Global Environmental Change 57 (2019) 101933

Contents lists available at ScienceDirect

Global Environmental Change

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

Certification, good agricultural practice and smallholder heterogeneity: Differentiated pathways for resolving compliance gaps in the Indonesian oil palm sector

George C. Schoneveld[a,*], Selma van der Haar[a], Dian Ekowati[a], Agus Andrianto[a], Heru Komarudin[a], Beni Okarda[a], Idsert Jelsma[b], Pablo Pacheco[c]

[a] Center for International Forestry Research (CIFOR), Jalan CIFOR, Situ Gede, Sindang Barang, 16115, Bogor, Indonesia
[b] Utrecht University, Vening Meinesz building A, Princetonlaan 8a, 3584 CB, Utrecht, the Netherlands
[c] World Wildlife Fund (WWF), 250 24th St NW, Washington, DC, 20037, United States

ARTICLE INFO

Keywords:
Certification
Farmer typology
Good agricultural practice
Smallholders
Oil palm
Indonesia

ABSTRACT

Enhancing smallholder compliance with sustainability standards and good agricultural practices features prominently on the global sustainability agenda. Operating in a sector that bears intense public scrutiny, Indonesia's oil palm smallholders are especially confronted by pressures to enhance their environmental performance. Because smallholders experience differentiated compliance barriers however, it is widely recognized that for the purpose of more effectively prioritizing and targeting the necessary intervention support, smallholder heterogeneity needs to be better understood. This is especially the case for independent – in contrast to 'plasma' - oil palm smallholders, for whom corporate technical, input and financial support is comparatively inaccessible. Through multivariate analysis, this article contributes to these needs by developing a typology of independent oil palm smallholders in Indonesian Borneo. We subsequently model the predicted probabilities of different types of smallholders complying with Indonesia's major national sustainability standard and select indicators of good agricultural practice. This analysis reveals structural compliance gaps, which threatens to restrict smallholder access to formal markets in future. In showing that intervention strategies to resolve these compliance gaps can be more impactful when these are adapted to smallholder livelihood assets, portfolios and strategies, this article points to the importance of more explicitly accounting for socio-economic differentiation when addressing contemporary smallholder upgrading challenges. With results however revealing how local entrepreneurs and elites complicit in regulatory evasion and illegal land encroachments play a significant role in the sub-sector, local political resistance to initiatives that aim to bring the sub-sector above board can be anticipated. This highlights how institutional building needs to be more explicitly incorporated into the design of smallholder-centric intervention strategies; through, for example, the adoption of more integrative landscape-level planning approaches.

1. Introduction

Consumer goods companies, governments and civil society organizations alike are increasingly demanding producers in high forest risk agricultural value chains such as oil palm, soy and cocoa to demonstrate commitment to reducing their negative environmental footprint (Jopke and Schoneveld, 2018). To that effect, producers are particularly expected to comply with generally accepted good agricultural practices (GAP) and public and private sustainability standards (Lee et al., 2012; Gnych et al., 2015; FoBSKI 2017). As a collection of best farm management practices to, amongst others, maintain soil fertility and water quality, control erosion and minimize pests and disease (Jelsma et al., 2019), GAP can contribute to improved land use efficiency (e.g. by contributing to productivity gains) and reduce environmental degradation; in turn helping ease pressure on (forested) land and decrease greenhouse gas emission intensities (Byerlee et al., 2014; Foley et al., 2011; Henderson et al., 2016). Even though compliance with GAP is often enforced through its incorporation into sustainability standards, standards tend to be more encompassing by also explicitly limiting conversion of ecologically significant lands, amongst other requirements. However, not all producers are equally capable of responding to these rising compliance demands. Smallholders in

* Corresponding author.
E-mail address: g.schoneveld@cgiar.org (G.C. Schoneveld).

https://doi.org/10.1016/j.gloenvcha.2019.101933
Received 18 July 2018; Received in revised form 5 June 2019; Accepted 10 June 2019

particular lack the knowledge, resources and legal documentation that facilitate compliance (Prokopy et al., 2008; Brandi et al., 2015). As major actors in high forest risk value chains are becoming more reluctant to source from incompliant producers, these barriers to compliance are beginning to produce market access problems; especially for smallholders (Henson and Humphrey, 2010; Jaffee et al., 2011; Lee et al., 2012).

Indonesia's independent oil palm smallholders, the fastest growing, but also most marginalized producer group in the oil palm sector, are especially confronted by these compliance barriers (Jelsma et al., 2017; Schoneveld et al., 2019). With many palm oil companies committing to fully eliminating deforestation from their supply chains and/or certifying their operations, sourcing from incompliant smallholders is increasingly posing reputational risks and creating a transaction cost problem (Gnych et al., 2015; Jopke and Schoneveld, 2018). Since independent smallholders rarely receive external support, they often lack the knowledge and resources needed to comply with GAP and sustainability standards, especially compared to 'plasma' smallholders participating in Indonesia's many nucleus estate smallholder (NES) schemes (Brandi et al., 2015; Rietberg and Slingerland, 2016; Jelsma et al., 2017). Because they are additionally often geographically highly dispersed, reliant on middlemen for market access and invisible to the public administration, for companies challenged to demonstrate their commitment to greening their supply chain, independent smallholder sourcing is becoming increasingly incompatible with the need to improve monitoring and traceability (FoKSBI, 2017; Jopke and Schoneveld, 2018).

In order to improve the image of the sector and safeguard the competitiveness of its producers, the Indonesian government introduced the Indonesian Sustainable Palm Oil (ISPO) standard in 2011 (Hospes, 2014; Wijaya and Glasbergen, 2016). This is a mandatory certification initiative whose standard integrates diverse ministerial legislation pertinent to oil palm production. A law promulgating a strengthened ISPO standard mandatory also for smallholders is expected to be passed in 2019. Given the limited success of more comprehensive voluntary sustainability standards such as the Roundtable for Sustainable Palm Oil (RSPO) to certify smallholders at a meaningful scale (Brandi et al., 2015), ISPO is being pushed as a viable alternative mechanism for making smallholders more visible for regulatory and traceability purposes and RSPO 'ready' (Newport, 2015; Higgins and Richards, 2019). In doing so, ISPO intends to restore corporate confidence in their smallholder sourcing strategies and facilitate more effective public service delivery (e.g. to enable smallholders to comply with GAP) (Newport, 2015). Early evidence however suggests that without extensive support most smallholders are unlikely to become ISPO compliant in the near future; thereby, undermining the capacity of ISPO to deliver on some of its objectives (Jelsma et al., 2017; Hutabarat, 2017).

Developing appropriate intervention strategies to facilitate smallholder compliance is complicated by Indonesia's large diversity of independent smallholders, as McCarthy and Zen (2016) and Jelsma et al. (2017) illustrate in Sumatra. Different types of smallholders are confronted by different types of compliance challenges due to differentiated capabilities and access to information and productive assets (Auld, 2010; Jaffee et al., 2011; Lee et al., 2012). Moreover, smallholders are also differently incentivized to devote resources to becoming more compliant; depending, for example, on how perceived benefits resonate with livelihood strategies (Tittonell et al., 2010; Verkaart et al., 2018). The development of effective interventions thus requires taking these barriers into account and recognizing that such barriers are not manifested uniformly across the smallholder population. Acknowledging that tailoring interventions to the individual is unviable at scale, in order to fine-tune and/or more effectively target intervention support, many countries and sectors are beginning to pay more attention to simplifying diversity by organizing farms and/or farmers into more homogenous sub-groups (Alvarez et al., 2018). Farm-systems based typologies are used especially widely for this purpose (Kuivanen et al., 2016; Douxchamps et al., 2016; Ordway et al., 2017; Kamau et al., 2018; Michalscheck et al., 2018). Because this literature is largely focused on sustainable intensification, typology development approaches are yet to be used in exploring how accounting for smallholder differentiation can contribute to more effectively resolving especially standards compliance gaps.

This article attempts to close this knowledge gap, while responding to the emerging demand for more targeted policy-making, both in Indonesia and elsewhere. It does this by examining how the development of effective intervention strategies to resolve smallholder compliance challenges might be informed by an actor-disaggregated approach. We do this by (a) developing a typology of smallholders based on their socioeconomic characteristics using non-hierarchical clustering techniques and (b) predicting the likelihood of different smallholder groups 'passing' select ISPO and GAP compliance indicators through multivariate regression modeling. Compared to farm-systems based typology development approaches, our approach enables closer scrutiny of the relationship between socioeconomic differentiation and farm-level (compliance) performance. This is largely inspired by Dorward et al. (2009), which demonstrate the importance of aligning intervention strategies with livelihood strategies. We exclusively focus our analysis on Indonesian Borneo, a recent epicenter of oil palm expansion. Indonesian Borneo accounts for 57% of the oil palm planted in Indonesia between 2005 and 2015 (Direktorat Jenderal Perkebunan (DJP, 2017); a significant proportion of which through forest conversion (Gaveau et al., 2016).

In the following section, we discuss the (antecedents of) contemporary upgrading challenges facing and posed by Indonesia's independent oil palm smallholders. This is followed by an overview of the study's methodological and analytical approach before proceeding with a results section. This section, firstly, presents the typology of smallholders and, secondly, the compliance modeling results. In the subsequent discussion section, we reflect on the implications of results for the development of more actor-disaggregated intervention strategies and propose an elaboration on Dorward et al. (2009). We conclude with a reflection on the broader relevance of findings and the governance challenges associated with developing more smallholder-centric intervention strategies.

2. Background: upgrading challenges facing and posed by Indonesia's independent smallholders

Few sectors face as much public scrutiny as the oil palm sector. The world's largest producer, Indonesia, where oil palm cultivation has long been associated with human rights abuses, peatland fires, deforestation and biodiversity loss (Obidzinski et al., 2012; Gaveau et al., 2016; Purnomo et al., 2017), is often the leading target. Most initial attempts to manage these impacts arose exogenously in the form of the RSPO, EU Renewable Energy Directive (RED) and myriad private zero-deforestation commitments that emanated from the 2014 New York Declaration on Forests (Pirard et al., 2015; Jopke and Schoneveld, 2018). Long an idle spectator as sector governance was increasingly externalized and privatized, the Indonesian government over the 2010s has become more actively engaged in regulating sector expansion. This is not only expressed by the formation of ISPO, but also by the declaration of national forest- and peatland conversion moratoria, the establishment of an estate fund financed by export levies to, amongst others, facilitate smallholder replanting, an agrarian reform program to improve rural community land access and myriad sub-national initiatives on spatial planning, green growth and jurisdictional certification (Pacheco et al., 2018; Luttrell et al., 2018).

Since producer alignment with the many regulatory initiatives has begun to increasingly dictate (terms of) market access, the challenges faced and posed by Indonesia's rapidly growing number of independent smallholders has taken centerstage. Independent smallholders account

for a significant majority of Indonesia's total smallholder oil palm acreage (Jelsma et al., 2017), which is projected to grow from 38.6% of total national acreage in 2016 to 60% by 2030 (DJP 2017; Saragih, 2017). This growth is driven by a number of interrelated factors, such as rural households becoming increasingly sensitized to and experienced with oil palm cultivation (Jelsma et al., 2017; Bissonnette and De Koninck, 2017), maturation of production infrastructure (Jelsma et al., 2017; Potter, 2016), increasingly unfavorable land and benefit distribution arrangements under modern iterations of NES (Gillespie, 2011; McCarthy et al., 2012) and rural households increasingly shifting from rubber, the most common alternative plantation crop, to oil palm for the latter's superior returns to labor (Papenfus, 2002; Schwarze et al., 2015). While the environmental impacts of smallholder oil palm expansion is considered less alarming than industrial plantation expansion by some (Lee et al., 2014), concerns are being raised that because zero-deforestation commitments and the moratoria are increasing competition for land free of forest and peat, smallholders are increasingly pushed into more ecologically sensitive areas (Mosnier et al., 2017; Jopke and Schoneveld, 2018). Schoneveld et al. (2019); Jelsma et al. (2017) and Potter (2016), for example, show how many smallholders are able to expand with impunity into areas not legally designated for oil palm production (e.g. state forestland). Illegal use of fire to establish smallholder plantations is also reportedly widespread (Marlier et al., 2015; Purnomo et al., 2017). This raises the urgency of developing more effective checks and balances on (the legality of) smallholder practices.

ISPO could play an important role in developing more effective checks and balances on oil palm smallholders by enabling government to provide more targeted regulatory oversight. Because ISPO in practice is largely focused on formalizing and registering smallholdings (Jelsma et al., 2017), should ISPO succeed in achieving compliance at scale, oil palm smallholders will become increasingly visible for (future) regulatory purpose. In order to realize this, smallholders foremost need to comply with a number of important legal requirements detailed in the ISPO standard (Government of Indonesia (GOI, 2015a). These include (a) ensuring plantations are located on lands legally designated for oil palm production (*Areal Pengunaan Lain*, APL); (b) using seedlings obtained through a government registered source; (c) possessing a plantation business license (*Surat Tanda Daftar Budidaya*, STD-B); and (d) possessing a land ownership certificate (*Sertifikat Hak Milik*, SHM) (Government of Indonesia (GOI, 2015a). It however remains unclear whether village-level land documentation such as a *Surat Keterangan Tanah* (SKT) may be acceptable in lieu of an SHM, which in contrast is provided by the national land agency. In many districts, a SHM is though demanded when applying for an STD-B because SKT's are often susceptible to competing and overlapping claims and do not guarantee that land is located on APL (Glenday and Paoli, 2015; Jelsma et al., 2017). To facilitate public service delivery and smallholder access to formal markets, ISPO also places organizational demands on smallholders by requiring membership of a cooperative or a legally-registered smallholder association (Government of Indonesia (GOI, 2015a; FoKSBI, 2017). Even though smallholders are additionally expected to comply with the government's Technical Guidelines on GAP under ISPO, there currently lacks a legal basis for sanctioning smallholders that fail to comply with the Guidelines.

Preliminary evidence, especially from Sumatra, suggests that few smallholders currently comply with the aforementioned legal and organizational requirements of ISPO (Serikat Petani Kelapa Sawit (SPKS, 2017; Jelsma et al., 2017; Hutabarat, 2017). The development community is increasingly recognizing the need to resolve this compliance gap, as is reflected in the large number of development projects initiated in recent years that promote and facilitate smallholder ISPO compliance (see Luttrell et al. (2018)). Many of these projects emerge from an environmental agenda, with a functional ISPO potentially playing an important role in rationalizing smallholder oil palm expansion. Furthermore, ISPO compliance is expected to help habilitate smallholders for RSPO (Higgins and Richards, 2019), with ISPO thus potentially serving as a stepping stone towards compliance with more environmentally comprehensive standards in future. The importance of addressing socio-economic risks associated with ISPO incompliance is also increasingly acknowledged by oil palm development initiatives. Not only could smallholder market access suffer in future as a result of ISPO incompliance, but access to inputs and services also threatens to be further compromised. Already, access to financial loans and official planting material are becoming increasingly conditional on possession of SHMs and STD-Bs (Sahara and Kusumowardhani, 2017). Public extension support and replanting grants are also largely reserved for smallholders with such documentation (Luttrell et al., 2018). Therefore, ISPO compliance could help attenuate structural smallholder access issues that frustrate upgrading.

For these reasons, many of Indonesia's smallholder-oriented development initiatives view GAP and certification as two sides of the same coin, with certification either contingent on, incentivizing investments in and/or facilitating service provision on GAP. Mewes and Dallinger (2012); Hidayat et al. (2016) and Bray and Neilson (2017), amongst others, demonstrate how certification helps smallholders become more productively integrated into value chains, which in turn enhances access to the services and inputs needed to become compliant of GAP. Nevertheless, GAP is a policy priority in Indonesia also independent from certification (FoKSBI, 2017). Independent smallholders on average attain less than 60% of their yield potential; in large part due to failure to comply with GAP (Rietberg and Slingerland, 2016; Soliman et al., 2016; Woittiez et al., 2017; Jelsma et al., 2019). Resolving this yield gap can therefore significantly improve Indonesia's competitiveness as an oil palm producing country. For many, GAP is also integral to improving the sector's social and environmental performance by reducing the extensification imperative, minimizing land degradation and raising smallholder incomes (Byerlee et al., 2014; FoKSBI, 2017; Woittiez et al., 2018; Jelsma et al., 2019). Low smallholder productivity is considered to be a major proximate driver of forest- and peatland conversion in Indonesia (Khor et al., 2015). Development organizations and certification schemes, including ISPO, therefore actively promote smallholder GAP compliance, with economic gains from resultant productivity and FFB quality improvements potentially offsetting the cost of certification (Rietberg and Slingerland, 2016; FoKSBI, 2017).

Despite the large number of initiatives targeting independent smallholders and the potential benefits of improving compliance, progress has been slow and marred by various structural upgrading barriers. A systemic lack of access to information, high quality inputs, and sufficient human and financial resources, especially in comparison to smallholders participating in NES, severely undermines compliance with GAP and ISPO (Brandi et al., 2015; Rietberg and Slingerland, 2016). The absence of strong institutional structures for extension support, lack of political will and capacity within lower-level government to implement and enforce sectoral regulation, weak vertical and horizontal coordination and lack of private sector incentives to foster more productive linkages with independent smallholders not only underlie and reinforce these barriers, but in many cases actually facilitate unsustainable practices such as fire, forest encroachment and peat conversion (McCarthy, 2012; Pacheco et al., 2018; Luttrell et al., 2018). Questions have also emerged about the government's willingness and capacity to enforce ISPO (McCarthy et al., 2012; Hospes, 2014; Hidayat et al., 2018). Furthermore, the prevalence of speculative land developments and absence of compliance incentives, such as price premiums and guaranteed market access, may discourage some smallholders from departing from low-input, low-output and legally ambiguous oil palm development strategies (Jelsma et al., 2019; Schoneveld et al., 2019).

Recognizing that these barriers and disincentives are experienced by different smallholders in different ways and how compliance targets are not uniformly compatible with the livelihood systems of all smallholders could go a long way to developing more effective intervention strategies (Sumberg, 2005; Dorward et al., 2009; Verkaart et al., 2018).

Doing so will enable 'one-size-fits-all' interventions to specifically target smallholders where support is likely to be most impactful or, alternatively, enable interventions to specifically tailor their strategies to the needs and interests of specific sub-groups (Alvarez et al., 2018). As conceptualized by Dorward et al. (2009) and Verkaart et al. (2018), more input and capital-intensive interventions are likely better suited to better resourced smallholders seeking to improve agricultural returns (e.g. those "stepping up") and low risk, low capital- and high labor-intensive interventions for poorer smallholders seeking to maintain current livelihood levels in the face of adverse circumstances (e.g. those "hanging in"). Smallholders accumulating assets for non-agricultural purposes (e.g. those "stepping out") are in contrast often not a strategic target group for intervention. Dorward et al. (2009) demonstrate how these three stylized strategies can be deduced from examining farmers' livelihood activities, portfolios and assets.

The Indonesian government is increasingly acknowledging that in the context of oil palm the current distinction between smallholders and corporate estates based on size (25 ha in the case of Indonesian law and 50 ha in the case of RSPO), level of dependency on household labor and nature of contractual relationships with companies (e.g. (variations of) NES or independent) does not satisfactorily capture these diversities and support needs (Jelsma et al., 2017). While the Indonesian Union of Oil Palm Farmers (Serikat Petani Kelapa Sawit (SPKS, 2017) made a proposal to only target intervention support to smallholders with fewer than four ha of oil palm, attempts to disaggregate independent smallholders more comprehensively is currently severely lacking. Where these have been undertaken, they tend to focus on traditional independent smallholder areas in Sumatra (e.g. McCarthy and Zen, 2016; Jelsma et al., 2017) and not in emergent areas in, for example, Indonesian Borneo, which, arguably, would particularly benefit from more regulated independent smallholder expansion; especially environmentally. Moreover, the nature and magnitude of the compliance gaps that interventions should aim to resolve is yet to be fully explored.

3. Methods

3.1. Site selection and case study context

Research activities were conducted in two smallholder oil palm landscapes in Central Kalimantan and two smallholder landscapes in West Kalimantan (see Fig. 1 for an overview of sub-districts contained within the sampled landscapes). Central and West Kalimantan are Indonesia's second and fourth largest oil palm producing provinces, which collectively account for 62% of oil palm cultivated and 67% of smallholders in Indonesian Borneo (DJP 2017). In order to effectively capture smallholder diversity in different ecological and economic contexts, in each province one landscape was selected with a well-established oil palm economy and one landscape that represents an oil palm frontier. As shown by Jelsma et al. (2017) in Riau, different types of independent oil palm smallholders can be observed in different types of landscapes.

In order to select landscapes that represent these two ends of the smallholder oil palm development spectrum, we manually mapped smallholder oil palm plots in both provinces through photo-interpretation of high-resolution satellite imagery obtained through Google Earth and SPOT-7 (Fig. 1). Smallholder oil palm plots are easily distinguishable from corporate plantations based on planting pattern and road networks (Jelsma et al., 2017). Based on these results, GIS analysis and subsequent field-based validation, we identified established smallholder oil palm landscapes in the districts of Sanggau (West Kalimantan), and Kotawaringin Barat (Central Kalimantan). This was based on the comparatively high density of smallholder oil palm farms and large-scale oil palm concessions and well developed physical and production infrastructure, notably mills. In West Kalimantan, we identified a frontier landscape spanning across the north of Sintang and west of Kapuas Hulu. In Central Kalimantan, we identified such a landscape in the district of Pulang Pisau. This was based on comparatively recent establishment of industrial oil palm plantations, low density of oil palm smallholdings, poorly developed production infrastructure and availability of 'unused' land (e.g. forest- and peatlands). See Table 1 for an overview of relevant district statistics.

The established oil palm areas of Sanggau and Kotawaringin Barat were the first districts targeted for large-scale oil palm development in their respective provinces. Located by major rivers, highways and/or ports, these districts are comparatively accessible. The first industrial oil palm plantation of Indonesian Borneo was established in Sanggau in 1979, with industrial oil palm plantations emerging in the early 1990s in Kotawaringin Barat. In 2015, approximatively 116,000 ha was cultivated industrially in Sanggau (Direktorat Jenderal Perkebunan (DJP, 2017), with 13 mills operational at the time of research. Approximately 186,000 ha of oil palm were planted industrially in Kotawaringin Barat by 2015 (Direktorat Jenderal Perkebunan (DJP, 2017), with 19 mills operational at the time of research. Many of these plantations are located in proximity to transmigration sites (Central Kalimantan Bureau of Plantations, 2009).

In the emerging oil palm areas of Sintang/Kapuas Hulu and Pulang Pisau, oil palm only made serious inroads in the late 2000s and early 2010s. In the case of Sintang/Kapuas Hulu, resistance from indigenous communities and its comparatively undeveloped infrastructure long deterred (serious) investment (Potter, 2008). With more than 60% of its area comprised of peatlands subject to fire, Pulang Pisau was neither attractive to investors (Government of Indonesia (GOI, 2015b). In 1995, a large proportion of its land area was designated for development under the failed 1.4 million ha Mega Rice Project (PLG). While no rice was ever planted under PLG, it did develop extensive canal networks and cleared large areas of peatforest. Following decentralization reforms in the late 1990s, district governments, in the context of a struggling logging industry, increasingly embraced the sector as a pillar of its development strategies (Potter, 2008; Galudra et al., 2010). In Sintang/Kapuas Hulu, approximately 101,000 ha were cultivated by corporations in 2015 (DJP 2017), with six mills operational at the time of research. In Pulang Pisau, only 9500 ha was planted by corporations in 2015 (Direktorat Jenderal Perkebunan (DJP, 2017), with two mills operational at the time of research.

3.2. Surveying activities

Since the district governments in research sites do not maintain comprehensive records of independent smallholders and given the well-established discrepancies between official statistics and realities on the ground, in order to ensure sampled smallholders are representative of the smallholder population we used a more refined version of the smallholder map developed for site selection (see Table 2 for mapping results). In the selected research areas, site visits were conducted to validate mapping results.

The research team visited 947 randomly selected independent smallholder plots from our refined map. At each plot, farm and farmer surveys were conducted. The farm survey involved collection of data on compliance with GAP, based on visual inspection, on topography, soil type, quality of on-farm infrastructure, planting patterns, weeding practices, presence of rotten FFB, cover crops, erosion and canopy cover (see Jelsma et al. (2019) for an overview of generally accepted GAP in the oil palm sector). Twenty trees were sampled in each plantation to determine incidence of pest, nutritional deficiencies (specifically P, K, Mg and B), quality of pruning and palm varieties (e.g. *dura* or *tenera*). This was based on the field audit standard developed by Fairhurst and Griffiths (2014). A farmer questionnaire was subsequently administered with the plot owner. This included questions on household characteristics, household livelihood activities and assets, types of oil palm farms owned, production practices, labor allocation to oil palm, nature of linkages to input and offtake markets, participation in farmer groups or cooperatives and legality of operations.

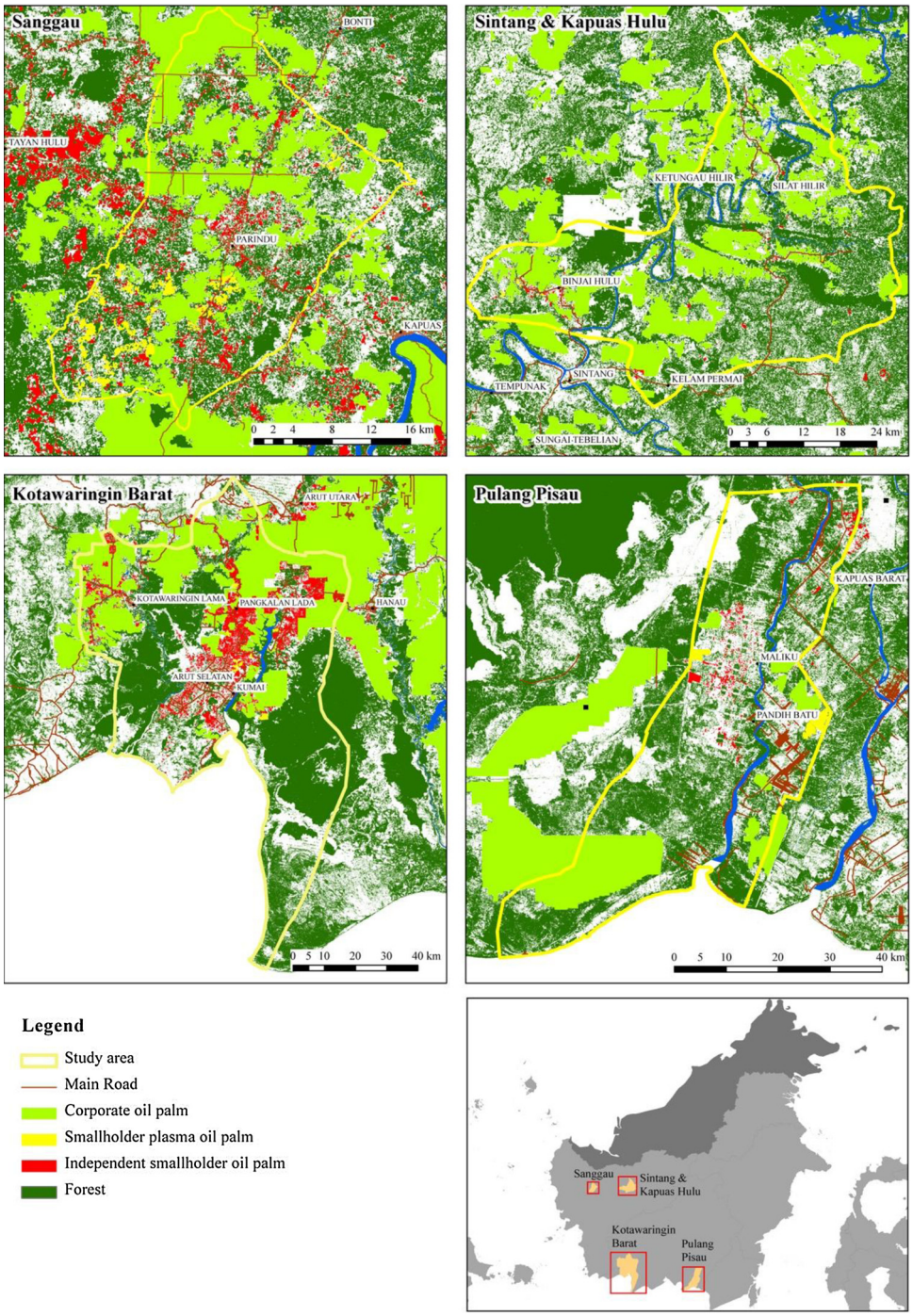

Fig. 1. Case study sites.
Source: Authors' representation, based on remote sensing analysis. Forest cover derived from Hansen et al. (2013).

3.3. Analytical approach

3.3.1. Mixed-data clustering

To develop our smallholder typology, we employed a non-hierarchical clustering technique, Partitioning Around Medoids (PAM) or *k*-medoid (Kaufman and Rousseeuw, 2005). It partitions observations into clusters where within-cluster similarities are minimizing and between-cluster similarities are maximized through iterative identification of medoids. PAM is less sensitive to 'irrelevant' cluster variables and outliers than the commonly used hierarchical methods (and in the case of outliers also to other non-hierarchical techniques such as *k*-means) (Kaufman and Rousseeuw, 2005; Mooi and Sarstedt, 2010).

Table 3 presents an overview of clustering variables. Based on four multi-stakeholder workshops involving public and private-sector experts, we identified 16 farmer characteristics that best capture smallholder socio-economic diversity and differentiated capabilities and strategies that may have bearing on oil palm-related practices and compliance with ISPO and GAP. This includes variables pertaining to farmers' livelihood systems, such as their livelihood activities, portfolios and assets (e.g. following Dorward et al. (2009) and Tittonell (2014)); to which we add demographic characteristics such as migration status and ethnicity, which play an integral role in shaping strategies and access to opportunities in Indonesia (Aspinall and Sukmajati, 2016). In doing so, we depart from the mainstream farm systems-based

Table 1
2016 District statistics.
Sources: Derived from BPS Sanggau (2018); BPS Sintang (2018); BPS Kapuas Hulu (2018); BPS Pulang Pisau (2018); BPS Kotawaringin Barat (2018); DJP (2017); derived from Hansen et al. (2013).

District	GDP/capita (constant US$/annum)	Area (km^2)	Population density (persons/km^2)	Forest cover (% total area) *	APL (% total area)	Area under oil palm (% total area)	Oil palm cultivated by smallholders (% oil palm area)
Kotawaringin Barat	3,826	10,759	27.1	51.8	28.2	21.5	19.5
Pulang Pisau	2,278	8,997	13.9	60.5	17.9	1.3	17.7
Sanggau	2,776	12,858	35.1	62.2	56.7	19.2	52.6
Sintang	2,014	21,638	18.6	73.2	39.9	4.6	36.2
Kapuas Hulu	2,381	29,842	8.4	87.2	23.8	1.3	2.2

* Forestlands are those with canopy cover exceeding 50%.

typology development approaches, which typically combine socio-economic characteristics of the farm household, with geographic and technical characteristics of the farm. By conflating the farm with the farmer, one arguably cannot fully explore the relationship between what a farmer is and what a farmer does or is able to do and needs, and how this relationship may be mediated by confounding factors.

Because we employ mixed-type variables (e.g. a combination of categorical, ordinal and scalar), we compute a Gower dissimilarity matrix prior to clustering (Gower, 1971), using the DAISY package in R. No other data manipulations were undertaken in order to conserve the underlying data structure. In contrast to hierarchical clustering techniques, PAM requires that the number of clusters are pre-defined (Kaufman and Rousseeuw, 2005). In order to identify suitable cluster numbers, we examined the silhouette width of PAM clusters and dendrograms produced through hierarchical clustering techniques (see Punji and Stewart (1983) and Mooi and Sarstedt (2010) for more information on this workaround method), which pointed to a five, six or seven cluster solution. We repeated the clustering with different variable combinations and weights to assess the stability of the solutions. Based on interpretability of results, we opted for a six-cluster solution, which best aligned with expert characterization of independent smallholders. In total, 932 farmers were assigned to specific clusters, with 15 farmers dropped due to missing data.

3.3.2. Econometric estimation strategy

To analyze differences between farmers assigned to the six clusters with respect to compliance with ISPO and GAP, we simultaneously estimate the effect of a set of explanatory variables on different types of compliance and GAP indicators using multivariate fixed effect regression models. We employ a conditional mixed-process framework for its flexibility in estimating multi-equation systems using mixed processes (e.g. different types of dependent variables) (Roodman, 2011). This approach allows for modeling the contemporaneous relationships between farmer performance on different types of performance indicators. In contrast to univariate regression models, multivariate regressions allow unobserved factors to be freely correlated and enable examination of the relationship between different types of compliance indicators.

In the case of ISPO compliance, we estimate a multivariate probit model using simulated maximum likelihood for the probability of farmers being compliant of a set of five different binary response outcomes (Y_{ij}) (Table 4), as explained in section 2. The model can be specified as follows:

$$Y_{ij}^{*} = x_{ij}^{'}\beta_j + \varepsilon_j,\ j = 1,\ ...,5$$

and

$$Y_{ij} = \begin{cases} 1\ if\ Y_{ij}^{*} > 0 \\ 0\ otherwise \end{cases}$$

where Y_{ij}^{*} denotes the underlying latent response, capturing unobserved factors, associated with j^{th} type of compliance indicator and i^{th} farmer. The latent variable is assumed to be a linear combination of x_{ij} covariates that affect compliance, such as farmer type (based on clustering results), soil type, plot characteristics and geography (see Table 4), and the stochastic component ε_j. Every ε_j follows a multivariate normal distribution with zero conditional mean and variance normalized to unity, where $\varepsilon \tilde{} N(0, \sum)$ and the covariance matrix $\sum$ is:

$$\Sigma = \begin{bmatrix} 1 & \cdots & \rho_{15} \\ \vdots & \ddots & \vdots \\ \rho_{51} & \cdots & 1 \end{bmatrix}$$

We use a similar procedure for estimating farmer compliance with GAP, but, due to the nature of the data, allow our four dependent variables to be both continuous and binary (Table 4). Consulted experts considered these four variables to best reflect over GAP compliance. For the two continuous dependent variables, individual models are estimated using Ordinary Least Squared (OLS), while for the two binary dependent variables, the individual models are estimated using a probit link function. Since we could not estimate joint probabilities using this approach (unlike the ISPO compliance model), we constructed a composite indicator reflecting overall farmer adherence to GAP using principal component analysis. Drawing on farmer adherence to 14 different good practices, we employed the Nardo et al. (2005,p. 89) procedure to weight indicators based on their collinearity. Our intention was not to value certain practices more than others, but rather to correct for collinearity between practice. Employing the same covariates as the multivariate GAP model, we model overall GAP performance using OLS. Robustness tests, confirming correct model specification, involved amongst others multicollinearity tests and use of the control function approach to test for the presence of endogenous regressors.

Table 2
Smallholder mapping results and sampling.

District	Surveyed farmers and farms	Total independent oil palm area owned by sampled farmers in surveyed areas	Total area under independent smallholder oil palm	Proportion total independent smallholder area captured
Kotawaringin Barat	306	5,552	43,785	12.7%
Pulang Pisau	112	2,187	3,581	61.1%
Sanggau	281	2,447	4,707	52.0%
Sintang/ Kapuas Hulu	248	1,385	2,568	53.4%
Total	**947**	**11,571**	**54,641**	**21.2%**

Table 3
Overview of clustering variables and descriptive statistics.

Variable	Mean (SD)	Description
Age	47.31 (0.288)	Age of plot owner
Female	0.041 (0.006)	Dummy variable of plot owner's gender
Education	2.384 (0.032)	Maximum attained education of plot owner. Ordinal variable with 5 levels (0 = none, 1 = primary; 2 = middle school; 3 = high school; 4 = tertiary education
Residency	2.227 (0.024)	Location of the primary residence. Ordinal variable with 5 levels (1 = within the village; 2 = outside the village, but within the sub-district; 3 = outside the sub-district, but within the district; 4 = outside the district, but within the province; 5 = outside the province
Ethnicity		Categorical variable of plot owner's ethnicity
Batak	0.021 (0.004)	
Dayak	0.397 (0.016)	
Javanese	0.465 (0.016)	
Malay	0.062 (0.008)	
Chinese	0.021 (0.005)	
Other	0.033 (0.006)	
Migration	0.328 (0.015)	Dummy variable of plot owner's migration status (only first generation)
Total area under oil palm	13.22 (1.291)	Combined area of all oil palm plots owned by plot owner (including NES plots)
Years cultivating oil palm	10.83 (0.392)	Years since first planting of plot owner (including other plots)
Prior experience in oil palm management	0.419 (0.016)	Dummy variable of plot owner experience prior to commencing independent oil palm cultivation
Livelihood activities - business	0.241 (0.014)	Dummy variable of plot owner's household business enterprises
Livelihood activities – civil service	0.092 (0.009)	Dummy variable of plot owner's household involvement in civil service
Livelihood activities - oil palm manual laborer	0.245 (0.014)	Dummy variable of plot owner's household employment as manual oil palm laborer
Livelihood activities - food crop cultivation	0.261 (0.014)	Dummy variable of plot owner's household involvement in subsistence food crop production
Livelihood activities - cultivation of plantation crops	0.341 (0.015)	Dummy variable of plot owner's household involvement in plantation crop production
Livelihood activities - other	0.145 (0.012)	Dummy variable of plot owner's household involvement in other income generating activities

Note: Dependency ratio and number of economically active household members were included in earlier iterations. These proved to be irrelevant variables since no statistically significant difference could be observed between groups. Because data on these variables was missing for 34 households, those variables were removed from the final clustering without meaningfully changing results.

Table 4
Variables and descriptive statistics.

Variable	Mean (SD)	Description
Dependent variables: Compliance		
APL	0.919 (0.009)	Dummy variable for whether plot is (partially) located on land where oil palm is legally permitted
Seed source	0.733 (0.014)	Dummy variable for whether owner obtained planting material from a officially certified seed source
Group membership	0.273 (0.015)	Dummy variable for whether owner is a member of a formal farmer's group
National land documentation	0.391 (0.016)	Dummy variable for whether owner obtained land documentation for the plot from the National Land Agency (SHM)
Plantation license	0.034 (0.006)	Dummy variable for whether owner obtained a plantation license (STD-B/IUP)
Dependent variables: GAP		
Pruning	0.686 (0.010)	Proportion of trees pruned correctly (between 0 and 1)
Fertilizer	0.400 (0.011)	Proportion of trees that display no signs of nutritional deficiency (between 0 and 1), as an indicator of appropriate fertilizer use
Weeding	0.747 (0.015)	Dummy variable for correct weeding of plot (e.g. absence of woody and creeping weeds, no clear weeding, circle weeding)
Cover crops	0.206 (0.014)	Dummy variable for presence of shade-tolerant legumes, soft grasses and ferns (*Nephrolepis spp.*)
GAP index	0.556 (0.004)	Composite indicator between 0 and 1 for adherence to 14 best management practices (higher scores are better)
Predictors		
Bought land	0.495 (0.016)	Dummy variable for whether plot was acquired through commercial transaction
Owns plasma*	0.288 (0.015)	Dummy variable for plot owner's ownership of plasma farms
Stand age	7.356 (0.158)	Age of the oil palm stand on the plot (in years)
Peat soils	0.3 (0.016)	Dummy variable for the presence of peat soils on the plot (irrespective of depth)
Direct sale to mill*	0.190 (0.013)	Dummy variable for FFB produced on the plot sold directly to a oil palm mill
Plot size (log)	5.610 (0.660)	Size of the plot (in hectares) with logarithmic transformation
Input source – cooperative*	0.112 (0.013)	Dummy variable for inputs used on the plot being sourced from cooperatives that offer subsidized inputs
Number of plots owned	1.959 (0.097)	Total number of non-contiguous oil palm plots owned (including plasma)
Distance to sub-district capital	15.463 (0.404)	Plot's distance to the administrative center of the sub-district (in km)

Note: Variables denoted with * were excluded from the compliance model since those variables may suffer from endogeneity problems. Although this can be controlled – for example, by using instrumental variables – this would not be appropriate for our compliance model because certain compliance-relevant decisions made at the time of establishment (e.g. whether to locate a farm on APL or use planting material from an official seed source) were for many farmers not influenced by their market relations since those were established following plantation establishment.

4. Results

4.1. Smallholder typology

The cluster analysis revealed six groups of independent smallholders. The individual groups can be characterized as follows (see Figs. 2, 3 and 4 for select descriptive statistics):

Group 1: Subsistence farmers

This group consists of smaller farmers (median size of total oil palm holdings is four ha – Fig. 2), originating from and residing in proximity to their oil palm farm(s); being either indigenous to the area (e.g. Dayak or Malay ethnicity) or second-generation Javanese (trans)migrants (Fig. 3). With limited off-farm diversification, livelihood portfolios tend to revolve around subsistence food crop production, notably rice and

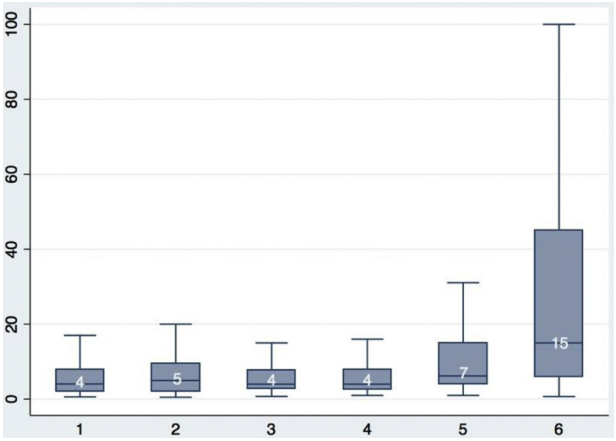

Fig. 2. Total land size by cluster, in hectares.
x-axis code: 1 = subsistence farmer; 2 = early adopter; 3 = migrant laborer; 4 = migrant farmer; 5= entrepreneur; 6= local elite.

horticulture (Fig. 4), also prior to adopting oil palm. Oil palm is the primary and often sole source of cash income. The majority cultivated rubber prior to adopting oil palm. In order to preserve food security, most converted rubber, as opposed to subsistence crops, to oil palm. Education levels are low and most households adopted oil palm without having gained any relevant prior experience.

Group 2: Early adopters

This group consists almost entirely of smaller farmers that like subsistence farmers originate from and reside in proximity to their oil palm farm(s). They are also mostly indigenous to the area or second-generation migrants. The median area of their oil palm holdings is slightly larger at five ha. Farmers in this group can be considered early adopters, being the first amongst all six groups to commence oil palm cultivation (this difference is statistically significant for all pairwise comparisons); on average in 2002 - five years earlier than other farmers. Prior to adopting oil palm, most farmers in this group specialized in rubber cultivation, with supplementary cash income obtained as manual laborers on corporate plantations or through ownership of plasma. Despite lacking education, almost three-quarters of farmers in this group gained relevant prior experience before cultivating oil palm independently. To mitigate risks, the vast majority of farmers in this group continued to cultivate rubber. Schwarze et al. (2015), for example, show how despite rubber's high labor demands, rubber can more easily be left idle (e.g. in rainy seasons). Compared to oil palm, it also is less capital-intensive and less susceptible to mismanagement

Group 3: Migrant laborers

Farmers in this group are mostly first-generation migrants of Javanese origin, cultivating oil palm on a median area of four ha. More than half (55.4%) arrived through transmigration schemes unrelated to oil palm, with the remainder migrating spontaneously (typically seeking out opportunities in the oil palm sector). More than 90% gained experience with the crop prior to cultivating it independently; by and large as plantation laborers. Often poor landless laborers from Java, less than a quarter of farmers in this group farmed subsistence or other plantation crops before adopting oil palm. Only oil palm is typically farmed, with supplementary income derived largely from menial labor on other oil palm plantations. This group is on average the least educated.

Group 4: Migrant farmers

Like migrant laborer, farmers in this group are mostly first-generation migrants of Javanese origin who cultivate oil palm on a median area of four ha. Almost half (48.8%) arrived through a transmigration

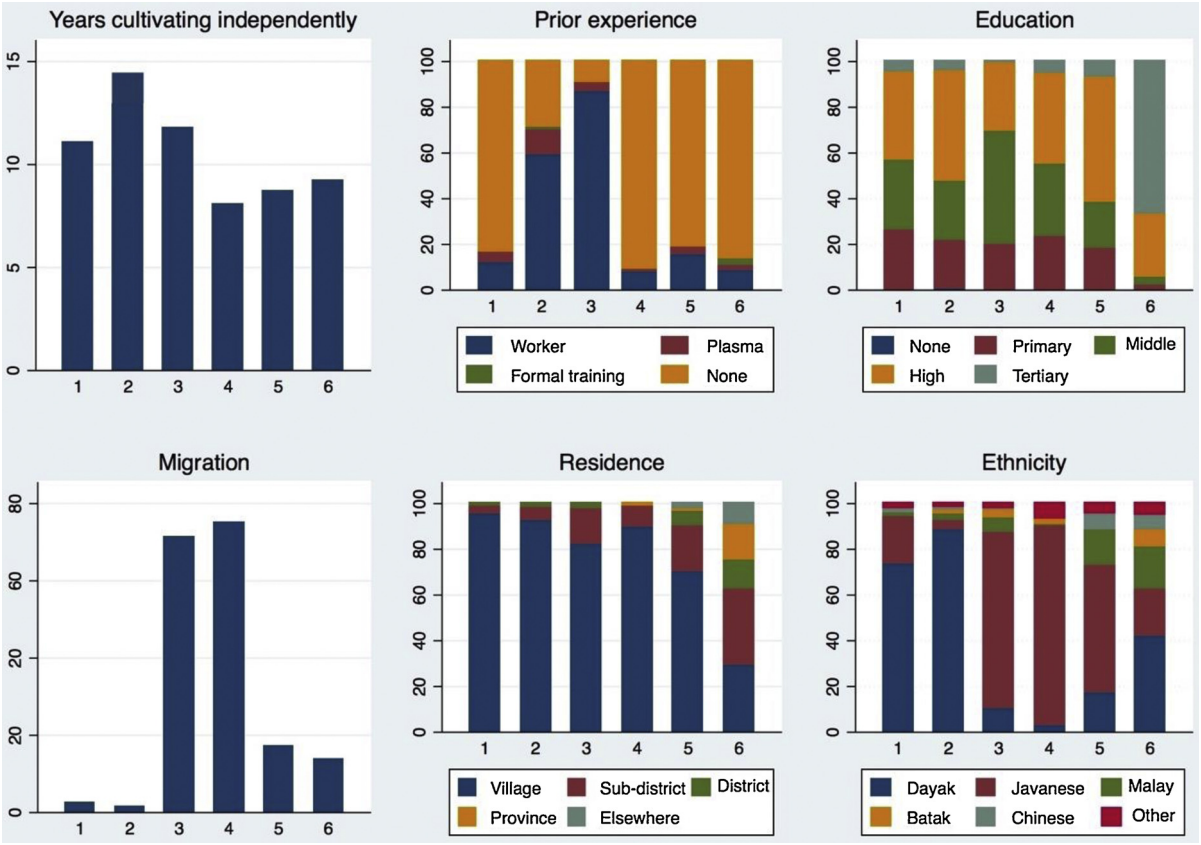

Fig. 3. Demographic characteristics by cluster, in proportions.
x-axis code: 1 = subsistence farmer; 2 = early adopter; 3 = migrant laborer; 4 = migrant farmer; 5= entrepreneur; 6= local elite.

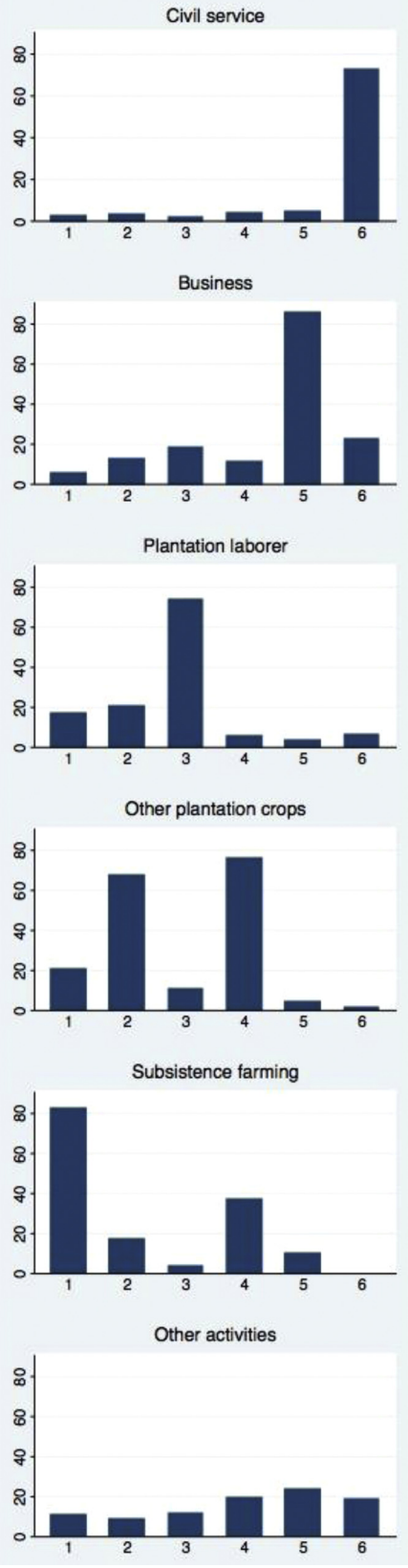

Fig. 4. Other livelihood activities, in proportions.
x-axis code: 1 = subsistence farmer; 2 = early adopter; 3 = migrant laborer; 4 = migrant farmer; 5 = entrepreneur; 6 = local elite.

initiative, with others migrating spontaneously. These, in contrast to migrant laborers, often sought out (more) land to produce various crops. Prior to adopting oil palm independently, most farmers produced a combination of subsistence and plantation crops, with little off-farm diversification, which continues to be low. Little external experience was and is being gained on the crop's agronomy. Like early adopters, the backbone of farmer households is the rubber-oil palm combination, though farmers in this group are especially late adopters of oil palm. This group is poorly educated and resides in close proximity to their farms.

Group 5: Entrepreneurs

With seven ha of oil palm, the median farm size of farmers in this group is larger than the above groups. While dominated by farmers of Javanese origin, this group is nevertheless comparatively diverse. Though more educated, fewer than 20% gained hands-on experience with oil palm before investing in it independently. This group is comparatively inexperienced, with 14.8% involved in any type of farming activities before oil palm. Rather, most were and continue to be engaged in small business activities such as shop-keeping, FFB trade and construction. Although absenteeism is comparatively prevalent, most do reside in close proximity to their plantation.

Group 6: Local elites

This group is evidently the most affluent and politically influential, cultivating a median area of 15 ha. Rarely first-generation migrants, almost two thirds associate with indigenous ethnic groups. This is, nevertheless, the most ethnically diverse group. Despite lacking relevant prior experience, this is the most educated group, with 68.1% having completed tertiary education. This group consists almost exclusively of white-collar employees, with 79.7% deriving an income from employment in civil service. Few local elites are engaged in other agricultural activities besides oil palm. Farmers in this group are also most likely to not reside in close proximity to their oil palm plots.

Each group, on average, represents between 10.3% and 23.2% of the sampled population per research area (Table 5). Results, however, show that certain groups are more prevalent in certain landscapes than in others. For example, subsistence farmers and early adopters are especially dominant in the Sanggau oil palm landscape. This reflects the composition of the population in its more established oil palm area, which is dominated by the indigenous Dayaks. Due to local resistance to transmigration schemes, Javanese and Madurese migrants in Sanggau tend to reside in peripheral areas (see also Li, 2015). Transmigration schemes are therefore more prevalent in the more peripheral Sintang/Kapuas Hulu landscape, which is reflected in the comparatively large number of migrant laborers. In Kotawaringin Barat, migrant laborers and migrant farmers are more plentiful than subsistence farmers and early adopters despite the population in the district consisting of primarily indigenous groups. This is partly a product of companies establishing plantations in close proximity to transmigration sites in order to enhance access to cheap and compliant labor given the area's low population density. Entrepreneurs are well-represented in Kotawaringin Barat because of the availability of cheap suitable land. There, surveyed farmers paid 35.1% of the per ha price paid by farmers in West Kalimantan. In Pulang Pisau, the majority of independent smallholders belong to Group 4. A number of transmigrant villages were established in the 1990s in the ex-PLG area (mostly of farmers experienced with Javanese-style rice production) (Potter, 2012; Government of Indonesia (GOI, 2015b). Exploiting ex-PLG peatland infrastructure, this is also the area where much of Pulang Pisau's independent oil palm expansion occurred in recent years.

Furthermore, results show that certain types of farmers are more likely to develop oil palm on peatlands. The large proportion of entrepreneurs and local elites developing peat is attributable to those farmers being better resourced to invest in developing the necessary peat infrastructure, preparedness to take risks (e.g. due to comparatively high production risks) and pursuit of larger contiguous areas of land. This is very much in line with findings from Jelsma et al. (2017).

Table 5
Distribution of farmers across clusters by research area.

Cluster	Peat soils	Sintang/Kapuas Hulu (n = 248)	Kotawaringin Barat (n = 304)	Pulang Pisau (n = 109)	Sanggau (n = 271)	Average prevalence per district
Subsistence farmer	26.6	12.9	11.8	3.7	31.7	15.0
Early adopter	25.1	14.1	8.9	5.5	45.4	18.5
Migrant laborer	29.9	37.1	24.3	13.8	5.2	20.1
Migrant farmer	45.6	20.2	19.4	50.5	3.0	23.2
Entrepreneur	44.0	11.3	26.3	6.4	7.4	12.9
Local elite	60.5	4.4	9.2	20.2	7.4	10.3

While the migrant farmers are likely more willing to develop peats given their general farming experience, the large proportion of these farmers encountered in Pulang Pisau contributes to overinflated results.

4.2. Characteristics of smallholder oil palm activities

Half the sampled plots (49.5%) were acquired through commercial transaction, suggesting that emergent land markets play an important role in enabling independent oil palm expansion (despite the prevalence of customary tenure regimes in Kalimantan). As expected, subsistence farmers and early adopters are more likely to develop plots obtained through inheritance, while most migrant laborers and farmers either purchased land or used land allocated by the government under transmigration initiatives (Fig. 5).

Interestingly, fewer than 2% of farmers depended on external sources of capital to buy and develop their plots, with private capital funding the lion's share of smallholdings (Fig. 5). No statistically significant difference between groups could be observed in this respect. Even entrepreneurs and local elites with more collateral and capacity to navigate the formal banking system are minimally dependent on external sources of capital. 63.2% of farmers claimed there is no need for external finance, while 20.5% claimed that external capital was inaccessible due to lack of land documentation and 12.8% considered terms of access unattractive.

With respect to input access, between 90 and 98% of farmers sourced inputs such as fertilizers and pesticides from local retailers (Fig. 5). Dependency on local retailers, which are often informal and notorious for disseminating substandard and sometimes counterfeit inputs, reveals lack of input provisioning (and support services more generally) from mills. Mostly, smallholders lack a direct relationship with companies, with more than 80% depending solely on middlemen to connect them to mills. Results do suggest that some farmers (18.9%) sell their FFB directly to mills, with the two groups dominated by indigenous farmers and more affluent farmers (e.g. entrepreneurs and local elites) more likely to sell directly than migrant laborers and farmers. For mills, purchasing directly through larger farmers is more viable given their larger production volumes; however, the presence of a direct relationship with smaller indigenous farmers is unexpected because transaction costs are reduced when procuring from FFB aggregators (e.g. middlemen). Particularly in Sanggau, smallholders use the right to sell to mill directly (the Delivery Order) allocated by mills to middlemen and/or cooperatives. While direct sales do translate into higher FFB prices for smallholders, few other benefits are discernable, suggesting that purely arm's length relations govern these transactions.

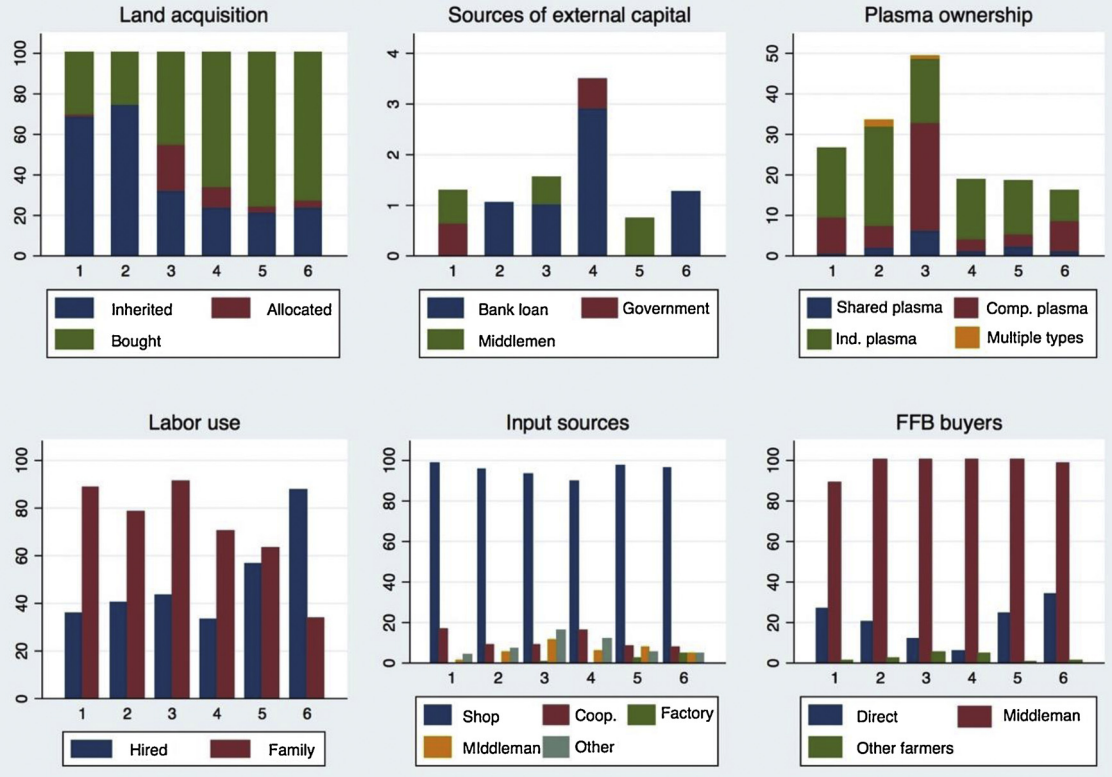

Fig. 5. Oil palm production activities, in proportion of smallholders by group.
x-axis code: 1 = subsistence farmer; 2 = early adopter; 3 = migrant laborer; 4 = migrant farmer; 5 = entrepreneur; 6 = local elite.

For example, only 1.1% of farmers that sell FFB directly receive any technical support and none receive production inputs. Similarly, supply-side technical service provision also appears weak, with only 8.7% of farmers claiming that input providers offer technical support.

Another pathway through which technical knowledge could be acquired is through ownership of oil palm smallholdings under NES arrangements; commonly referred to as 'plasma' plots. 28.9% of farmers own plasma plots, with migrant laborers most actively engaged in NES (Fig. 5). Most plasma plots were acquired following the establishment of independent oil palm plantations, suggesting that experience gained through plasma rarely motivated smallholders to farm oil palm independently. Moreover, with more than three-quarter of the entrepreneurs and local elites owning multiple plasma plots, better resourced farmers were found to be buying up others' plasma plots. Most of the plasma plots are managed individually by farmers, rather than through collective or company management, as is the case in some NES schemes. In case of the latter, companies fully manage the plasma plots against a fee and smallholders are not actively involved in plantation management and are therefore unlikely to gain hands-on experience with GAP. Section 4.4 further explores whether engagement in NES produces positive spillover effects.

Almost half the sampled smallholders rely on hired labor to undertake (some of) their plantation management activities, notably harvesting and pruning. A quarter do not allocate any household labor to plantation management, especially entrepreneurs and local elites. This suggests that a large proportion of sampled farmers do not meet the popular definition of smallholders (e.g. those that predominantly rely on household labor). While 96%–99% of smaller farmers oversee the general management of their plantations themselves, 16.0% and 29.7% of entrepreneurs and local elites, respectively, outsource plantation management completely – notably those who do reside away from their plantation.

4.3. Standards compliance

Table 6 presents the results of our multivariate ISPO compliance regression model. The first equation models the probability of complying with land designation rules; specifically, whether surveyed plots from smallholders are located on land designated for oil palm production (e.g. APL). As can be seen in Table 4, 91.9% of sampled plots are fully located on APL. When controlling for confounding variables, only migrant farmers are significantly (positively) associated with compliance with APL requirements. However, predicted compliance probabilities by farmer group do suggest that the entrepreneurs (84.9%) and local elites (81.1%) are especially likely to be located outside APL (Fig. 6). The probability of farms being located outside APL is especially high in Kotawaringin Barat, where much of the land is designated as state forestland (see Table A1 for predicted compliance probabilities by district). We estimate that 34.8% of the independent smallholder oil palm area in Kotawaringin Barat is uncertifiable because of this. In Pulang Pisau, we estimate that 25.9% of the smallholder area is for similar reasons uncertifiable. Recent agrarian reform regulations do provide avenues for reclassifying state forestland to APL if smallholders commenced cultivation on that land more than 20 years ago. However, from the sampled smallholders, the oldest development outside APL was 13 years, suggesting that few smallholders outside APL will be able to benefit from these regulations and risk becoming permanently incompliant.

The second compliance indicator we modelled is whether smallholders obtained planting material from a certified source. With 73.3% claiming to have done so, this proportion is comparatively high, especially compared to Riau (Jelsma et al., 2017). Results show that larger plots, proximity to the sub-district capital (and therefore input markets) and being located on mineral soils are positively associated with compliance, as are plots owned by migrant laborers and local elite. Predicted compliance probabilities show that migrant farmers and entrepreneurs are least likely to obtain planting material from certified sources. Lack of prior experience and awareness of the importance of good planting material likely factor into this. Farmers in Central Kalimantan are also considerably less likely to use certified materials than farmers in West Kalimantan (Table A1). This is attributable to the more developed production infrastructure in West Kalimantan, notably in

Table 6
Compliance determinants - multivariate probit regression with landscape fixed effects.

Variables	APL	Seed source	Group membership	National land	License
Plot size (log)	−0.211 (0.07)***	0.124 (0.06)**	−0.103 (0.06)	−0.102 (0.05)*	0.513 (0.12)***
Years since first planting	0.043 (0.03)	0.003 (0.01)	0.012 (0.01)	0.053 (0.01)***	0.072 (0.02)
Bought land	−0.328 (0.38)	−0.072 (0.18)	0.133 (0.16)	−0.119 (0.21)	−0.3434 (0.31)
Located on peat soils	0.681 (0.59)	−0.644 (0.20)***	0.096 (0.18)	0.007 (0.17)	−0.452 (0.39)
Distance to sub-district capital	−0.052 (0.009)***	−0.014 (0.001)**	0.016 (0.24)***	0.008 (0.004)***	0.003 (0.10)
Cluster number					
2	−0.130 (0.28)	0.162 (0.16)	−0.128 (0.16)	0.277 (0.15)	−0.259 (0.28)
3	0.092 (0.27)	0.537 (0.19)***	0.583 (0.18)***	0.582 (0.16)***	−0.770 (0.49)
4	0.455 (0.29)*	0.079 (0.18)	0.441 (0.19)**	0.321 (0.17)*	−0.514 (0.48)
5	0.043 (0.27)	0.071 (0.18)	0.220 (0.20)	0.515 (0.17)***	−0.492 (0.43)
6	−0.209 (0.30)	0.453 (0.23)**	0.053 (0.23)	0.598 (0.20)**	0.663 (0.33)**
Constant	1.99 (0.37)***	0.778 (0.19)***	−0.166 (0.17)	−1.171 (0.18)***	−2.028 (0.29)***
Landscape fixed effects	YES	YES	YES	YES	YES
Summary statistics					
N	900	900	900	900	900
Pseudo R-squared	0.264	0.211	0.141	0.070	0.252
LR Chi-squared	136.37***	214.81***	149.07***	79.65***	60.99***
Log pseudolikelihood	−189.88	−402.12	−454.98	−564.56	−90.74
Hosmer-Lemeshow Chi-squared	3.32	12.29	4.13	8.84	2.70
Full model					
Log pseudolikelihood	−1705.21				
Wald Chi squared	437.62***				

Standard errors in brackets.
The Spearman correlation matrix in A2 depicts relationships between the five equations.
* = Significant at p > 0.1.
** = Significant at p > 0.05.
*** = Significant at p > 0.01.

Sanggau, which hosts a major seedling production station. The widespread use of sub-standard planting material contributes significantly to the large independent smallholder yield gap (Woittiez et al., 2017). FFB from the *tenera* variety, for example, contains approximately 30% more oil than the commonly cultivated *dura* variety due to its high mesocarp to endocarp ratio (Corley and Tinker, 2016). Results from our tree inspection confirm that migrant laborers, who are most likely to use certified planting materials, also cultivate the highest proportion of the *tenera* variety (82.4% of sampled trees); compared to 62.8%–65.9% of trees owned by farmers in other groups.

Incompliance with our third indicator, membership of a registered farmers group or cooperative, appears to be more widespread than the first two indicators. 72.7% of farmers are not a member of a group and/or cooperative. In much of Indonesia, developing effective farmer groups and cooperatives is problematic due to lack of effective leadership and organizational capabilities and skepticism about the utility of formal organization (Feintrenie et al., 2010; Brandi et al., 2015). Owning plots further away from district capitals positively predicts membership. This could be explained by farmers being more inclined to organize when public services and inputs are less accessible. Assignment to the two migrant groups also positively predicts membership due to organizational support provided to migrants under transmigration initiatives and a stronger culture of collective organization in Java. Despite this, the limited collective organization observed across all groups poses a serious compliance challenge, especially in Kotawaringin Barat (Table A1).

The majority of sampled smallholders (60.9%) also did not pass our fourth compliance indicator: possessing nationally-recognized land documentation in the form of an SHM. The predicted probability of possessing such documentation is highest for migrant laborers and lowest for subsistence farmers and early adopters. We observe that transmigrants are generally more aware of (the need for) SHM, with transmigration schemes typically providing titling support. As discussed above, migrants laborers are also most inclined to use certified planting material, which requires land documentation. The covariance matrix presented in Table A2 also suggests a positive relationship between SHM and certified planting material.

Farmers without an SHM often possess village-level documentation such as an SKT (47.3% of sampled farmers), which, as noted earlier, rarely guarantees that land is free from dispute or is properly demarcated. That 94.7% of farmers with plots outside APL possess land documentation suggests that SKT's do not guarantee legality. Furthermore, 13.4% of farmers are yet to obtain land documentation. Almost three quarters of these farmers are subsistence farmers and early adopters. This can be ascribed to perceived security of historical claims and reluctance to incur high costs of obtaining an SHM. Moreover, none of the sampled farmers obtained a *Hak Guna Usaha* (HGU), a Right to Cultivate that farmers are required to obtain in lieu of an SHM when they own a plot with more than 25 ha of oil palm. By these rules, 3.5% of sampled farmers, which collectively account for 21.2% of the total sampled oil palm area, should have obtained a HGU and, therefore, they are mandated to follow the full ISPO standard, not the less comprehensive smallholder standard. These are mostly entrepreneurs and local elites, 5.9% and 14.8% of whom, respectively, require a HGU for one or more of their plantations. In Pulang Pisau, 11.0% of sampled farmers, collectively cultivating an estimated 49.1% of total independent smallholdings in the district, fail to comply with HGU procedures. These procedures include, amongst others, undertaking an environmental impact assessment and a technical feasibility study, obtaining a plantation business license and developing at least 20% of the plantation for smallholders when exceeding 250 ha (see Baudoin et al. (2017)). Some of the sampled farmers sought to circumvent these costly and time-consuming requirements by either remaining unregistered or registering plots in different names. For example, more than 60% of farmers cultivating more than 25 ha of land (5.5% of the sample) do not require a HGU because landholdings are either subdivided or scattered. Since HGU's only afford usufructuary rights over state land (as opposed to freehold rights provided through SHM), they are more susceptible to expropriation and revocation and less suitable for land speculation strategies.

Especially few farmers (3.4%) complied with the fifth indicator, possessing a plantation license (e.g. STD-B). Local elites and farmers possessing larger plots are more inclined to obtain an STD-B. The ability of especially local elites to more effectively navigate the public bureaucracy likely contributed to this. As also pointed out by others (INOBU, 2016; Jong, 2018), district governments responsible for issuing these licenses tend to lack the will and capacity to issue STD-Bs, which require them to map smallholder plots to determine whether these are located on APL. In this context, possession of an SHM thus facilitates the plantation licensing process. Moreover, in some areas (e.g. Kotawaringin Barat), the district government devolves these responsibilities to the sub-district where significant 'fees' are charged, despite the licenses technically being free of charge. Farmers wishing to fully formalize operations therefore often fail to obtain an STD-B despite concerted efforts. However, those farmers cultivating more than 25 ha require a plantation business license instead, which is also a requirement for obtaining a HGU.

The conditional probability of smallholders passing all five indicators is 2.4%. If we overlook STD-B incompliance given resistance from local government, then the predicted farmer probability of complying with all other compliance indicators remains low at 10.0% (Fig. 6). With an overall predicted compliance probability of 16.0%, only migrant laborers differed significantly from other groups (7.2% to 9.1%). This suggests that experienced and specialized oil palm farmers are most inclined to comply with national regulations. While more ISPO compliant entrepreneurs and local elites would have been expected given their affluence, entrepreneurialism, political embeddedness and education, this is not reflected in the results. Attempt to evade regulatory scrutiny due to improper licensing and state forestland encroachment partly underlies this.

4.4. Adherence to good agricultural practices

Table 7 presents the results of our multivariate GAP regression model. Descriptive statistics presented in Table 2 show that insufficient fertilizer application and absence of cover crops are the most significant GAP gaps (at least of those sampled practices included in the model). Results suggest that farmers' engagement in NES and direct marketing to mills does not have a resoundingly positive effect on practices. Plasma ownership is negatively associated with proper fertilizer application and positively with good weeding practices, while direct sales to mills is positively associated with proper fertilizer application and negatively with good weeding practices. Table A5 suggest that neither indicator positively predicts overall GAP compliance. While the lack of knowledge spillovers from closer relations to mills was to be anticipated due to the lack service provisioning, a positive effect from engagement in NES would have been expected, but could not be observed. Accounting for differentiated effects of involvement in different types of NES did not yield significantly different results.

Mixed results are also apparent for many of the other predictors. However, younger plantations do tend to be better managed on the basis of three of the four practices, though overall performance is not meaningfully influenced by the age of the plantation (Table A5). Distance to sub-district capitals is positively associated with most practices modelled, including overall performance. This is a surprising result since proximity to administrative centers is typically assumed to positively affect access to inputs and services. This result may be attributable to more experienced farmers having greater confidence to develop plantations in more remote areas; for example, on average, a farmer with prior oil palm experience resides 4.0 km further away from a sub-district capital than an inexperienced farmer. While farmers located on peatlands perform better on some indicators than others, the

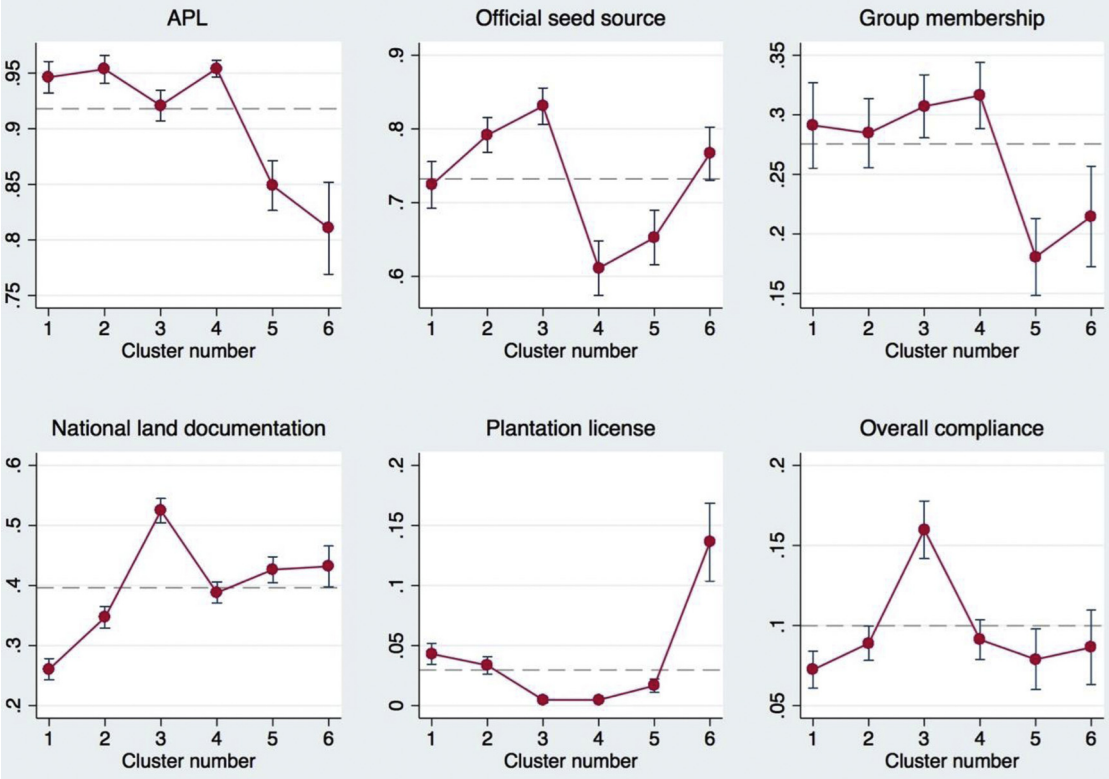

Fig. 6. Predicted compliance probabilities.
*Error bars depict 95% confidence interval.
** Overall compliance are the *conditional* probabilities of complying with the first four. compliance indicators. Plantation license was omitted from the conditional probability analysis due it being a state rather than farmer responsibility.
x-axis code: 1 = subsistence farmer; 2 = early adopter; 3 = migrant laborer; 4 = migrant farmer; 5 = entrepreneur; 6 = local elite.

overall effect is negative. More experience and resources are needed to cultivate peatlands responsibly due to heightened risk of fire and disease and the importance of good water-table management. The covariance matrix (Table A4) suggests that appropriate pruning of trees best predicts compliance with other good practices.

Predicted probabilities and margins for the different GAP compliance indicators clearly demonstrate that migrant laborers outperform other farmers on all indicators, including overall GAP compliance (Fig. 7). Mirroring standards compliance results, this points to more highly performing experienced and specialized oil palm farmers. Migrant farmers and entrepreneurs appear to systematically underperform. This could be the result of competing labor demands in the case of migrant farmers (e.g. with rubber). In the case of entrepreneurs, lack of general farming experience and reliance on hired labor undermines adoption of GAP. Underperformance is also widespread amongst local elites; presumably, due to the prevalence of speculative strategies. Subsistence farmers, in contrast, perform above average. Reliance on oil palm as the primary source of cash income ensures sufficient labor is allocated to plantation management. Better performance would have been expected from early adopters however. Competing labor demands, like migrant farmers, possibly factors into this.

5. Discussion

Our typology provides important theoretical and policy-relevant insights into the heterogeneity of independent oil palm smallholders in Central and West Kalimantan. The cluster analysis produced six smallholder groups, distinguishable by their livelihood portfolios, ethnicity, migration status, place of residence, education, size of oil palm holdings and prior oil palm experience. This includes (1) subsistence farmers, (2) early adopters, (3) migrant laborers, (4) migrant farmers, (5) entrepreneurs and (6) local elites. The early adopters and migrant laborers most closely resemble what Dorward et al. (2009) consider to be smallholders that are “stepping up”. Oil palm cultivation is integral to long-term livelihood strategies and alternative sources of cash income and plantation management experience can be leveraged to facilitate (investment in) upgrading. Since these farmers are comparatively abundant (comprising on average 43% of farmers in the four landscapes) and few are complicit in state forest encroachment, such farmers are clearly low hanging fruit for interventions that aim to efficiently and economically facilitate smallholder upgrading at scale; especially migrant laborers who are already most compliant of GAP and ISPO. Because these farmers are likely willing and sufficiently able to absorb the income shocks of replanting, they are prime candidates for Indonesia’s replanting grants, which typically demand co-financing (Luttrell et al., 2018). Given their plantation management experience, upgrading the operations of these farmers are unlikely to demand extensive technical support. Rather, ensuring these farmers become ISPO compliant (e.g. through targeted bureaucratic support and procedural streamlining) will contribute to strengthening productive linkages to mills, which in turn will enhance access to better quality inputs. Such linkages emerge because mills are often motivated to develop formal coordination mechanisms with certified independent smallholders to help build their sustainable supply base (Hidayat et al., 2015). The ISPO standard also actively encourages this by mandating mills to demonstrate that more than 70% of FFB originates from ISPO certified plantations by 2020 and establish direct sourcing relationships with smallholders (Hidayat et al., 2018). Hidayat et al. (2015) demonstrate how certification can produce such linkages and in turn improve productivity and incomes as middlemen are more easily bypassed.

The subsistence and to a lesser extent the migrant farmers most closely resemble smallholders that are “hanging in”. For most,

Table 7
GAP determinants - multivariate regression with landscape fixed effects.

Variables	Pruning	Fertilizer	Weeding	Cover crops
Bought land	0.028 (0.029)	0.095 (0.038)**	−0.191 (0.167)	0.622 (0.216)***
Owns plasma plots	0.022 (0.023)	−0.075 (0.030)**	0.242 (0.140)*	0.047 (0.197)
Buys subsidized inputs	−0.075 (0.050)	−0.108 (0.037)***	0.242 (0.235)	−0.125 (0.224)
Years since first planting	−0.006 (0.003)**	−0.006 (0.003)**	0.006 (0.012)	−0.030 (0.015)**
Located on peat soils	0.062 (0.031)**	−0.088 (0.044)**	−0.461(0.18)***	0.518 (0.223)**
Direct sale to mill	0.032 (0.026)	0.130 (0.031)***	−0.404 (0.14)***	0.197 (0.174)
Plot size (log)	0.016 (0.012)	−0.030 (0.012)**	0.111 (0.063)*	0.048 (0.063)
Number of other plots	0.000 (0.004)	0.001 (0.003)	0.024 (0.020)	−0.051 (0.040)
Distance to sub-district capital	0.003 (0.001)***	0.006 (0.001)***	0.002 (0.001)	0.002 (0.001)**
Cluster number				
2	0.005 (0.031)	−0.039(0.036)	−0.240 (0.159)	−0.192 (0.194)
3	0.087 (0.032)***	0.066 (0.037)*	0.173 (0.186)	0.712 (0.196)***
4	−0.066 (0.040)*	−0.138 (0.042)***	−0.033(0.181)	−0.178 (0.223)
5	−0.065 (0.038)*	−0.081 (0.040)**	0.057 (0.194)	−0.358 (0.212)*
6	−0.048 (0.046)	−0.105 (0.046)**	0.009 (0.234)	0.352 (0.232)
Constant	0.783 (0.034)***	0.677 (0.043)***	0.092 (0.177)	−2.675 (0.391)***
Landscape fixed effects	YES	YES	YES	YES
Summary statistics				
F(17)	10.05***	14.43***	–	–
(pseudo) R-squared	0.140	0.216	0.137	0.258
Likelihood Ratio Chi-squared	–	–	13.08***	131.33***
Log likelihood	–	–	−425.48	−329.20
Ramsay RESET, F(3)	1.72	2.02	–	–
Hosmer-Lemeshow Chi-squared		–	4.21	8.60
Full model				
Chi-squared	617.15***			
Log-likelihood	−1037.31			

Robust standard errors in brackets.
The Spearman correlation matrix in S4 depicts relationships between the four equations.
* = Significant at p > 0.1.
** = Significant at p > 0.05.
*** = Significant at p > 0.01.

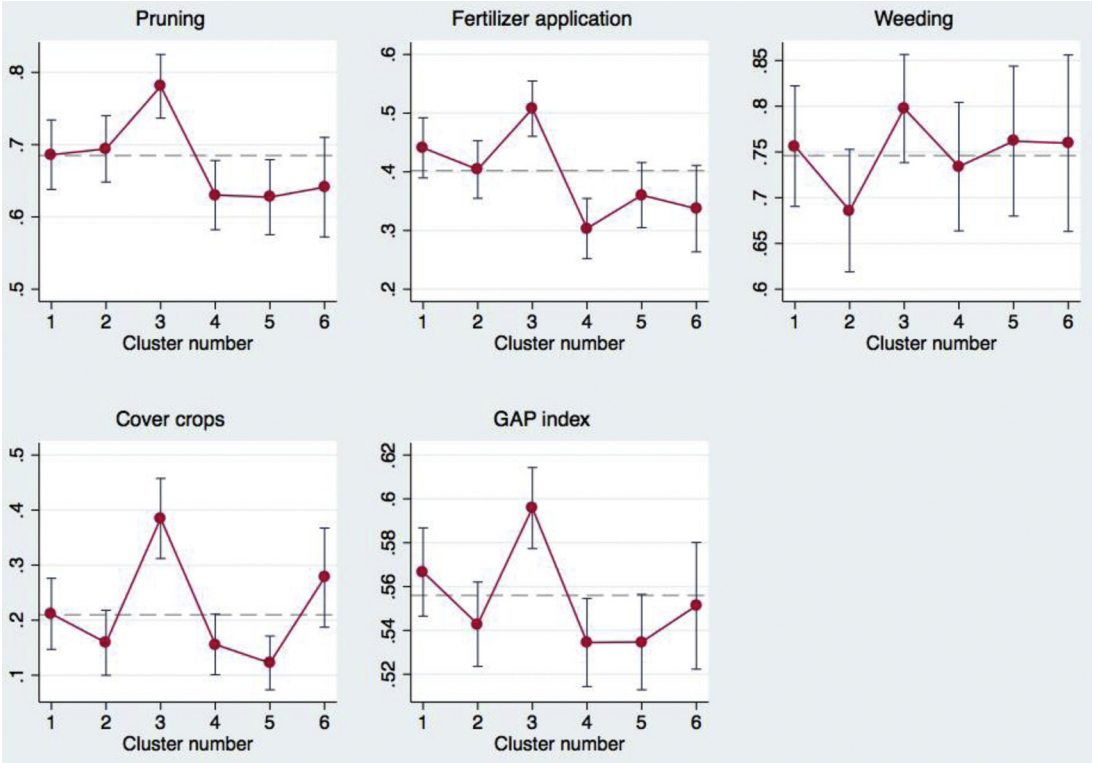

Fig. 7. Predicted margins for select best practice indicators.
*Error bars depict 95% confidence interval.
x-axis code: 1 = subsistence farmer; 2 = early adopter; 3 = migrant laborer; 4 = migrant farmer; 5 = entrepreneur; 6 = local elite.

livelihoods are focused almost exclusively on agriculture, with oil palm the sole source of cash income for most subsistence farmers. Farmers in both groups, especially the migrant farmers, gained little prior experience with managing oil palm and continue to be poorly linked to sources of technical knowledge (e.g. as laborers, plasma plot owners or through direct relations with mills). The cost and complexity of ISPO compliance will for many be prohibitive and replanting financially and arguably socially undesirable, especially for migrant farmers with comparatively young stands. Capital intensive interventions are not immediately suitable; instead, as pointed out by Verkaart et al. (2018), interventions that leverage farmers' labor resources may be more appropriate. This is especially the case for subsistence farmers, but likely less so for migrant farmers devoting labor to rubber. Targeted extension support and technical trainings could contribute to raising productivity and habilitate farmers for certification; for example, as GAP-induced productivity and FFB quality gains raise incomes, which in turn can be reinvested into certification (Woittiez et al., 2018). Therefore, in contrast to the migrant laborers and early adopters, GAP is likely to facilitate certification, not the other way around. Many subsistence and migrant farmers currently lack the direct industry ties and plantation management experience to develop the technical fundamentals to effectively and efficiently make use of the new opportunities brought about by ISPO compliance to access better inputs.

None of the groups neatly fit into Dorward et al.'s (2009) "stepping out" category. Very few farmers newly entered the non-farm economy since commencing oil palm cultivation. For the farmers assigned to the entrepreneurs and local elite groups, we propose two new categories: farmers that are "moving in" and farmers that are "moving through". Farmers "moving in" we consider to be those that are not actively engaged in agriculture prior to developing oil palm and are investing non-farm profits into developing oil palm plantations in appreciation of its profitability. Entrepreneurial capabilities enable such farmers to buy large areas of cheap land - often in more remote locations – and efficiently access more distant input and offtake markets. Farmers "moving through" fit a similar profile, but adopt more speculative strategies. Cheap 'empty' lands are bought and converted to oil palm, with the aim of eventually selling these off at a profit. FFB returns are in contrast of lesser interest, with few harboring long-term aspirations in the sector. As shown by Purnomo et al. (2017) and Jelsma et al. (2017), such strategies are commonplace and highly profitable in Indonesia, with public servants often adopting or being complicit in them, especially for land within the state forest domain and on peatlands. Although more research is needed to identify which entrepreneurs and local elites are "moving in" and "moving through", many entrepreneurs can likely be placed into the former and local elites in the latter category. Absenteeism, outsourcing of plantation management, the use of land markets, employment in civil service and ownership of plots located outside APL and/or on peatlands are likely useful proxy indicators for speculative strategies (see also Jelsma et al., 2017); all of which more commonly observed amongst local elites. Regardless, farmers in neither group deserve to be prioritized for intervention support. With capital and capacity to navigate Indonesia's bureaucracy, where that is possible and properly incentivized, these farmers face comparatively few barriers to becoming ISPO compliant. The lack of farming experience, prevalence of absenteeism and reliance on hired labor will however pose a serious challenge to improving farmers' GAP compliance, as also noted by Jelsma et al. (2019). Those "moving through" and complicit in illegal encroachments are also poorly incentivized to invest in GAP. Only technical support to those "moving in" is therefore warranted. Better enforcement of Indonesia's environmental, spatial planning and business regulations can furthermore play a critical role in curbing speculative strategies and (the environmental effects associated with) the establishment of plantations on peat- and forestlands. Nevertheless, Jayne et al. (2016) posit that while such farmers may exacerbate land scarcities and clientelism, important agricultural growth and employment multipliers can emerge if the right farmers are effectively leveraged.

Based on this, we question current proposals in Indonesia (and elsewhere) to prioritize intervention support on the basis of plantation size and reliance on household labor; and by extension the popular definition of smallholders commonly adopted by policy makers and in academia. At least in our study sites, the vast majority of smallholders own more than the proposed four ha threshold. We rather contend that for the purpose of prioritizing support that is both effective and achieves societal co-benefits the role of oil palm in livelihood portfolios and strategies and the nature of smallholders' sectoral ties could be vastly more meaningful and useful indicators. For example, a smallholder with three ha of oil palm who owns a business, plants rubber and/or is able to gain agronomic experience through plasma ownership or as a plantation laborer is arguably less needing of technical and capital support than a smallholder with three ha only deriving cash income from oil palm. Similarly, reliance on hired labor poorly reflects support needs, with many farmers "hanging in" also relying on hired labor to help overcome household labor constraints and prevent diversion of labor from other socially-important activities such as food crop cultivation.

While our results demonstrate the importance of more actor-disaggregated intervention strategies, the similarities between groups with respect to their articulation to other value chain actors and service providers and the large observed compliance gap for all smallholder groups reveal a number of structural sectoral issues that deserve more attention. For example, because of arm's length relations with mills, dependency on middlemen and small-scale informal input suppliers and reluctance to engage financial institutions and to organize into groups, most farmers not only lack access to the necessary resources, but also the productive linkages, needed to incentivize compliance with GAP and ISPO. This suggests that farmer-oriented interventions need to be complemented by value chain-oriented interventions. Productive linkages could emerge organically as smallholder ISPO compliance reduces mills' risk of more directly engaging smallholders. They could also emerge through public incentives and regulations on minimum smallholder sourcing thresholds and provisioning of technical assistance and inputs under guaranteed offtake agreements. Since both the ISPO standard and the recently passed FFB Price Setting Regulation (Government of Indonesia (GOI, 2018) specify that companies should source FFB from smallholder organizations through long-term contracts, the Indonesian government is too recognizing the need for regulating how smallholder FFB enters the supply chain and improving traceability by circumscribing the influence of middlemen.

As pointed out in section 2, systemic institutional challenges contribute to many of the identified compliance issues; not least the large ISPO compliance gap observed within each of the six groups. For ISPO to be effectively leveraged as a tool for improving industrial competitiveness and inclusive and environmentally responsible sector development, much will depend on how well prevailing political economic structures that (re)produce, sustain and vindicate informality in the sub-sector are accounted for in the design of the ISPO governance system. Such structures emerged as the rescaling of state power following Indonesia's decentralization reform also rescaled patronage politics (Varkkey, 2015), as is manifested by the rising prevalence of more localized socio-economic coalitions involving local state-based actors, business networks and village elites that exploit newly acquired discretionary powers and private capital flowing into the oil palm sector for individual gain and to consolidate territorial authority (Gillespie, 2011; McCarthy et al., 2012; Brad et al., 2015). Because most district governments remain highly dependent on fiscal transfers from the central government and oil palm revenues are not hypothecated downwards, state-based actors are incentivized to capitalize 'informally' on the decentralization of certain plantation licensing and permitting procedures, which have afforded district government significant influence over land access (ibid). This, in many situations, has served to privilege private and corporate over societal interests, as the

declining support to oil palm smallholder in recent decades illustrates (McCarthy et al., 2012). Findings from this article that demonstrate the structural absence of effective productive linkages, collective organization and legal documentation in the sub-sector can in large part be ascribed to this declining support, and the erosion of both downwards and upwards accountability at the sub-national level more generally. The prevalence of local elite and entrepreneurs in the sub-sector with a propensity to encroach onto peat- and state forestland further points to the prevalence of socio-economic coalitions that use their power and resources to accumulate land for oil palm, bypass legal requirements and avoid regulatory scrutiny. In the provinces of Jambi and Sanggau, McCarthy et al. (2012) highlight how such actors often gain access to land through mutually accommodative arrangements with village leaders; often exploiting tenurial insecurities prevalent in provinces with dualistic tenure regimes. Such coalitions also often derive significant rents from land brokering (Brad et al., 2015; Jelsma et al., 2017). In this context, many locally influential stakeholders are clearly vested in maintaining the status quo and, therefore, likely to resist efforts by the central government to use ISPO as a mechanism to bring the sub-sector above board. The limited authority of the ISPO Commission may further empower district governments to thwart effective ISPO implementation (Hidayat et al., 2018). Such challenges threaten to undermine concerted efforts by the central government in recent years to bolster the credibility and international recognition of ISPO. While the myriad smallholder compliance initiatives may be impactful regardless, should ISPO fail to deliver on its objectives because of the various institutional failings, oil palm markets are likely to become increasingly bifurcated and many independent smallholders will remain locked into unsustainable and opaque supply chains that offer few incentives and means to upgrade.

6. Conclusion

In demonstrating the large diversity of independent smallholders in West and Central Kalimantan, this article builds on and extends the geographic scope of an emerging body of work on the socio-economic differentiation of oil palm smallholders in Indonesia (Jelsma et al., 2017; McCarthy and Zen, 2016) and of smallholders in developing countries more generally (Ordway et al., 2017; Kamau et al., 2018; Kuivanen et al., 2016). By extending our analysis to sustainability standards and GAP, we also illustrate (the determinants of) the large smallholder compliance gap in value chains confronted by pressures to augment sustainability performance; thereby offering empirical evidence and an actor-disaggregated perspective in support of, for example, Henson and Humphrey (2010) and Lee et al. (2012). In doing so, this article shows how designing and/or targeting intervention support to address contemporary smallholder upgrading challenges can be informed by differentiating smallholders based on their socio-economic, as opposed to their farms' technical, characteristics. Thereby departing from the more mainstream farm-systems based typology development approaches, our analytical approach lends itself especially well to exploring alternative intervention strategies that are specifically tailored to smallholders' livelihood portfolios, strategies and aspirations – in similar vein to Dorward et al. (2009) and Verkaart et al. (2018). In exploring these strategies, we build on the conceptual framework of these authors by demonstrating the prevalence of more business-oriented and speculative strategies employed by non-farmers, which we respectively term "moving in" and "moving through" strategies.

Since typologies are necessarily context specific (Tittonell, 2014; Alvarez et al., 2018), we caution against extrapolating results to Indonesia at large. Our results indeed illustrate that sizeable differences in group distribution and the nature and magnitude of the compliance gaps can be observed across the four landscapes and even within the same landscape (based especially on distance to the sub-district capital and soil type). This suggests that actor-disaggregated intervention strategies demand adaptation to landscape-specific realities. Despite this, our results do closely mirror those from Jelsma et al. (2017), the only other published study on oil palm smallholder heterogeneity in Indonesia employing data-driven methods. This suggests that certain results are externally valid and structural in nature; especially since that study was conducted in one of Indonesia's most developed oil palm landscapes, Sumatra's Riau, which in many ways is highly dissimilar from the more frontier oil palm landscapes of Indonesian Borneo. By similarly observing a structural absence of vertical and horizontal linkages conducive to upgrading and widespread dependency on informal input markets, our results suggest that more targeted smallholder interventions need to be nested within wider value chain reform efforts. Furthermore, we observe, like Jelsma et al. (2017), how many independent smallholdings are owned by entrepreneurs and local elite. While we do not observe the same level of differentiation across ethnic lines, the farmers we identify are nevertheless highly comparable in their pursuit of more speculatively livelihood strategies, high rates of absenteeism, reliance on hired labor, large farm size, use of (illicit) land markets and propensity to establishing plantations on state forestland and peatlands. The prevalence of such farmers in both established and frontier landscapes in Indonesia highlights how the structural-institutional constraints that underpin weak regulatory enforcement by lower level government likely plays into "moving in" and "moving through" strategies across many parts of the country. With Jayne et al. (2016) demonstrating how medium-scale farmers with similar non-farm profiles are also increasingly changing farm structures in sub-Saharan Africa, what we observe in Indonesia is likely symptomatic of agricultural commercialization and land commodification trends encountered in the developing world more generally. This points to the need for more (globally comparative) research into changing rural land market dynamics, the resultant effects on smallholder land access and rural inequalities and implications for designing appropriate upgrading strategies.

In demonstrating that the local elites and entrepreneurs that often control local socio-economic coalitions are a dominant force in the independent smallholder oil palm sub-sector, the results of this article also have important implications for the design of appropriate ISPO implementation structures and top-down sustainability and legality initiatives in the context of decentralized governance more generally. Local resistance to initiatives like ISPO that threaten the status quo is inevitable, as influential local actors complicit in illicit land trading, regulatory evasion and illegal land encroachments look to protect their discretionary authorities, oil palm investments and sources of personal accumulation. Vested interests such as these thrive on opaqueness and regulatory ambiguity, but are compromised when initiatives such as ISPO threaten to subject an instrumental economic sector such as oil palm to greater extra-territorial oversight and compliance demands.

Nesadurai (2018) however illustrates that transnational social processes consolidated around private standards such as RSPO and the zero-deforestation movement are able to disrupt the modus operandi of patronage networks and embed more progressive social and environmental standards and smallholder-centric policies in political economic spaces inimical to external oversight. Jurisdictional and landscape approaches are becoming particularly in vogue by such processes, in recognition that reconciling divergent objectives within many oil palm landscapes demands a more grounded, participatory and integrated planning approach. This represents a discursive shift from private governance beyond the state to deliberative, bottom-up forms of governance that place greater emphasis on local institution building and strengthened public-private engagement. The deployment of such approaches may culminate in local governance arrangements and strategic partnerships more conducive to the formulation and operationalization of the types of locally appropriate farmer- and value chain-oriented intervention strategies discussed above. Because such approaches are still undergoing proof-of-concept, however, the jury is still out as to whether they can effectively resolve deep-seated local misgovernance issues, especially at scale. Nevertheless, with the

Indonesian central government increasingly seeking to restore ISPO's international credibility and legitimacy and acknowledging the implementation challenges that lie ahead, increased convergence of state and private interests is both probable and necessary. Whether this convergence will yield the necessary smallholder-centric regulatory and institutional innovation will ultimately depend on whether the central government is prepared to change its stance on engaging the transnational social processes that ISPO at conception aimed to disrupt.

Acknowledgement

This work was partly funded by the United States Agency for International Development through the Governing Oil Palm Landscapes for Sustainability (GOLS) Project and undertaken as part of the CGIAR Research Program on Forests, Trees and Agroforestry (CRP-FTA) led by the Center for International Forestry Research (CIFOR) in partnership with Bioversity International, CATIE, CIRAD, ICRAF, INBAR and TBI. We would like to extend our gratitude to the staff and students from SPKS, University of Palangka Raya and University of Tanjungpura for their enumeration support.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.gloenvcha.2019.101933.

References

Alvarez, S., Timler, C.J., Michalscheck, M., Paas, W., Descheemaeker, K., Tittonell, P., Anderson, J.A., Groot, J.C., 2018. Capturing farm diversity with hypothesis-based typologies: An innovative methodological framework for farming system typology development. PLoS One 13 (5), e0194757.

Auld, G., 2010. Assessing certification as governance: effects and broader consequences for coffee. J. Environ. Dev. 19 (2), 215–241.

Badan Pusat Statistik (BPS), Kapuas Hulu, 2018. District Statistics. Retrieved 08/05/2018 from. https://kapuashulukab.bps.go.id/.

Badan Pusat Statistik (BPS), Kotawaringin Barat, 2018. District Statistics. Retrieved 08/05/2018 from:. https://kobarkab.bps.go.id/.

Badan Pusat Statistik (BPS), Pulang Pisau, 2018. District Statistics. Retrieved 08/05/2018 from. https://pulpiskab.bps.go.id/.

Badan Pusat Statistik (BPS), Sanggau, 2018. District Statistics. Retrieved 08/05/2018 from. https://sanggaukab.bps.go.id/.

Badan Pusat Statistik (BPS), Sintang, 2018. District Statistics. Retrieved 08/05/2018 from. https://sintangkab.bps.go.id/.

Baudoin, A., Bosc, P.M., Bessou, C., Levang, P., 2017. Review of the diversity of palm oil production systems in Indonesia. Case Study of Two Provinces: Riau and Jambi. Working Paper 219. CIFOR., Bogor, Indonesia.

Bissonnette, J.F., De Koninck, R., 2017. The return of the plantation? Historical and contemporary trends in the relation between plantations and smallholdings in Southeast Asia. J. Peasant Stud. 44 (4), 918–938.

Brad, A., Schaffartzik, A., Pichler, M., Plank, C., 2015. Contested territorialization and biophysical expansion of oil palm plantations in Indonesia. Geoforum 64, 100–111.

Brandi, C., Cabani, T., Hosang, C., Schirmbeck, S., Westermann, L., Wiese, H., 2015. Sustainability standards for palm oil: challenges for smallholder certification under the RSPO. J. Environ. Dev. 24 (3), 292–314.

Bray, J.G., Neilson, J., 2017. Reviewing the impacts of coffee certification programmes on smallholder livelihoods. International Journal of Biodiversity Science, Ecosystem Services & Management 13 (1), 216–232.

Byerlee, D., Stevenson, J., Villoria, N., 2014. Does intensification slow crop land expansion or encourage deforestation? Glob. Food Sec. 3 (2), 92–98.

Central Kalimantan Bureau of Plantations, 2009. History of Oil Palm Development in Central Kalimatan. Retrieved 08/05/2018 from:. http://aminjaya.desa.id/berita/detail/sejarah-perkebunan-kelapa-sawit-di-kalimantan-tengah.

Corley, R.H.V., Tinker, P.B., 2016. World Agriculture Series–The Oil Palm. Wiley-Blackwell.

Direktorat Jenderal Perkebunan (DJP), 2017. Statistik Perkebunan Indonesia: 2015-2017 Kelapa Sawit. DJP., Jakarta, Indonesia.

Dorward, A., Anderson, S., Bernal, Y.N., Vera, E.S., Rushton, J., Pattison, J., Paz, R., 2009. Hanging in, stepping up and stepping out: livelihood aspirations and strategies of the poor. Dev. Pract. 19 (2), 240–247.

Douxchamps, S., Van Wijk, M.T., Silvestri, S., Moussa, A.S., Quiros, C., Ndour, N.Y.B., Ouedraogo, M., 2016. Linking agricultural adaptation strategies, food security and vulnerability: evidence from West Africa. Reg. Environ. Change 16 (5), 1305–1317.

Fairhurst, T.H., Griffiths, W., 2014. Oil Palm: Best Management Practices for Yield Intensification. International Plant Nutrition Institute., Singapore.

Feintrenie, L., Chong, W.K., Levang, P., 2010. Why do farmers prefer oil palm? Lessons learnt from Bungo district, Indonesia. Small-scale For. 9 (3), 379–396.

Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M., Mueller, N.D., O'Connell, C., Ray, D.K., West, P.C., Balzer, C., 2011. Solutions for a cultivated planet. Nature 478 (7369), 337.

[FOKSBI] Forum Kelapa Sawit Berkelanjutan Indonesia, 2017. Indonesian Sustainable Palm Oil National Action Plan. FoKSBI., Jakarta, Indonesia.

Galudra, G., van Noordwijk, M., Sunyato, I.S., Pradhan, U., 2010. Hot Spot of Emission and Confusion: Land Tenure Insecurity, Contested Policies, and Competing Claims in the Central Kalimantan Ex-mega Rice Project Area. Working Paper 98. Bogor. ICRAF., Indonesia.

Gaveau, D., Sheil, D., Salim, M.A., Arjasakusuma, S., Ancrenaz, M., Pacheco, P., Meijaard, E., 2016. Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. Sci. Rep. 6, 32017.

Gillespie, P., 2011. How does legislation affect oil palm smallholders in the Sanggau district of kalimantan, indonesia? Australasian J. Nat. Res. Law and Pol. 14 (1), 1–37.

Glenday, S., Paoli, G., 2015. Indonesian Oil Palm Smallholder Farmers: A Typology of Organizational Models, Needs, and Investment Opportunities. Daemeter Consulting., Bogor, Indonesia.

Gnych, S.M., Limberg, G., Paoli, G., 2015. Risky Business. Motivating Uptake and Implementation of Sustainability Standards in the Indonesian Palm Oil Sector. Working Paper 139. Bogor. CIFOR, Indonesia.

Government of Indonesia (GOI), 2015a. Principles and Criteria of Indonesian Sustainable Palm Oil (ISPO) for Independent Smallholding, 11/Permentan/OT.140/3/2015. Minister of Agriculture, Jakarta.

Government of Indonesia (GOI), 2015b. Pulang Pisau Green Growth Strategy. District Government of Pulang Pisau, Palangka Raya, Indonesia.

Government of Indonesia (GOI), 2018. FFB Price Setting Regulations, 1/Permentan/KB.120/1/2018. Minister of Agriculture, Jakarta, Indonesia.

Gower, J.C., 1971. A general coefficient of similarity and some of its properties. Biometrics 857–871.

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O., Townshend, J.R.G., 2013. High-resolution global maps of 21st-Century forest cover change. Science 342 (15 November), 850–853.

Henderson, B., Godde, C., Medina-Hidalgo, D., van Wijk, M., Silvestri, S., Douxchamps, S., Stephenson, E., Power, B., Rigolot, C., Cacho, O., Herrero, M., 2016. Closing system-wide yield gaps to increase food production and mitigate GHGs among mixed crop–livestock smallholders in Sub-Saharan Africa. Agric. Syst. 143, 106–113.

Henson, S., Humphrey, J., 2010. Understanding the complexities of private standards in global agri-food chains as they impact developing countries. J. Dev. Stud. 46 (9), 1628–1646.

Hidayat, N.K., Glasbergen, P., Offermans, A., 2015. Sustainability certification and palm oil smallholders' livelihood: a comparison between scheme smallholders and independent smallholders in Indonesia. Int. Food Agribusiness Manag. Rev. 18 (3), 25–48.

Hidayat, N.K., Offermans, A., Glasbergen, P., 2016. On the profitability of sustainability certification: an analysis among Indonesian palm oil smallholders. J. Eco.Sust. Dev. 7 (18), 45–62.

Hidayat, N.K., Offermans, A., Glasbergen, P., 2018. Sustainable palm oil as a public responsibility? On the governance capacity of Indonesian Standard for Sustainable Palm Oil (ISPO). Agric. Human Values 35 (1), 223–242.

Higgins, V., Richards, C., 2019. Framing sustainability: alternative standards schemes for sustainable palm oil and South-South trade. J. Rural Stud. 65, 126–134. https://www.sciencedirect.com/science/article/pii/S0743016717313311.

Hospes, O., 2014. Marking the success or end of global multi-stakeholder governance? The rise of national sustainability standards in Indonesia and Brazil for palm oil and soy. Agric. Human Values 31, 425–437.

Hutabarat, S., 2017. ISPO certification and Indonesian oil palm competitiveness in global market smallholder challenges toward ISPO certification. Agro Ekon. 28 (2), 170–188.

INOBU, 2016. A Profile of Oil Palm Smallholders and Their Challenges of Farming Independently. INOBU, Jakarta, Indonesia.

Jaffee, S., Henson, S., Diaz Rios, L., 2011. Making the Grade: Smallholder Farmers, Emerging Standards, and Development Assistance Programs in Africa a Research Program Synthesis. Report No. 62324-AFR. World Bank, Washington, DC.

Jayne, T.S., Chamberlin, J., Traub, L., Sitko, N., Muyanga, M., Yeboah, F.K., Kachule, R., 2016. Africa's changing farm size distribution patterns: the rise of medium-scale farms. Agric. Econ. 47 (S1), 197–214.

Jelsma, I., Schoneveld, G.C., Zoomers, A., Van Westen, A.C.M., 2017. Unpacking Indonesia's independent oil palm smallholders: an actor-disaggregated approach to identifying environmental and social performance challenges. Land Use Policy 69, 281–297.

Jelsma, I., Woittiez, L.S., Ollivier, J., Dharmawan, A.H., 2019. Do wealthy farmers implement better agricultural practices? An assessment of implementation of Good Agricultural Practices among different types of independent oil palm smallholders in Riau, Indonesia. Agric. Syst. 170, 63–76.

Jong, H.J., 2018. Small Farmers Not Ready As Indonesia Looks to Impose Its Palm Oil Sustainability Standard on All. Mongabay. April 13. Retrieved on 08/05/2018 from. https://news.mongabay.com/2018/04/small-farmers-not-ready-as-indonesia-looks-to-impose-its-palm-oil-sustainability-standard-on-all/.

Jopke, P., Schoneveld, G.C., 2018. Corporate Commitments to Zero Deforestation: an Evaluation of Externality Problems and Implementation Gaps. Occasional Paper 181. CIFOR, Bogor, Indonesia.

Kamau, J.W., Stellmacher, T., Biber-Freudenberger, L., Borgemeister, C., 2018. Organic and conventional agriculture in Kenya: a typology of smallholder farms in Kajiado and Murang'a counties. J. Rural Stud. 57, 171–185.

Kaufman, L., Rousseeuw, P.J., 2005. Finding Groups in Data: an Introduction to Cluster Analysis Voleme 344 John Wiley & Sons.
Khor, Y.L., Saravanamuttu, J., Augustin, D., 2015. Haze control through the sustenance of Indonesian oil palm smallholders. Think ASEAN 5, 7–10.
Kuivanen, K.S., Alvarez, S., Michalscheck, M., Adjei-Nsiah, S., Descheemaeker, K., Mellon-Bedi, S., Groot, J.C.J., 2016. Characterising the diversity of smallholder farming systems and their constraints and opportunities for innovation: A case study from the Northern Region, Ghana. Njas - Wageningen J. Life Sci. 78, 153–166.
Lee, J., Gereffi, G., Beauvais, J., 2012. Global value chains and agrifood standards: challenges and possibilities for smallholders in developing countries. Proc. Natl. Acad. Sci. 109 (31), 12326–12331.
Lee, J.S.H., Abood, S., Ghazoul, J., Barus, B., Obidzinski, K., Koh, L.P., 2014. Environmental impacts of large-scale oil palm enterprises exceed that of smallholdings in Indonesia. Conserv. Lett. 7 (1), 25–33.
Li, T.M., 2015. Social Impacts of Oil Palm in Indonesia: a Gendered Perspective From West Kalimantan. Occasional Paper 124. CIFOR, Bogor, Indonesia.
Luttrell, C., Komarudin, H., Zrust, M., Pacheco, P., Limberg, G., Nurfatriani, F., Wibowo, L.R., Hakim, I., Pirard, R., 2018. Implementing Sustainability Commitments for Palm Oil in Indonesia: Governance Arrangements of Sustainability Initiatives Involving Public and Private Actors. Working Paper 241. CIFOR, Bogor, Indonesia.
Marlier, M.E., DeFries, R.S., Kim, P.S., Koplitz, S.N., Jacob, D.J., Mickley, L.J., Myers, S.S., 2015. Fire emissions and regional air quality impacts from fires in oil palm, timber, and logging concessions in Indonesia. Environ. Res. Lett. 10 (8), 085005.
McCarthy, J.F., 2012. Certifying in Contested Spaces: private regulation in Indonesian forestry and palm oil. Third World Q. 33 (10), 1871–1888.
McCarthy, J.F., Zen, Z., 2016. Agribusiness, agrarian change, and the fate of oil palm smallholders in Jambi. The Oil Palm Complex: Smallholders, Agribusiness and the State in Indonesia and Malaysia. pp. 109–154.
McCarthy, J.F., Gillespie, P., Zen, Z., 2012. Swimming upstream: local Indonesian production networks in “globalized” palm oil production. World Dev. 40 (3), 555–569.
Mewes, E., Dallinger, J., 2012. Thailand case study. Smallholders in Global Energy Value Chains and Certification: Evidence From Three Case Studies. FAO., Rome, pp. 14–46.
Michalscheck, M., Groot, J.C.J., Kotu, B., Hoeschle-Zeledon, I., Kuivanen, K., Descheemaeker, K., Tittonell, P., 2018. Model results versus farmer realities. Operationalizing diversity within and among smallholder farm systems for a nuanced impact assessment of technology packages. Agric. Syst. 162, 164–178.
Mooi, E., Sarstedt, M., 2010. Cluster Analysis. Springer, Berlin, Germany.
Mosnier, A., Boere, E., Reumann, A., Yowargana, P., Pirker, J., Havlík, P., Pacheco, P., 2017. Palm Oil and Likely Futures: Assessing the Potential Impacts of Zero Deforestation Commitments and a Moratorium on Large-scale Oil Palm Plantations in Indonesia. InfoBrief 177. CIFOR, Bogor, Indonesia.
Nardo, M., Saisana, M., Saltelli, A., Tarantola, S., Hoffman, A., Giovannini, E., 2005. Handbook on Constructing Composite Indicators. OECD Statistics Working Papers, No. 2005/03. OECD Publishing, Paris.
Nesadurai, H.E., 2018. New constellations of social power: states and transnational private governance of palm oil sustainability in Southeast Asia. J. Contemp. Asia 48 (2), 204–229.
Newport, S., 2015. Indonesia Kicks Off Scheme for Palm Oil Farmers to Meet New Sustainability Standards. February 24. Retrieved January 15, 2019 through. UNDP. http://www.undp.org/content/undp/en/home/news-centre/news/2015/02/24/indonesia-kicks-off-scheme-for-palm-oil-farmers-to-meet-new-sustainability-standards.html.
Obidzinski, K., Andriani, R., Komarudin, H., Andrianto, A., 2012. Environmental and social impacts of oil palm plantations and their implications for biofuel production in Indonesia. Ecol. Soc. 17 (1).
Ordway, E.M., Naylor, R.L., Nkongho, R.N., Lambin, E.F., 2017. Oil palm expansion in Cameroon: insights into sustainability opportunities and challenges in Africa. Glob. Environ. Chang. Part A 47, 190–200.
Pacheco, P., Schoneveld, G.C., Dermawan, A., Komarudin, H., Djama, M., 2018. Governing sustainable palm oil supply: disconnects, complementarities, and antagonisms between state regulations and private standards. Regul. Gov.
Papenfus, M.M., 2002. Investing in Oil Palm: an Analysis of Independent Smallholder Oil Palm Adoption in Sumatra, Indonesia. ICRAF., Bogor, Indonesia.
Pirard, R., Gnych, S., Pacheco, P., Lawry, S., 2015. Zero-deforestation Commitments in Indonesia: Governance Challenges. Working Paper 132. CIFOR., Bogor, Indonesia.
Potter, L., 2008. The oil palm question in borneo. Reflections on the Heart of Borneo Volume 24. Wageningen, Tropenbos International, pp. 69–90.
Potter, L., 2012. New transmigration ‘paradigm’ in Indonesia: examples from Kalimantan. Asia Pac. Viewp. 53 (3), 272–287.
Potter, L., 2016. How can the people’s sovereignty be achieved in the oil palm sector? Is the plantation model shifting in favour of smallholders. Land and development in Indonesia. Searching for the people’s sovereignty 315–342.
Prokopy, L.S., Floress, K., Klotthor-Weinkauf, D., Baumgart-Getz, A., 2008. Determinants of agricultural best management practice adoption: evidence from the literature. J. Soil Water Conserv. 63 (5), 300–311.
Punji, G., Stewart, D.W., 1983. Cluster analysis in marketing research: review and suggestions for application. J. Mark. Res. 20 (2), 134–148.
Purnomo, H., Shantiko, B., Sitorus, S., Gunawan, H., Achdiawan, R., Kartodihardjo, H., Dewayani, A.A., 2017. Fire economy and actor network of forest and land fires in Indonesia. For. Policy Econ. 78, 21–31.
Rietberg, P.I., Slingerland, M., 2016. Barriers to smallholder RSPO certification. A Science-for-policy Paper for the RSPO. Wageningen University, Wageningen, the Netherlands.
Roodman, D., 2011. Estimating fully observed recursive mixed-process models with cmp. Stata J. 11 (2), 159–206.
Sahara, Haryadi, Kusumowardhani, N., 2017. Smallholder Finance in the Oil Palm Sector: Analyzing the Gaps Between Existing Credit Schemes and Smallholder Realities. Occasional Paper 174. CIFOR., Bogor, Indonesia.
Saragih, B., 2017. Oil Palm smallholders in Indonesia: origin, development strategy and contribution to the national economy. Presented at the World Plantation Conference.
Schoneveld, G.C., Ekowati, D., Andrianto, A., van der Haar, S., 2019. Modeling peat-and forestland conversion by oil palm smallholders in Indonesian Borneo. Environ. Res. Lett. 14 (1), 014006.
Schwarze, S., Euler, M., Gatto, M., Hein, J., Hettig, E., Holtkamp, A.M., Izhar, L., Kunz, Y., Lay, J., Merten, J., Moser, S., 2015. Rubber vs. Oil Palm: an Analysis of Factors Influencing Smallholders’ Crop Choice in Jambi, Indonesia. Georg-August-Universität Göttingen, Göttingen, Germany.
Serikat Petani Kelapa Sawit (SPKS), 2017. The Key Characteristics of Independent Smallholders in The Context of Sustainable Palm Oil. SPKS., Jakarta, Indonesia.
Soliman, T., Lim, F.K.S., Lee, J.S.H., Carrasco, L.R., 2016. Closing oil palm yield gaps among Indonesian smallholders through industry schemes, pruning, weeding and improved seeds. R. Soc. Open Sci. 3 (8), 160292.
Sumberg, J., 2005. Constraints to the adoption of agricultural innovations: Is it time for a re-think? Outlook Agric. 34 (1), 7–10.
Tittonell, P., 2014. Livelihood strategies, resilience and transformability in African agroecosystems. Agric. Syst. 126, 3–14.
Tittonell, P., Muriuki, A., Shepherd, K.D., Mugendi, D., Kaizzi, K.C., Okeyo, J., Verchot, L.V., Coe, R., Vanlauwe, B., 2010. The diversity of rural livelihoods and their influence on soil fertility in agricultural systems of East Africa – a typology of smallholder farms. Agric. Syst. 103 (2), 83–97.
Varkkey, H., 2015. The Haze Problem in Southeast Asia: Palm Oil and Patronage. Routledge, New York.
Verkaart, S., Mausch, K., Harris, D., 2018. Who are those people we call farmers? Rural Kenyan aspirations and realities. Dev. Pract. 28 (4), 468–479.
Wijaya, A., Glasbergen, P., 2016. Toward a new scenario in agricultural sustainability certification? The response of the Indonesian national government to private certification. J. Environ. Dev. 25 (2), 219–246.
Woittiez, L.S., Slingerland, M., Rafik, R., Giller, K.E., 2018. Nutritional imbalance in smallholder oil palm plantations in Indonesia. Nutr. Cycl. Agroecosystems 111 (1), 73–86.
Woittiez, L.S., van Wijk, M.T., Slingerland, M., van Noordwijk, M., Giller, K.E., 2017. Yield gaps in oil palm: a quantitative review of contributing factors. Eur. J. Agron. 83, 57–77.