9]. The concept of driving forces has distinguished direct causes and underlying causes of land change. The direct causes are the activities of actors that directly affect land use [10]. The extension and intensification of plantations are a direct cause of deforestation of primary forests in tropical areas [11]. The expansion of agriculture and forestry by large companies is creating significant land change [12]. Direct causes of land change have been influenced or determined by a more fundamental force, called underlying causes. Underlying causes are fundamental societal processes that drive

the proximate causes, either operating at the local level or indirectly from a higher level [8]. Forestry and agricultural policies that regulate land allocation are the underlying causes that determine land change [3,13]. The Indonesian government supports large-scale land use through policies because this scheme is considered capable of improving the country's economic and development conditions [14].

Actors play a special role because actors are responsible for, and play an important role in, the driving forces of land change. Actors make decisions, act accordingly, and influence other actors and the environment with their actions [9]. Most countries in Africa and Southeast Asia show that land-use systems controlled by the government lead to land use dominated by large companies through permits [15,16]. Indonesia also makes state claims on forest cover through the Forest Use Agreement (TGHK), strengthening the central government's position in controlling the use of state forest areas for companies; therefore, an understanding of the power of actors in land-use arrangements is important as a bridge to exploring options for improving land management [17].

The various causes that drive land change in the area reflect global trends and regional peculiarities, depending on social and ecological conditions; however, understanding the drivers of land change has its challenges. A robust variety of studies on these themes exist, but have limited relevance due to their scope and context [18]. Local-level studies are particular in their contexts, actors, main processes, scale, and resolution [19]. Based on the uniqueness of the local landscape and the causes of its changes, the use of a comparative framework will be useful to allow more generalized insight that can be transferred across places [20]. Systematic reviews provide a robust and more comprehensive picture based on multiple studies and settings compared to a single study and provide context for interpreting the results of new primary studies [18]. This systematic review technique is also a promising approach for integrating and considering land change at a local scale into land change at a more general level [21].

Several systematic reviews on a global scale have been carried out and resulted in invaluable insights into the landscape approach [22], deforestation [21,23,24] land tenure security [25], agricultural intensification in the tropics [26], climate effects and habitat loss [27], urban land [28], and wetlands conversion [13]; however, studies that synthesize the causes of land change on a national scale, particularly in areas with the highest land-change dynamics in Indonesia, have not been carried out. Over the past several decades, Sumatra and Kalimantan have been the areas with the most significant land change in Indonesia [14,29]. From 1985 to 1997, forest loss in Sumatra and Kalimantan was above the average for forest loss in Indonesia as a whole, and became the largest contributor to tree cover loss in Indonesia during the 2001–2019 period [7]; therefore, in our study, we chose Sumatra and Kalimantan as the study areas, as they are the areas with the largest forestry and plantation operations in Indonesia.

We divided systematic literature reviews into several types depending on their purpose, including testing, extending, critical, and descriptive reviews [30]. In this study, we used a descriptive review by organizing the studies into more homogeneous subgroups without statistical analysis [30]. We used a standardized coding format based on the characteristics of each publication with comments on the strength of available evidence. This literature review followed an established methodology that consists of pre-defining specific inclusion criteria, conducting a replicable search of the literature, assessing quality through a stage process, extracting data based on coding book/form-data extraction, and analyzing data [21,30].

We aimed to generate a general understanding of the direct and underlying causes of land change in Indonesia from various local-scale studies. In particular, our review had the following objectives: (1) to identify the most important drivers of land change in Sumatra and Kalimantan discussed in empirical case studies; (2) to reveal which actors were categorized as the decision-maker actors, direct land-change actors, and supporting actors of land change in Indonesia based on empirical case studies. A more generalized understanding of the causes of land change in Sumatra and Kalimantan, which have experienced rapid land

change, can help design national policies and governance to suppress uncontrolled land change moving forward. On a broader scale, this study provides information about the causes of land change and its actors from Indonesia as the largest producers of oil palm and the world's top ten largest industrial timber exporters.

## 2. Materials and Methods

### *2.1. Study Inclusion Criteria*

Before the study began, we formulated the inclusion criteria. These criteria were vital to the review process as a clear guide for selection of the publications obtained. They also increased the review's reliability because they allow others to use the same protocol to repeat the study for cross-checking and verification [30]. Table 1 shows the inclusion criteria for this study.

**Table 1.** Inclusion criteria for studies included in systematic review.

| No. | Criteria | Rationale |
| --- | --- | --- |
| 1 | The journals used have been indexed by Scopus or Thomson Reuters or at least peer-reviewed, and were not grey literature | Ensures a quality level, avoids broadening the search to an unmanageable level |
| 2 | The studies described the causes of land change and its actors | Ensures that the assessed study fits the purpose of the review |
| 3 | The studies were the result of primary research located in Sumatra and Kalimantan | |
| 4 | Publications are written in English or Indonesian | Uses language that the researcher can understand, thereby minimizing the occurrence of misunderstandings in extracting data |
| 5 | Studies only focused on land change for the benefit of plantation and agricultural areas (land changes caused by natural disasters and the need for non-renewable resources, such as mining, were not included in this study) | Over the last few decades, agriculture and plantations have become the sectors that have contributed most to land change in Indonesia [31,32] and worldwide [5] |

### *2.2. Search Literature Strategy*

There are three primary sources to find literature: (1) electronic databases; (2) backward-searching; and (3) forward-searching [30]. In this study, we used an electronic database to obtain studies that addressed our research objectives. This literature search used Google Scholar and Web Journal Publisher, as well as Springer link, Science direct, PLOS ONE, Taylor & Francis, and ISI Web of Science. The Indonesian and English search words used in this study were developed on the basis of several aspects:

1. Terms used for searches referring to context and interventions in the land-change process;
2. Identified synonyms and alternative spellings of the terms used;
3. Some search engines allowed the use of Boolean operators in the search. Frequently, "AND" was used to join target terms and "OR" to include synonyms.

Based on these aspects, the keywords used were as follows (See Supplementary Materials):

Search keywords in English ("landscape change" OR "landscape dynamics" OR "land use change" OR "land cover change") AND ("plantation" OR "agriculture" OR "crops" OR "estate" OR "forest") with case studies in Sumatra and Kalimantan selected and "Sumatra" OR "Kalimantan" then added. Search keywords with Indonesian ("perubahan lanskap" OR "dinamika lanskap" OR "perubahan penggunaan lahan" OR "perubahan tutupan lahan") AND ("perkebunan" OR "pertanian" OR "tanaman" OR "Perkebunan" OR "Hutan") AND ("Sumatra" OR "Kalimantan").

### 2.3. Screening and Quality Assessment

After compiling the list of references, researchers further screened each article to decide whether it should be included for data extraction and analysis [30]. The screening process and quality assessment were carried out in two stages: (1) selection of primary studies based on titles and abstracts; and (2) assessment based on the full text of the study. This screening and quality assessment process referred to the inclusion criteria (Table 1). The process is shown in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram in Figure 1, which includes the number of studies identified during the search, screening, and quality assessment process.

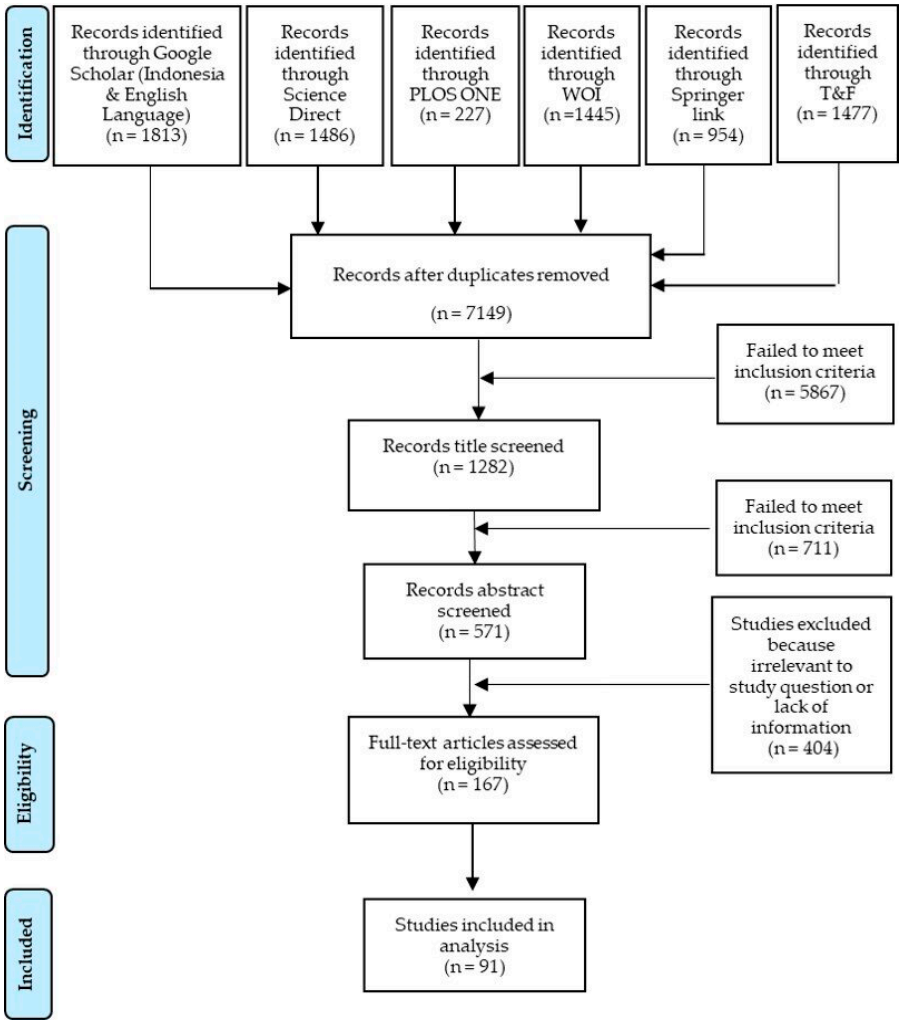


**Figure 1.** A PRISMA diagram depicting the screening process and quality assessment of each publication.

### 2.4. Study Characteristics

Our review resulted in the selection of 91 studies performed in 13 provinces in Sumatra and Kalimantan (Figure 2). Jambi was the most intensively studied province.


**Figure 2.** Map of the areas in the systematic review study, presenting various provinces on Sumatra and Kalimantan islands.

From a total of 91 studies, there were 21 studies with research areas that covered more than one province or extended across multiple provinces, and 70 studies with research areas within one province; therefore, there were 180 studies if counted on the basis of distribution by province, which was more than the actual number of studies. Furthermore, there were only three studies in North Kalimantan because this province was recently established, in 2012, and previously was an East Kalimantan region. For this reason, research in East Kalimantan conducted before 2012 also included the North Kalimantan region. The study of land-change causes has increased sharply from year to year, especially since the 2000s (Figure 3).

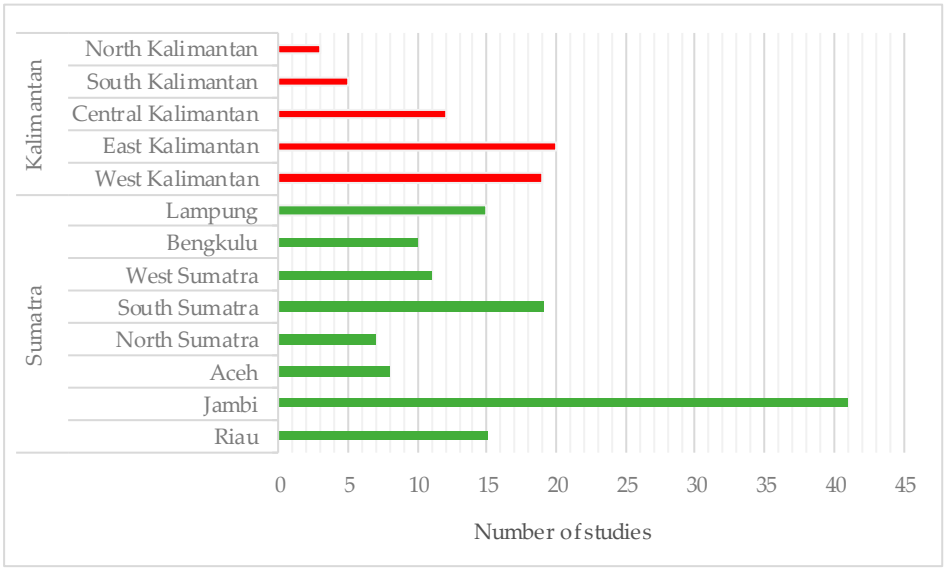


**Figure 3.** Distribution of studies by province.

### *2.5. Data Extraction and Analysis*

Our systematic review adopted a formal and systematic approach to the extraction of relevant information from primary studies, so it required a form of data extraction that comprised a complete review of each journal [33]. Our systematic review explains the causes of land change, which consist of underlying causes and direct causes. There has been a feedback loop concept in the land change phenomenon [34] (See Figure 4). The phenomenon of land change is driven by underlying causes that give rise to land

use activities at the site level (direct causes). The impact of land change will generate responses from various actors who feel the impact. The actors' responses will influence the decision-making process and subsequent land-use activities. In this study, the scope was limited to only the causes of land change.

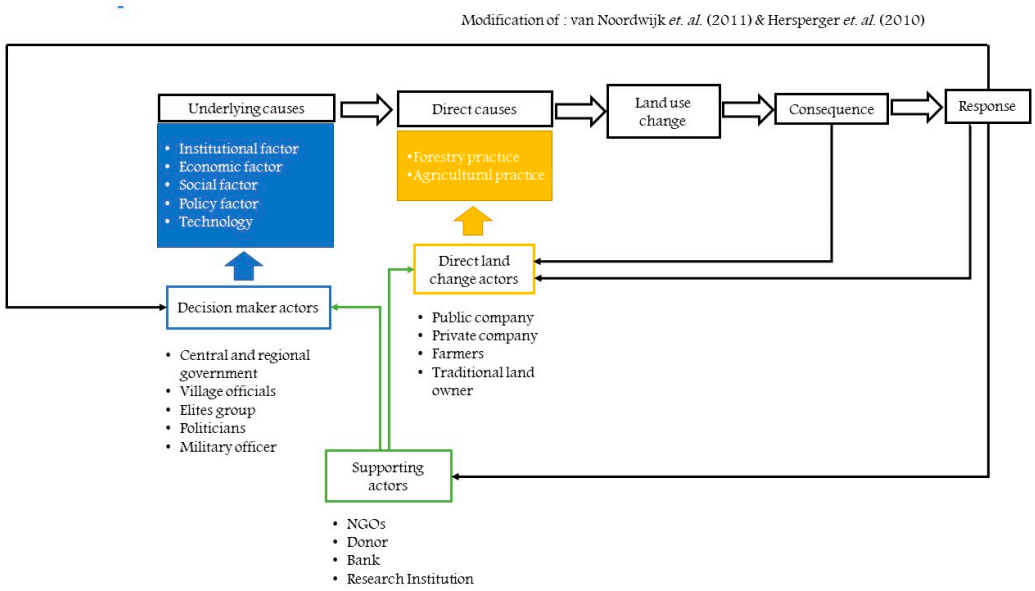


**Figure 4.** Conceptual framework for data extraction.

The causes of land change are the causes that, together with actors, shape land change. This concept explains that there are two types of actors, namely, actors that affect the underlying causes and actors that directly change land (direct cause) [9,35]. Apart from these actors, there are supporting actors who influence the land change process but are not directly related to decision-making or land change activities at the site level [20].

Our data extraction method was a modification of the HERCULES systematic review protocol and systematic review on tropical deforestation [8,20]. The phenomenon of land change is caused by direct causes carried out by actors who use land directly. In this case, forestry and agricultural practices are the focus because they are the largest contributors to land change in Indonesia, especially in the Sumatra and Kalimantan regions. This land-use activity can take place because underlying causes drive it. HERCULES and tropical deforestation studies have shown that economic factors, institutional factors, policy factors, social factors, and technological factors are the underlying causes of land change in tropical areas, including wetlands [8,20]. Therefore, the categorization used in this coding book referred to those studies.

There are three actors who influence the land change process. These actors are categorized into the following categories:

1. Direct land change actors Actors who carry out activities that cause immediate change at the site level.
2. Decision-making actors who contribute to the underlying causes of land change Actors who, through their political power, are decision-makers or formulate regulations that affect land use.
3. Supporting actors Actors who support government policies related to land use, or actors that support solving problems regarding land management.

We compiled codebooks to define, categorize, and sub-categorize the direct causes, underlying causes, and actors [36]. They were used to guide a coherent coding process, so that the researcher could obtain phrases that captured the essential facts from a set of language or visual data. In an attempt to allow for new sub-categories to emerge, the final codebooks were developed as well [37]. Using the codebooks as guidance to categorize

and sub-categorize, we identified the data and then coded or grouped them using NvivoR1 for Windows [20]. The codebooks are detailed descriptions of the causes of land change and their actors (See Appendix A, Tables A1–A4).

The output generated by the NvivoR1 software was in the form of a diagram showing the sum in each category and sub-category of land change causes and their actors. As a result, it was possible in this study to describe the causes of land change and their most dominant actors in Sumatra and Kalimantan. In addition, based on the output of the NvivoR1 software, we also described the combination of underlying causes and the relationships between underlying and direct causes that are most commonly found in primary studies.

## 3. Results

### *3.1. Direct Causes*

The diagram represents the sum of each sub-category of direct causes of land change in Sumatra and Kalimantan from the total studies analyzed (Figure 5). The expansion of agricultural areas has been by far the main direct cause of land change in Sumatra and Kalimantan. The activities that led to the most changes in land were oil palm plantations (agricultural expansion sub-category) and wood extraction and timber plantations (forest expansion sub-category). Although shifting cultivation is not a dominant direct cause, shifting cultivation and wood extraction are distributed throughout the province. Oil palm and timber plantations that led to the most changes can be found in all provinces except North Kalimantan (See Appendix B, Table A5). North Kalimantan is a new province resulting from the division of East Kalimantan; thus, the direct causes of land change occurring in this region can be seen in the eastern province.

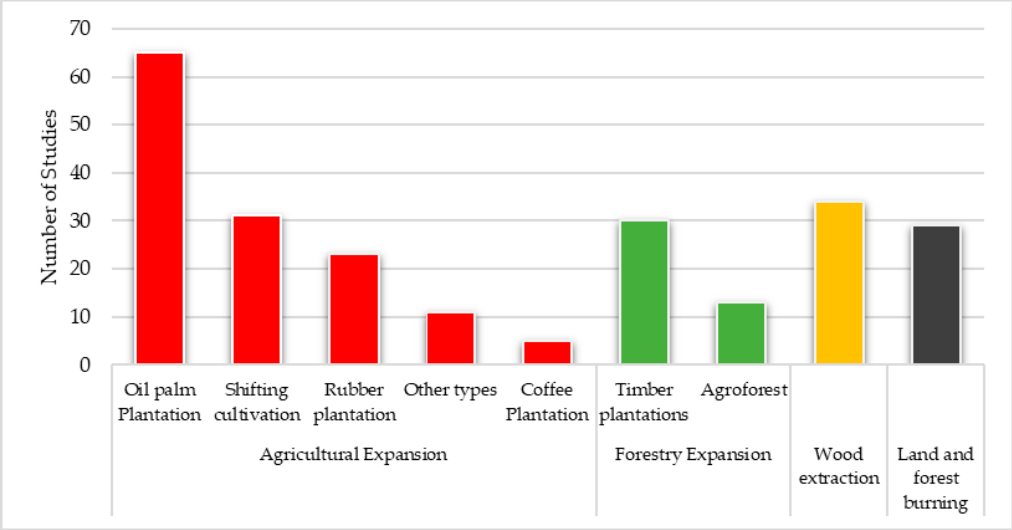


**Figure 5.** Diagram of direct causes of land change in Sumatra and Kalimantan.

The highest proportion of oil palm plantations are found in Riau Province (86.7%) (See Appendix B, Table A5). Based on data from the Sub Directorate of Plantation Statistics in 2018, the total area of oil palm plantations in Riau represented Indonesia's largest land-use type. The highest proportion of wood extraction operations are concentrated in the province of South Kalimantan (80%); this form of land use comprises wood extraction activities carried out by companies with forest concession rights (*Hak Pengusahaan Hutan*/HPH) or illegal logging by specific individuals (See Appendix B, Table A5). Data for 2018 show that Kalimantan Island was the area with the highest number of forest concession rights (HPH) issued in Indonesia, i.e., comprising 222 company permits with total production of around 4.6 million $m^3$ [38]. The highest proportion of timber plantations are located in

Riau Province (73.3%) (See Appendix B, Table A5). Riau is the area with the largest timber plantation in Indonesia, totaling 1.43 million hectares [39].

Agroforestry, coffee, and rubber plantations were the least important causes of land change. The highest proportions of agroforestry (19.5%) and rubber plantations (43.9%) were located in Jambi Province (See Appendix B, Table A5). Rubber has undergone significant development as a commodity since it was first introduced to Jambi in 1904 [40]. Monoculture rubber has begun expanding sharply, replacing rubber agroforestry in this province. In 2019, the cultivated area and production of rubber in Jambi Province were the fourth-highest in Indonesia, at 390.707 ha and 306.942 tons, respectively [41].

The highest frequency for coffee plantation activities, 26.7%, can be found in studies located in Lampung (See Appendix B, Table A5). In 2019, the coffee plantation area in Lampung totaled 156.862 ha and had production of 110,291 tons, which was the second-biggest coffee plantation industry in Indonesia after South Sumatra Province [42]. Land and forest burning also affected land change in Sumatra and Kalimantan provinces, with the highest frequency found in studies located in Riau Province, at 47%. Burning land was the most effective and efficient way for farmers to claim land or prepare the land before planting [43].

### *3.2. Underlying Causes*

Various other underlying causes drive land change activities in the field. The institutional/political driver is by far the leading underlying cause of land change in Sumatra and Kalimantan [44]. Although politics and policy are two things that cannot be separated, in this study, we separated the two concepts. Politics talks about goals such as fighting for certain values by certain actors, whereas policy is the product of a political process to respond to certain problems [45]; therefore, we separated politics and policy as different underlying causes of land change phenomena. The results showed that political and policy factors were leading causes of land change activities (Figure 2).

The higher proportions related to institutional factors were property rights issues and lack of institutional capacity (Figure 6). The issue of property rights is the dominant underlying cause of land change in Riau Province, at 46.7% (See Appendix B, Table A6). The issue of property rights over land is a major contributing factor for state forest areas that overlap with community-managed areas [31,32,44,46,47]. Claims by the state without clear boundaries [48–50], the granting of permits for large-scale concessions, and community management not recognized by the state [51–55] are the most frequent problems in Indonesia.

Lack of institutional capacity was distributed throughout the provinces of Sumatra and Kalimantan. West Kalimantan is the province with the highest proportion (52.6%) of institutions responsible for land governance (See Appendix B, Table A6). Lack of institutional capacity is related to the fact that: (1) provincial governments are unable to enforce land management regulations [29]; (2) the government has failed to address the problems of the people living in forest areas [56]; (3) government bodies often hand out permits without the knowledge of the people living in the area [57]; and (4) the state is weak in exercising control and supervision [12].

Apart from institutional factors, policy factors are also a leading cause of land change activities. Jambi is the province with the highest proportion of transmigration policy, at 41.5% (See Appendix B, Table A6). Factors that affect transmigration policy include (1) the transmigration program, which involves the agricultural development of a region [58]; (2) the intensification of monoculture rubber and particularly oil palm plantations that were brought to Sumatra in the late 1980s through the transmigration program based on the Nucleus Estate System (NES) [59]; (3) a successful transmigration program followed by a massive increase in land clearing by slash-and-burn [60]; and (4) transmigration development that led to decline in areas of mature high forest [61].

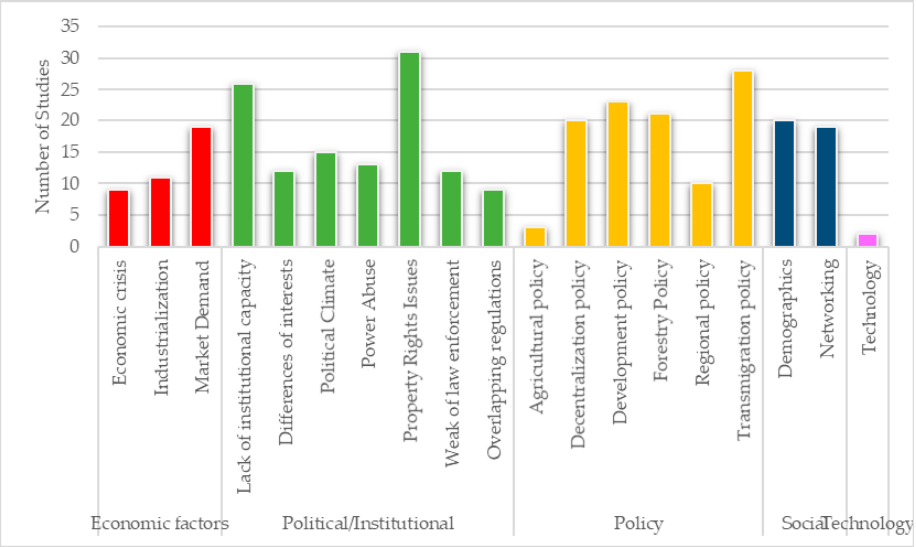


**Figure 6.** Diagram of underlying causes of land change in Sumatra and Kalimantan.

### *3.3. Combination of Direct Causes and Underlying Causes in Land Change*

Of all the cases reviewed, the property rights issue was the leading underlying cause for oil palm plantation expansion, with 24 studies addressing the issue (See Figure 7); this also showed that the expansion of oil palm plantations and land and forest burning were activities influenced by all the underlying causes, and that the two direct causes of land change require complex solutions because they are driven by a variety of other underlying causes. The technology factor only influenced agricultural expansion and forestry expansion. The technological factor was related to the development of monoculture rubber by offering high-quality clones of rubber and the development of oil palm plantations that offer less labor-intensive approaches and new technical knowledge in oil palm management. Indonesia's lack of technological progress has caused heavy reliance on slash-and-burn activities for agricultural expansion [49].

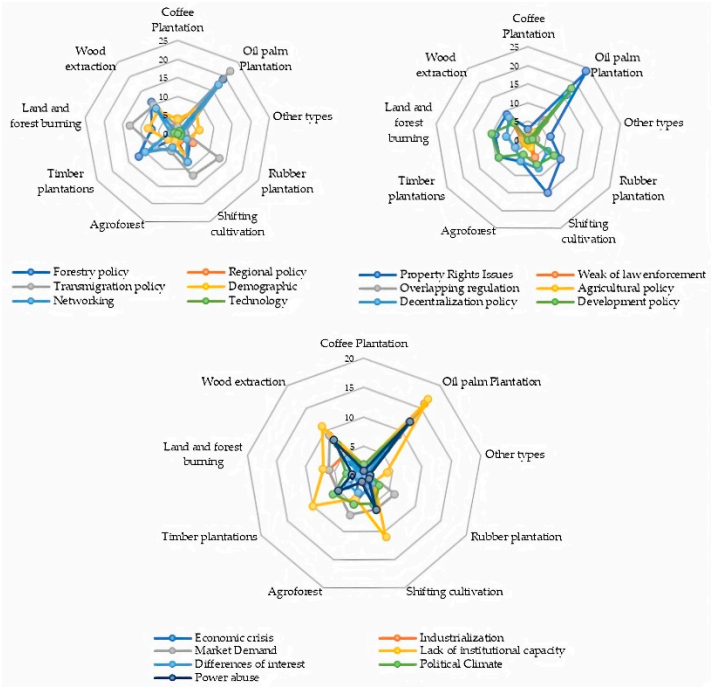


**Figure 7.** Radar charts for the combination of direct causes and underlying causes in land-use change. (The numbers in the charts indicate the studies of combination direct causes and underlying causes cited).

Most of the land change in Sumatra and Kalimantan was explained by a combination of several underlying direct and indirect causes rather than by a single underlying cause. Only a few direct causes of land change were related to one single underlying driver in about 31.87% of total cases (See Appendix C, Table A7). The combination of two underlying causes was the most common, accounting for 28.57% of total cases combined with economic, institutional, political, and social factors.

### *3.4. Actors in the Causes of Land Change*

The driving forces are the forces that, together with the actors, shape land change [9]. In this study, we extracted information on the actors identified in the literature categorized as decision-making actors, direct land change actors, and supporting actors. The systematic review results showed that decision-making actors and direct land change actors are the most discussed in the literature (Figure 8). In the category of decision-making actors, the central and local governments are the main actors that play a role in land change through their political activities, e.g., granting land management permits. The government's role is translated into policy and institutional factors that are the most influential underlying causes in the land change process. For example, the governor grants permits for oil palm plantations [50], and the Ministry of Environment and Forestry (MoEF) and regional government grant forest concession rights (*Hak Pengusahaan Hutan*/HPH) [57,62]. Further, MoEF also issues permits to convert some protected forests into timber plantations [63] and grants a trial license for non-forest land (*Area Penggunaan Lain*/APL) [32].

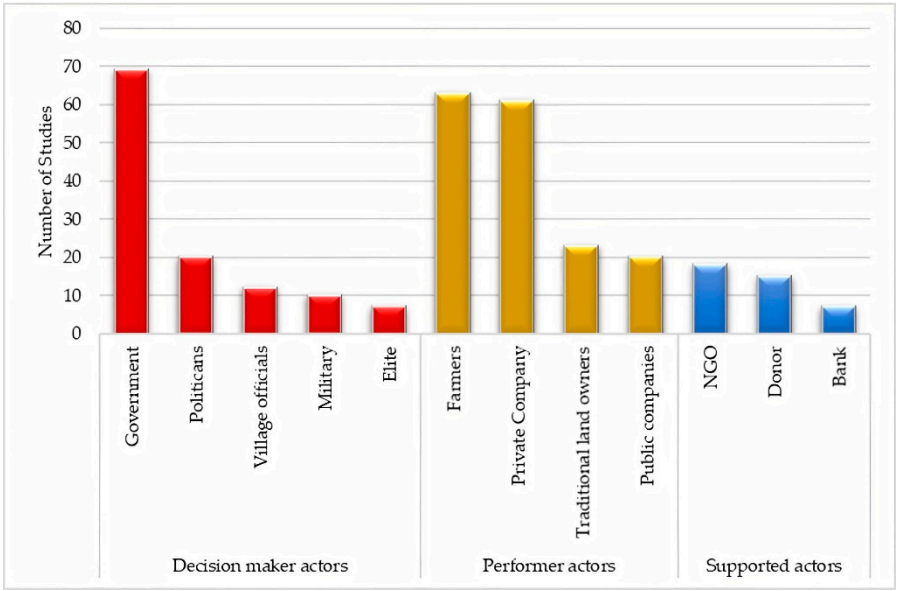


**Figure 8.** Diagram of land change actors in Sumatra and Kalimantan.

The "elite" decision-making actors are actors from a certain network that ensures control of land outside existing formal control or by bringing their land interests under formal control. For example, Indonesian pulp and paper conglomerates, with close links to Indonesian political elites, have accelerated their timber planting rates, especially in Sumatra and Kalimantan [64]. Governors, mayors, and district heads with military backgrounds can also establish cooperative arrangements with regional military commanders to cut and sell timber and other commodities [65].

Direct land change actors consist of farmers, private companies, public companies, and traditional land owners. The traditional land owner is indigenous people who own and manage land-based on traditional law. Inthis category, farmers (landowners and managers, both residents and migrants) and private companies are the most influential land management actors in Sumatra and Kalimantan (Figure 8). Private companies carry

out large-scale land management based on permits from the government, the majority of which are used to develop oil palm plantations [38,49,61], timber plantations (*Hutan Tanaman Industri*/HTI) [66], and forest concession rights (*Hak Pengusahaan Hutan*/HPH) [67]. Communities mostly manage small-scale land to meet household needs from generation to generation, for example, by shifting cultivation [32,38] or agroforestry [67–70].

Donor agencies and banks fall into the category of supporting actors, as they support government programs related to land resource management through grants or loans. During the period of state development, the Indonesian state and donor agencies initiated a strategy for agricultural development in transmigration areas [12]. Non-governmental organizations (NGOs) and research institutions are actors that seek to support improvements in land governance by raising awareness and supporting the strengthening of civil society as well as providing decision-makers with options for improving land use. Local actors supported by non-governmental organizations (NGOs) started to reclaim authority over former customary land and began occupying corporate plantations and state forests [71].

## 4. Discussion

Land change, often thought of as a local problem, has become a global problem [72]. The challenge is determining which process at the local level causes the greatest effect; the interactions between multiple drivers and their geographic manifestations remain poorly understood [20]. In this study, we adopted and modified the HERCULES systematic review protocol (2014) and the Geist and Lambin tropical deforestation causes (2002) [8,20] to study the driving forces of land change at the national scale, making it comparable with the systematic review of other land changes. We modified the categories of causes in both references to suit the context of Sumatra and Kalimantan. For example, both references state that infrastructure construction is a direct cause of deforestation and land change. In our research, we focused on agricultural and forestry practices, where infrastructure construction is not directly involved, so we opted not to use this category.

Compared to previous reviews of land change using the continental and global scale [13,25,31,32,46], our study focused on the national scale with the scope of land change that considers Indonesian forestry and agricultural development. To the best of our knowledge, a systematic review of the drivers of land change focusing on Indonesia's different regional characteristics has never been conducted before. Our results indicate the factors and processes essential for land change.

### *4.1. Agricultural and Forestry Practices as Direct Causes of Land Change*

Agriculture is the primary land use globally because half of the world's habitable land is used for agriculture [5,50]. This condition shows that the leading direct causes of land change in Indonesia are the same as the global trend. This finding is also reinforced by several previous studies stating that the direct cause of land change in countries globally, including Indonesia, is agricultural expansion [8,13,32]. Oil palm is one of the most strategic commodities due to the high demand in various countries worldwide. Currently, Indonesia is the world's largest palm oil producer [5], with an area of oil palm plantations in Indonesia to date reaching nearly 15 million hectares [73]. The plantation sector is also one of the largest contributors to gross domestic product (GDP), accounting for 0.29% amidst a GDP contraction rate of 5.32% [74].

The positive growth in the development of the oil palm industry has ignored the prevailing regulations and negative externalities resulting from the development of oil palm plantations. The licensing of oil palm plantations often does not comply with applicable legal procedures There are several stages of the legal procedures. First, investors must submit permits consisting of location permits, environmental impact analysis (AMDAL), and environmental permits sequentially to local governments. Second, when implementing the AMDAL and environmental permits, a boundary setting is carried out by the NLA and release approval of forest area by the MoEF. Third, with the completeness of the AMDAL permit, environmental permit, and forest release permit, investors apply for a Plantation

Business Permit (IUP) to the local government. Fourth, investors apply for Business Use Rights (HGU) to NLA on the condition that they have obtained an IUP and an forest area release permit. Local governments provide permits for oil palm plantations within forest concessions [32]. The rapid development of oil palm also influences land conflicts between communities or between communities and companies [46] and is closely related to corrupt practices through licensing [41,54].

In the forestry sector, important direct causes have led to land changes such as wood extraction and timber plantations. Wood extraction from forests on a large scale took place in Indonesia starting in the 1960s after the government issued the Forest Concession Rights (HPH) policy [52]. In the 1970s, HPH reached its peak, by which time the government-military relationship was powerful. The military has the privilege of carrying out large-scale logging business activities (HPH) [75] and is at the forefront of maintaining conservation forests [67]. Logging on a large scale has resulted in a logged-over area (LOA) that has become a quasi-open access area vulnerable to conflicts due to mutual claims from certain actors. LOAs with lower productivity than primary forest are very vulnerable to being claimed and converted to other uses [14].

Apart from companies, illegal wood extraction is also carried out by a particular party. The existence of HPHs at the site level under state permits raises the issue of illegal logging, that is, logging by parties without state permits. Illegal timber does generate new job opportunities for local people, but their labor force can be easily exploited. People want to be involved in illegal activities to earn wages; however, they still depend on middlemen for equipment and transportation, making local people vulnerable to exploitation [67], trapping them in this line of work and poverty. Unstable political conditions (post-reform and decentralization) have led to rampant illegal logging; illegal timber is even exported to various countries worldwide [67].

Timber production from natural forests has declined worldwide since the late 1980s [76] and has been replaced by forest plantations, which accounted for approximately 51% of the world's industrial roundwood production in 2018 [77]. The rapid development of forest plantations has made Indonesia one of the top 10 producers of forest plantation products (round wood, pulp for paper, paper, and paperboard) [77]. In Indonesia, timber plantation (*Hutan Tanaman Industri*/HTI) development begins with utilizing a logged-over area (LOA) using government subsidies from reforestation funds. However, HTI development is mostly carried out in productive forests. Companies logs in productive areas through timber utilization permits (IPK) as input in HTI development [78]. This fact shows that the companies greatly benefit from obtaining subsidies for HTI development and at the same time obtaining income from the use of wood from productive forests.

### *4.2. Institutional and Policy Factors as Underlying Causes of Land Change*

Our study revealed that institutional factors (e.g., property rights issues and lack of institutional capacity) and policy factors (transmigration policy) are the most important underlying causes of land change in Sumatra and Kalimantan. These two factors are also the leading causes of land change in various countries. Institutional factors have become critical underlying causes of land change in some parts of Europe [20]. Policy is also a significant factor and an underlying cause of land change in Latin America, Africa, and Southeast Asia [79].

Property rights issues, as the leading underlying causes of land change in Sumatra and Kalimantan, are related to land resource management history, especially in the forestry sector. The Draft Regulation of the Government of the Republic of Indonesia regarding the Settlement of Inconsistencies between Spatial Planning and Forest Areas, Permits, and/or Land Rights indicates that 40.97% of Indonesia's territory overlaps. Unilateral claims by the state have been made since the Dutch colonial era; the government issued an Agrarian Decree that stated that all land that other parties could not prove to be property was the state domain (*domainverklaring*) [80]. Government policies in land allocation, especially forest areas, still maintain the domain-converting ideology as a form of state control over

resources. This ideology is reflected in the Basic Forestry Law Number 1967, which states that forest area is based on its function throughout Indonesia and is listed in the Forest Use Agreement (TGHK) in 1986.

The government's forest area claims are not accompanied by clear forest area boundary demarcation at the site level. Social mapping is not considered to determine whether management has been carried out by the community long before the stipulation of TGHK. This creates confusing boundaries between state forests and community-managed areas. Forest land use and allocation are problematic because they often overlap with traditional and customary claims by local communities [81–83]. The unfinished forest gazettement process at the site level has resulted in a 'gray' area and has become an area of conflict for various parties. The situation of unclear land ownership also encourages illegal cutting of natural forest [49]; forest conversion is also possible because of the need to assert control over land under tenure insecurity conditions (certainty of rights).

The issue of land ownership is also related to the lack of institutional capacity [84,85]. Provincial and local governments cannot implement regulations properly, particularly trial licenses for non-forest land (APL), many parts of which are managed by local communities. The license itself did not follow GR No. 7/1990, requiring that industrial team-related plantations be established on state forestland [32]. The provincial government also implements rules in use and rules in form, meaning that the government has ruled at the site level, which can differ from the existing rules in form. These rules are often incompatible with their duties and functions in field governance. An institution cannot carry out its functions properly because there are people who "mess up" the duties and functions of the government. For this reason, district or sub-district officials gain greater control over forest resources and go beyond their official legal authority [50].

The government also failed to recognize the people living in forest areas and gave permits to large companies without considering the community's management. The government does not pay attention to the reality of state forest areas in the field but symbolically observes its legality through the available means [86]. Government Regulation No. 59 of 1997 concerning land registration has controlled the granting of rights to communities that occupy state land. Article 24 paragraph (2) states that the government recognizes an applicant's property rights when the applicant and their predecessors have physically occupied a parcel of land for 20 years or more consecutively by the applicant. The fact is that the government has not been able to implement the process properly, governing land acquisition is unclear, and the government would not address the problems of in-generational displacement [87].

The weakness of state control and supervision makes it difficult to identify actors that must be dealt with in a targeted manner; these failings allow for the perpetuation of crime. Actors who do not have many choices due to limited resources choose to take illegal actions because of past experience that violations are not fatal and provide benefits (rational choice). Violations can also be committed by people who have many choices because the punishment for violating norms or laws and regulations can be borne by their resources [88]. Weak law enforcement encourages power abuse by government actors and rent-seeking behavior such as by entrepreneurs. These behaviors will continue to be replicated because their benefits are far greater than the negative impacts they receive.

The transmigration policy is also an example of the government's weakness in implementing its policy products that are directly related to land management in forest areas. The government provided $\pm 2$ hectares of land for settlement and agricultural development for transmigrant communities [47]. Plantation development by transmigrants was expected to be a source of economic benefit for transmigrants; therefore, Sumatra and Kalimantan, as the target areas for the transmigration program, experienced massive forest conversion after the transmigration program was implemented [89].

During development of the transmigration program, the government also encouraged the industrialization of natural resource management, including large-scale plantations; the government developed Nucleus Estate Smallholder (NES) for transmigrant communities

to accelerate the development of monoculture plantations by collaborating with large companies. The NES program was first introduced for rubber plantations [90]. This program was quite effective in accelerating the development of monoculture plantations; however, in the end, NES was not popular because the contracts between the companies and farmers were often unclear, which in turn created conditions of economic distress for the communities [91].

The unclear area allocated to migrants for cultivation has caused uncontrolled land clearing. Migrants were clearing land on a large scale for the development of plantation crops [90]. The non-transparent land allocation and unclear boundaries of transmigration areas with local communities have also caused social conflict among communities. Social jealousy in local communities encourages participation in land clearing by burning as a form of land claim.

Community socio-cultural changes due to the transmigration program were also not well-anticipated by the government. The success of migrants in managing their land attracted spontaneous transmigrants to claim land illegally. The expansion of the regional economy due to the development of plantation areas has encouraged the arrival of newcomers to clear natural forests by burning as a form of land claim [54,92]. Transmigrants who did not get land access have to go through a long, high-cost administrative process to own land recognized by the state, so they choose instead to clear land by burning.

The transmigration program's domino effect, which encouraged spontaneous transmigrants/newcomers to migrate, became one of the important factors that led to the conversion of natural forests into agricultural and plantation areas. Land in Sumatra and Kalimantan is not only subject to conversion pressure from transmigrants and large-scale companies, but also spontaneous transmigrants/newcomers, which are difficult for the government to monitor. For example, in 2019, one of the peat hydrological unit areas on the island of Sumatra only had a forest area of less than 10% due to the conversion carried out by 90% of the migrants from Java [93].

In contrast to the two previous factors, technology is the least common cause of land change. Technology in plantation development includes quality seeds and new technical knowledge in management. In practice, farmers find it difficult to obtain quality seeds, which causes low productivity [12]. Low productivity compels farmers to extend their plantation areas to achieve desired production. In addition, not everyone can access information about good management techniques in developing oil palm; therefore, communities continue to clear land by burning to expand their plantation area. Land is cleared by burning because this is the most effective and efficient method.

### *4.3. The Most Prominent Actor in Land Change in Indonesia*

Indonesia's current forest and land governance systems assign various responsibilities to district, provincial, and national authorities. Land allocation is regulated by the Ministry of Environment and Forestry (MoEF) and the National Land Agency (NLA); the MoEF controls forest areas, whereas the NLA manages non-forest areas [83]. Based on Law Number 32 of 2004 concerning Regional Government, the implementation of operational land management (forest areas and outside forest areas) lies with the district and provincial governments [85,94,95]

The institution that is responsible for controlling land governance has not been able to carry out its functions effectively for several reasons: (1) power abuse is closely related to violations of applicable regulations and corruption; (2) the inability of the institution to see land management at the site level; and (3) weak coordination between related institutions, which can be caused by conflicts of interest. Power abuse relates to actors who have dynamic and ambiguous identities, which at one time represent public interests and at other times represent private interests, allowing authorities to use their publicly derived powers to fulfill their own interests [40]. The authorized institution sees that the truth in policy is determined more by legal default (based on the legal documents) than the truth at the site level, resulting in the neglect of pre-existing management options [86].

Land use issues are often answered by formulating policies that are not accompanied by implementation of the proper legal products from the policymakers and implementers themselves. Legal development comprises the renewal of legal products and their exemplary implementation by the authorized institutions. The weakness of such a regulatory agency provides opportunities for actors at the site level, including companies and communities, to undertake "informal land management". Governments that have great control over land allocation without effective performance from government agencies (legal institutions, local governments, central government etc.) are a cause of prolonged conflicts [62,70].

Government control over land allocation through policies does not reflect actual control at the site level. Actors tend to be opportunistic by making maximum use of policies and ignoring existing legal regulations because these regulations have never actually worked effectively. Village elites, communities, and brokers form networks to manage land allocation at the site level without legal mechanisms [67,69]. These actors are, in fact, the most powerful at the site level in controlling land use.

### *4.4. Limitations and the Strength of the Study*

A systematic review can provide a full, more comprehensive picture based on multiple studies and settings than a single study [18]; however, relevant information reported in the empirical studies used may be lost. We selected only peer-reviewed journals that contained specific electronic databases that matched our English and Indonesian search words. Other studies that focused more on land change processes but did not meet our criteria were not included in this study. Despite these limitations, this study provides an overview derived from multiple single studies, originating from multiple study periods and across regions, that were robust in the local context and provided in-depth explanations of the processes and leading causes of land change. For Indonesia, as one of the countries with the most significant deforestation rates and $CO_2$ emissions (from land use) in the world [5], the generalization is fundamental as a basis for improving land management systems. This systematic review also provides a broad and deep understanding of existing research, allowing future researchers to advance our land use knowledge.

### *4.5. The Future of Land Governance and Systematic Review Research*

This systematic review of land change can provide an overview of the causes and associated actors driving the dynamic changes in land in Sumatra and Kalimantan. It is necessary to develop a systematic review of land change using a quantitative approach, known as a meta-analysis, and to expand the scope of the literature analyzed both in the type of search database and the type of literature: for example, comparing findings in the peer-reviewed literature with the grey literature [22].

The large number of legal products used to control land governance, without any assignment from the government itself as the policymaker to ensure compliance with the implementation process, has resulted in unclear management at the site level. Policymakers only set policies based on specific regulations without being able to see the reality on the ground. Rent seekers exploit this problem by managing land beyond formal control [86]; therefore, policy implementation must consider the social realities in land management. Problems in the field do not always have to be answered with a uniform legal product. Still, the government supports the resource instruments needed to improve governance through strong actors at the site level.

## 5. Conclusions

Empirical case studies show that oil palm expansion is the agricultural practice most commonly found to alter land use in Sumatra and Kalimantan. Oil palm is an agricultural commodity mostly developed both by large-scale companies and independent farmers. The underlying causes of land change from forestry and agricultural practices are property rights issues, lack of institutional capacity, and transmigration policy. These institutional

and policy factors are the main causes of uncontrolled land changes that are closely related to the participation of the central and local governments as decision-makers in land use.

Our study has identified the parties that contribute most to land change in Sumatra and Kalimantan. The central and local governments' inability to translate broad legal and political policy to management at the site level, as well as corruption in governing bodies, has resulted in unclear management at the site level. Due to the government's weak structural condition, actors have responded at the site level by taking action on mutual claims accompanied by the massive use of resources (logging) and burning of forests and land to convert the land. This shows that the government's contribution in accelerating land change is in spite of the government's ability to control and govern effectively. Land control by the government through regulation (de jure land control), followed by poor governance, allows land control by actors in the field (de facto land control), resulting in uncontrolled land changes.

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## Appendix A

**Table A1.** Contextual aspects of the journal and characteristics of the study area.

| Category Groups | Category | Descriptions |
|---|---|---|
| Formal information | Journal Title<br>Author<br>Publication Year<br>Journal source/outlet | |
| Location and Time | Research Location<br>Publication Time | Province<br>Year in which study was published |

**Table A2.** Underlying causes of land change in Sumatra and Kalimantan.

| Category | Underlying Causes | Descriptions |
|---|---|---|
| Economic | Economic crisis | Affected trade conditions; decreased demand |
| | Industrialization | Structural changes in agriculture and forestry |
| | Demand/consumption | Demand for wood, agricultural, and plantation products, and their derivative products; high demand also has an impact on high commodity prices |
| Institutional | Differences in interests | The difference in interests among government agencies causes ineffective land management at the site level; formal and informal interests of the actors |
| | Political climate | Change in leaders/elections |
| | Power abuse | Use of authority for personal gain; Corruption, collusion, and nepotism |
| | Property rights issues | "Land races", land tenure insecurity, quasi-open access conditions, maladjusted customary rights, titling/legalization, low empowerment of local users |
| | Weak law enforcement | There are no strict punishments for environmental crimes. The regulations are not well-implemented |
| | Lack of institutional capacity | Poor performance and low coordination between institutions |
| | Overlapping regulations | The substance of regulations that overlap one another |
| Policy factors | | |
| | Development policy | Policies to accelerate the economy (infrastructure development, REPELITA, etc.) |
| | Forestry policy | Policies related to the allocation of forest areas, including licensing in forest areas, changes to forestry laws, subsidies |
| | Agricultural policy | Policies related to the acceleration of plantation and agricultural development, including credit/subsidies for the development of the agricultural and plantation sectors |
| | Decentralization policy | Policies related to granting authority to local governments |
| | Regional policy | Regional policies regarding land allocation for agricultural or plantation purposes |
| | Transmigration policy | The relocation of the Javanese population to the Sumatra and Kalimantan areas had an impact on resource management and triggered spontaneous transmigrants. |
| Social/Cultural | Demographics | Population growth, population distribution, in–out migration |
| | Networking | Coalition formation by certain actors for the operation of private interests |
| Technological | Technological modernization agricultural sector | Technologies that increase yieldsare capital- intensive, and allow farmers to employ less labor. |

**Table A3.** Direct causes of land change in Sumatra and Kalimantan.

| Category | Direct Causes | Descriptions |
|---|---|---|
| Land and forest burning | | Burning on quasi-open access land for preparation before planting |
| Agricultural expansion | | |
| Settled cultivation | Coffee plantations | Monoculture planting of coffee trees |
| | Oil palm plantations | Monoculture planting of oil palm |
| | Rubber plantations | Monoculture planting of rubber trees |
| | Other types | Monoculture planting of sugarcane, resin, cocoa, pepper, cinnamon, coconut |
| Shifting cultivation | | Commodities planted include fruit trees, vegetable crops, tubers |
| Forestry expansion | Timber plantations | Planting of fast-growing species by companies for round wood, pulp, paper, and paperboard |
| | Agroforestry | A land-use system that combines woody plants (trees, shrubs, bamboo, rattan, and others) with non-woody plants (vegetables, grasses, and other crops) |
| Wood extraction | Logging and illegal logging | Logging is wood extraction that is carried out by companies legally. In contrast, illegal logging is wood extraction that is carried out by certain individuals without any legal permission from the government. |

**Table A4.** Actors related to land change phenomena.

| Actor Category | Descriptions |
|---|---|
| Decision-making actors | Actors who, through their political power, become decision-makers or formulate regulations that affect land-use |
| Direct land change actors | Actors who carry out activities that cause direct change at the site level |
| Supporting actors | Actors who support land change at the site level and support improvements in land management to minimize the impacts of land change. For example, through processes of advocacy, mentoring, research, etc. |

## Appendix B

**Table A5.** Frequency of direct causes of land change in Sumatra and Kalimantan.

| | | | Aceh (*n* = 8) | North Sumatra (*n* = 7) | West Sumatra (*n* = 11) | Riau (*n* = 15) | South Sumatra (*n* = 19) | Bengkulu (*n* = 10) | Jambi (*n* = 41) | Lampung (*n* = 15) | North Kalimantan (*n* = 3) | South Kalimantan (*n* = 5) | Central Kalimantan (*n* = 12) | East Kalimantan (*n* = 20) | West Kalimantan (*n* = 19) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agricultural expansion | Coffee Plantation | *n*= | 0 | 0 | 1 | 0 | 2 | 0 | 2 | 4 | 0 | 0 | 0 | 1 | 1 |
| | | % | 0.0 | 0.0 | 9.1 | 0.0 | 10.5 | 0.0 | 4.9 | 26.7 | 0.0 | 0.0 | 0.0 | 5.0 | 5.3 |
| | Oil palm Plantation | *n*= | 3 | 5 | 5 | 13 | 11 | 4 | 32 | 8 | 0 | 3 | 7 | 14 | 15 |
| | | % | 37.5 | 71.4 | 45.5 | 86.7 | 57.9 | 40.0 | 78.0 | 53.3 | 0.0 | 60.0 | 58.3 | 70.0 | 78.9 |
| | Other types | *n*= | 1 | 1 | 4 | 2 | 1 | 1 | 5 | 3 | 0 | 1 | 0 | 1 | 0 |
| | | % | 12.5 | 14.3 | 36.4 | 13.3 | 5.3 | 10.0 | 12.2 | 20.0 | 0.0 | 20.0 | 0.0 | 5.0 | 0.0 |
| | Rubber Plantation | *n*= | 0 | 0 | 1 | 2 | 0 | 0 | 18 | 1 | 0 | 0 | 0 | 3 | 1 |
| | | % | 0.0 | 0.0 | 9.1 | 13.3 | 0.0 | 0.0 | 43.9 | 6.7 | 0.0 | 0.0 | 0.0 | 15.0 | 5.3 |
| | Shifting Cultivation | *n*= | 2 | 2 | 6 | 5 | 4 | 3 | 15 | 5 | 1 | 2 | 4 | 8 | 8 |
| | | % | 25.0 | 28.6 | 54.5 | 33.3 | 21.1 | 30.0 | 36.6 | 33.3 | 33.3 | 40.0 | 33.3 | 40.0 | 42.1 |
| Forest expansion | Agroforestry | *n*= | 0 | 0 | 1 | 1 | 1 | 1 | 8 | 2 | 0 | 0 | 0 | 1 | 2 |
| | | % | 0.0 | 0.0 | 9.1 | 6.7 | 5.3 | 10.0 | 19.5 | 13.3 | 0.0 | 0.0 | 0.0 | 5.0 | 10.5 |
| | Timber Plantation | *n*= | 3 | 5 | 5 | 11 | 8 | 4 | 14 | 5 | 2 | 3 | 5 | 7 | 11 |
| | | % | 37.5 | 71.4 | 45.5 | 73.3 | 42.1 | 40.0 | 34.1 | 33.3 | 66.7 | 60.0 | 41.7 | 35.0 | 57.9 |
| Land and Forest Burning | | *n*= | 2 | 3 | 5 | 7 | 8 | 3 | 14 | 6 | 0 | 2 | 3 | 5 | 7 |
| | | % | 25.0 | 42.9 | 45.5 | 46.7 | 42.1 | 30.0 | 34.1 | 40.0 | 0.0 | 40.0 | 25.0 | 25.0 | 36.8 |
| Wood extraction | | *n*= | 4 | 5 | 6 | 10 | 9 | 4 | 14 | 6 | 1 | 4 | 7 | 10 | 10 |
| | | % | 50.0 | 71.4 | 54.5 | 66.7 | 47.4 | 40.0 | 34.1 | 40.0 | 33.3 | 80.0 | 58.3 | 50.0 | 52.6 |

**Table A6.** Frequency of underlying causes of land change in Sumatra and Kalimantan.

| | | Aceh (*n* = 8) | North Sumatra (*n* = 7) | West Sumatra (*n* = 11) | Riau (*n* = 15) | South Sumatra (*n* = 19) | Bengkulu (*n* = 10) | Jambi (*n* = 41) | Lampung (*n* = 15) | North Kalimantan (*n* = 3) | South Kalimantan (*n* = 5) | Central Kalimantan (*n* = 12) | East Kalimantan (*n* = 20) | West Kalimantan (*n* = 19) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Economic crisis | *n*= | | | 1 | 2 | 3 | 1 | 2 | 2 | | | | 2 | 1 |
| | % | 0.0 | 0.0 | 9.1 | 13.3 | 15.8 | 10.0 | 4.9 | 13.3 | 0.0 | 0.0 | 0.0 | 10.0 | 5.3 |
| Industrialization | *n*= | | | | 3 | 1 | | 1 | 1 | | | 1 | 3 | 3 |
| | % | 0.0 | 0.0 | 0.0 | 20.0 | 5.3 | 0.0 | 2.4 | 6.7 | 0.0 | 0.0 | 8.3 | 15.0 | 15.8 |
| Market demand | *n*= | 2 | 1 | 1 | 4 | 3 | 3 | 6 | 3 | | 1 | 2 | 5 | 3 |
| | % | 25.0 | 14.3 | 9.1 | 26.7 | 15.8 | 30.0 | 14.6 | 20.0 | 0.0 | 20.0 | 16.7 | 25.0 | 15.8 |
| Political climate | *n*= | 1 | 1 | 2 | 2 | 3 | 2 | 6 | 4 | | | 1 | 3 | 3 |
| | % | 12.5 | 14.3 | 18.2 | 13.3 | 15.8 | 20.0 | 14.6 | 26.7 | 0.0 | 0.0 | 8.3 | 15.0 | 15.8 |
| Lack of institutional capacity | *n*= | 2 | 2 | 3 | 5 | 5 | 4 | 9 | 6 | 1 | 2 | 5 | 3 | 10 |
| | % | 25.0 | 28.6 | 27.3 | 33.3 | 26.3 | 40.0 | 22.0 | 40.0 | 33.3 | 40.0 | 41.7 | 15.0 | 52.6 |
| Differences in interests | *n*= | 1 | 1 | 2 | 2 | 3 | 2 | 6 | 2 | 1 | 2 | 1 | 1 | 3 |
| | % | 12.5 | 14.3 | 18.2 | 13.3 | 15.8 | 20.0 | 14.6 | 13.3 | 33.3 | 40.0 | 8.3 | 5.0 | 15.8 |
| Power abuse | *n*= | | | | | 1 | 1 | 2 | 1 | | | 1 | 7 | 6 |
| | % | 0.0 | 0.0 | 0.0 | 0.0 | 5.3 | 10.0 | 4.9 | 6.7 | 0.0 | 0.0 | 8.3 | 35.0 | 31.6 |
| Property rights Issues | *n*= | | | 2 | 7 | 3 | 1 | 16 | 3 | 1 | 2 | 2 | 7 | 7 |
| | % | 0.0 | 0.0 | 18.2 | 46.7 | 15.8 | 10.0 | 39.0 | 20.0 | 33.3 | 40.0 | 16.7 | 35.0 | 36.8 |
| Weak law enforcement | *n*= | 3 | 2 | 2 | 3 | 3 | 3 | 5 | 3 | | 1 | 3 | 2 | 2 |
| | % | 37.5 | 28.6 | 18.2 | 20.0 | 15.8 | 30.0 | 12.2 | 20.0 | 0.0 | 20.0 | 25.0 | 10.0 | 10.5 |
| Overlapping regulations | *n*= | | | | | | | 2 | 1 | | 1 | 1 | 1 | 3 |
| | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.9 | 6.7 | 0.0 | 20.0 | 8.3 | 5.0 | 15.8 |
| Forestry policy | *n*= | 2 | 1 | 2 | 4 | 5 | 2 | 7 | 1 | | 1 | 4 | 6 | 8 |
| | % | 25.0 | 14.3 | 18.2 | 26.7 | 26.3 | 20.0 | 17.1 | 6.7 | 0.0 | 20.0 | 33.3 | 30.0 | 42.1 |
| Agricultural policy | *n*= | | | | | | | 2 | | | | | | 1 |
| | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.3 |
| Decentralization policy | *n*= | 1 | 1 | 3 | 3 | 3 | 2 | 9 | 1 | | | 4 | 3 | 3 |
| | % | 12.5 | 14.3 | 27.3 | 20.0 | 15.8 | 20.0 | 22.0 | 6.7 | 0.0 | 0.0 | 33.3 | 15.0 | 15.8 |
| Development policy | *n*= | | 2 | 2 | 4 | 5 | 1 | 11 | 3 | | 1 | 4 | 3 | 4 |
| | % | 0.0 | 28.6 | 18.2 | 26.7 | 26.3 | 10.0 | 26.8 | 20.0 | 0.0 | 20.0 | 33.3 | 15.0 | 21.1 |
| Regional policy | *n*= | | | | 1 | | | 4 | 1 | | | 3 | 3 | |
| | % | 0.0 | 0.0 | 0.0 | 6.7 | 0.0 | 0.0 | 9.8 | 6.7 | 0.0 | 0.0 | 25.0 | 15.0 | 0.0 |
| Transmigration policy | *n*= | 1 | 1 | 1 | 4 | 5 | 1 | 17 | 5 | | 1 | 2 | 5 | 4 |
| | % | 12.5 | 14.3 | 9.1 | 26.7 | 26.3 | 10.0 | 41.5 | 33.3 | 0.0 | 20.0 | 16.7 | 25.0 | 21.1 |
| Demographics | *n*= | 3 | 3 | 5 | 4 | 6 | 2 | 11 | 6 | | 2 | 1 | 3 | 1 |
| | % | 37.5 | 42.9 | 45.5 | 26.7 | 31.6 | 20.0 | 26.8 | 40.0 | 0.0 | 40.0 | 8.3 | 15.0 | 5.3 |
| Networking | *n*= | 1 | | | 3 | 1 | 1 | 4 | | | | 1 | 4 | 6 |
| | % | 12.5 | 0.0 | 0.0 | 20.0 | 5.3 | 10.0 | 9.8 | 0.0 | 0.0 | 0.0 | 8.3 | 20.0 | 31.6 |
| Technology | *n*= | | | | | | | 1 | | | | 1 | | |
| | % | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 0.0 | 0.0 | 0.0 | 8.3 | 0.0 | 0.0 |

## Appendix C

**Table A7.** The proportion of the combined causes of land change.

| | Number of Studies | (%) |
|---|---|---|
| | Single-underlying cause | |
| Economy | 1 | 31.87 |
| Institutional | 9 | |
| Policy | 15 | |
| Social | 4 | |
| | Two-underlying causes | |
| Eco-Inst | 2 | 28.57 |
| Eco-Pol | 5 | |
| Eco-Soc | 1 | |
| Inst-Pol | 13 | |
| Inst-Soc | 1 | |
| Pol-Soc | 4 | |
| | Three-underlying causes | |
| Eco-Inst-Pol | 7 | |
| Eco-Inst-Soc | 1 | 27.47 |
| Eco-Pol-Soc | 2 | |
| Inst-Pol-Soc | 14 | |
| Inst-Soc-Tech | 1 | |
| | Two-underlying causes | |
| Eco-Inst-Pol-Soc | 10 | 12.09 |
| Inst-Pol-Soc-Tech | 1 | |
| | | 100 |

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