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UNDERSTANDING HETEROGENEITY IN CONTRACT FARMING AMONG INDONESIAN SUGARCANE FARMERS

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Abstract: The transformation of the agricultural value chain on the production side is illustrated by the increased engagement of small-scale farmers facilitated by agribusiness firms through contract farming agreements. It is believed that the varied ramifications of contract farming are influenced not solely by contextual and implementation disparities but also by variations in the attributes of participating farmers. The dataset utilized in this investigation was sourced from the 2014 Indonesian Household Plantation Survey, comprising information from 8816 sugarcane farmers. Principal component analysis and cluster analysis were employed to categorize sugarcane farmers statistically and scrutinize the structure of sugarcane contract farming in Indonesia. Findings unveiled four distinct clusters of sugarcane farmers with discernible and significant dissimilarities in attributes. Contract farming is predominantly characterized by adult farmers with moderately sized self-owned land managed intensively and relatively favorable institutional access. Conversely, non-contract farming consists of adult farmers with small self-owned land working non-intensively and having limited institutional access.

Keywords: cluster analysis, contract farming, principal component analysis, sugarcane

Abstrak: *Transformasi rantai nilai pertanian dari sisi produksi salah satunya ditandai dengan peningkatan pelibatan petani kecil oleh perusahaan agribisnis melalui pertanian kontrak. Dampak pertanian kontrak yang masih beragam diduga tidak hanya akibat perbedaan konteks dan penerapan namun juga akibat perbedaan karakteristik petani mitra. Data yang digunakan pada penelitian ini berasal dari Survei Rumah Tangga Usaha Perkebunan Indonesia Tahun 2014 yang terdiri dari 8816 petani tebu. Principal component analysis dan cluster analysis digunakan untuk melakukan klasifikasi secara statistik serta menganalisis struktur petani pertanian kontrak tebu di Indonesia. Hasil penelitian menunjukkan bahwa ada empat kelompok petani tebu yang unik dengan karakteristik yang mudah dikenali dan berbeda signifikan. Pertanian kontrak didominasi oleh petani dewasa dengan lahan milik sendiri berukuran sedang yang dikelola secara intensif dan memiliki akses kelembagaan yang relatif baik. Adapun pertanian non kontrak mayoritas merupakan petani dewasa dengan lahan milik sendiri berukuran kecil, dikelola tidak intensif, dan memiliki akses kelembagaan relatif buruk.*

Kata kunci: *analisis klaster, analisis komponen utama, pertanian kontrak, tebu*

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INTRODUCTION

The increasing involvement of smallholders by agribusiness companies is part of transforming the agricultural value chain from the production side (Timmer, 1988; Reardon et al. 2009). Research on food security globally has concluded that food production by agribusiness companies in developed countries alone will not meet the needs of the earth's growing population (Tilman et al. 2011; Bruinsma, 2009; Ittersum, 2011). There is a need to involve small-scale farmers in developing countries who have the potential to increase productivity, given their generally low productivity (Fischer et al. 2009; Ittersum, 2011). One form of farmer engagement in agricultural value chains that is currently being widely re-adopted is contract farming (Xie et al. 2023; Temesgen et al. 2024).

Contract farming is a win-win solution for all parties involved in the agricultural value chain. Through partnerships, companies can get a guaranteed supply of raw materials with good quantity, quality, and certainty of delivery. Simultaneously, for farmers, partnerships are seen as capable of improving their welfare because they can open up access to financing, markets, and technical counseling (Eaton and Shepherd, 2001; Ton et al. 2015). However, in practice, partnerships are also not immune from criticism. Contract farming is seen by some researchers as a new form of dispossession (Martiniello et al. 2022; Twongyirwe et al. 2022) and has led some farmers to drop out of or discontinue their contracts (Hambloch 2022; Ikeda and Natawidjaja 2022).

Sugarcane is one of the agricultural commodities that extensively adopts contract farming in organizing its supply chain. There are three reasons why research related to the organization of the sugarcane supply chain is crucial. First, for Indonesia, sugarcane is one of the nine staple foods that play a vital role in meeting the food needs of the public and the food and beverage industry. Second, in efforts to meet sugarcane demand, the government and private sector face the reality that a significant portion of Indonesia's sugarcane production comes from smallholder plantations (perkebunan rakyat, hereafter denoted as PR). In 2021, 58.7 percent of Indonesia's sugarcane was produced by smallholder plantation farmers (BPS, 2022), leaving little choice for sugar mills (pabrik gula, hereafter denoted as PG) in Indonesia other than partnering with farmers to fulfill the majority of their raw material needs. Third, the nature of sugarcane, such as its perishable after harvest, its low value-to-volume ratio, and large-scale processing (Minot and Sawyer, 2016; Dania et al. 2019) do not allow farmers to store their harvest or PGs to buy sugarcane without proper planning.

These descriptions emphasize the importance of managing partnerships between stakeholders in the sugarcane agribusiness. Although alliances between farmers and agribusiness companies can have various impacts, the context of the Indonesian sugarcane agribusiness suggests the need for improving partnerships rather than eliminating them. The diverse effects of partnerships can be understood as a result of different contextual applications and due to the heterogeneity of farmers as partners (Dubb et al. 2017). These farmers have different livelihoods and social classes, leading to varying aspirations when participating in contract farming. Therefore, the analysis of farmers typology is necessary to identify the most suitable profiles for inclusion in the agricultural value chain (Sjauw-Koen-Fa and Blok, 2016) and to determine the specific needs of each cluster, ensuring success in agricultural development programs and policies (Christen and Anderson, 2013).

Previously, several studies have been conducted on the characteristics of sugarcane farmers in Indonesia. The characteristics of farmers have been examined in terms of contract farming (Rokhani et al. 2020). Its production efficiency (Rosidah et al. 2023) and impacts of certified seed adoption (Suwandari et al. 2020), have implications for agricultural extension both in the Indonesia context (Rokhani A et al. 2021) and in the specific context of East Java (Kosim et al. 2021), and participation in farmers groups, associations, and cooperatives (Rokhani et al. 2021). However, all those studies were conducted at the individual farmer level by comparing the treated and control farmers. Recent studies showed that Indonesian farmers are heterogeneous at the group level (Umberger et al. 2015; Suprehatin 2016; Akzar et al. 2023). Additionally, though the studies have concluded the impacts of program intervention or the factors influencing sugarcane farmers' decisions to participate in institutional arrangements such as contract farming, they still need to provide operational policy recommendations when faced with the diversity of sugarcane farmers.

To address this knowledge gap, the research employs statistical clustering of sugarcane farmers in Indonesia using Cluster Analysis (CA), preceded by Principal Component Analysis (PCA), and linked to the farmers' structure in contract farming. This approach aims to unveil a framework for classifying farmers that can serve as the foundation for effective agricultural development and targeted partnership policies within the Indonesian sugar value chain.

METHODS

The data used in this study are the results of the Indonesian Plantation Farm Household Survey 2014 (*Survei Rumah Tangga Usaha Perkebunan,* denoted as ST2013 SKB hereafter), which is one of the follow-up surveys from the 2013 Agricultural Census (ST2013) in all regions of Indonesia, except DKI Jakarta. The ST2013 SKB coverage includes four national commodities and ten leading provincial commodities, which, in this survey, cover eight provinces. There are two stages of sample determination: the sample frame for selecting census blocks (provinces) and household samples. Census blocks are eligible if there are ten or more plantation crop households. The household sample will be eligible if it meets the minimum business limit, which in sugarcane commodities is 650 m^2. After removing 15 outlier household samples, the details of the number of samples used in this study can be seen in Table 1.

The purpose of conducting the ST2013 SKB is to obtain data about 1) plantation household profiles, 2) plantation commodity cost structure, and 3) the socio-economic conditions of plantation households. The broad survey aspects, not limited to agricultural production alone, can serve as a solid foundation for determining the typology of Indonesian sugarcane farmers (Kuswardhani et al. 2014; Staal et al. 1997). In this research, 25 variables are utilized and clustered into the household, farming system, agricultural production characteristics, and institutional access (Table 2).

This categorization resembles that of Musafiri et al. (2020), which employs the same first three categories as in this research and adds another category that becomes its main focus: nitrogen fertilizer and its impact on greenhouse gas emissions. In this study, contract farming, as a medium of partnership and institutional arrangement, inspires the inclusion of institutional access variables.

Research aimed at developing policy interventions to assist farmers requires a good understanding of their typology or cluster. This typology is not limited to production aspects but also includes aspects of household resources and access to supporting institutions. In this study, the analysis of farmer typology was conducted in two stages of multivariate analysis that combined Principal Component Analysis (PCA) with Cluster Analysis (CA). PCA was conducted first to reduce the number of variables used without discarding important information (data variation) by converting a group of correlated variables into a group of uncorrelated variables called principal components according to the principle of parsimony (Miller and Whicker, 1999). The use of PCA will reduce this constraint by retaining the most important variations of all variables by forming new variables and using them as CA inputs to cluster farmer households (Kuswardhani et al. 2014; Makate et al. 2018; Chipfupa and Tagwi, 2021; Staal et al. 1997). The key strengths of this approach include its reproducibility, ease of comparison across space and time, and manageability (Kostrowicki, 1977).

Table 1. Number of samples of the Indonesian Plantation Farm Household Survey 2014 (ST2013 SKB)

Province	Number of samples	Percentage (%)
East Java	5272	59.80
Central Java	3140	35.62
South Sulawesi	104	1.18
Lampung	88	1.00
Gorontalo	86	0.98
West Java	75	0.85
The Special Region of Yogyakarta	48	0.54
North Sumatera	3	0.03
Total	8816	100

Table 2. Summary statistics for the sample of sugarcane farming households (n= 8816)

Variables	Description	Mean	Standard deviation	Minimum	Maximum
Household Characteristics					
Household size	Number of people in the household	3.90	1.46	1	15
Gender HH head	Gender of the household head (1 = male)	0.90	0.30	0	1
Age	Age of the household head (years)	51.59	11.82	17	98
Education	Education of the household head (1 = if finished 6th grade or above)	0.72	0.45	0	1
Farming System Characteristics					
Farmed land	Farmed land (ha)	0.90	3.16	0.01	100.00
Owned-farmed landa	Farmed land that is owned (1 = own)	0.81	0.39	0	1
Rented-farmed landa	Farmed land that is rented (1 = rent)	0.12	0.33	0	1
Irrigated land	Land that is irrigated (1 = irrigation)	0.34	0.47	0	1
Farming systems	Type of farming systems (1 = monoculture)	0.99	0.10	0	1
Farming techniques	Type of farming technique (1 = regular planting)	0.94	0.23	0	1
Certified seed	Seed that is certified (1 = yes)	0.16	0.37	0	1
Agricultural Production Characteristics					
Labor	Number of labor per ha (person)	37.39	70.26	0.1	2720
Paid men labor	Number of paid men labor per ha (person)	21.62	42.77	0	1570
Paid women labor	Number of paid women labor per ha (person)	7.29	23.37	0	1080
Production Cost	Total production cost per ha (thousand Rp)	27805.24	23331.57	876.23	490746.70
Revenue	Total revenue per ha (thousand Rp)	35472.64	32569.28	648	603840
Institutional Access					
Mechanization	Use of mechanization (tractor) (1 = yes)	0.16	0.37	0	1
Credit	Use of financialization with interest (1 = yes)	0.23	0.42	0	1
Aid/Granta	Received aid/grant (1 = yes)	0.45	0.50	0	1
Extension	Received extension visits (1 = yes)	0.16	0.36	0	1
Cooperative	Membership in cooperative (1 = yes)	0.15	0.36	0	1
Farmers group	Membership in farmer group (1 = yes)	0.31	0.46	0	1
APTRa	Membership in sugarcane association (1 = yes)	0.05	0.22	0	1
Contract farming	Participated in contract farming (1 = yes)	0.52	0.50	0	1
Transportation	Delivered the sugarcane to the buyer (1 = yes)	0.16	0.37	0	1

Determination of principal components through PCA was done in three stages. First, we selected variables a priori based on themes that are not only considered essential to capture the diversity of farmer typology but also those that are the focus of the research and policy plans (Staal et al. 1997; Staal et al. 2001) as mentioned in Table 2. For each theme, a set of variables considered to reflect the main variability measures in the theme were selected. Second, we conducted the Kaiser-Maier-Olkin test (KMO test) to determine whether the data used can be analyzed using PCA or not (Kaiser 1970; Kaiser and Rice, 1974), which is obtained through the following equation:

$$KMO = \frac{\left(\sum_j \sum_{k \neq j} r_{jk}^2\right)}{\left(\sum_j \sum_{k \neq j} r_{jk}^2 + \sum_j \sum_{k \neq j} p_{jk}^2\right)}$$

Where r is the standard correlation coefficient, p is the standard partial correlation coefficient, and the KMO value ranges from 0 to 1. This study used the KMO value of 0.5 as the minimum eligibility limit.

Once it is known that the data used can be analyzed with PCA, the third step is determining the main components. The principal component in PCA is a linear combination of the initial variables, as shown in the following equation:

$$PC_{(i)} = w_{(i)1}X_1 + w_{(i)2}X_2 + ...+ w_{(i)j}X_j$$

This linear combination attempts to maximize the variation of the initial variable (Xp) over all combinations, and the coefficients found are the eigenvectors (w(i)) of the sample covariance matrix. Once the first principal component is generated, the second principal component is calculated by maximizing the variation not captured in the first principal component without being correlated with it (orthogonal) (Miller and Whicker, 1999). The amount of variation a principal component captures is shown by its eigenvalue. Only principal components that have an eigenvalue greater than 1.0 are retained.

CA in typology determination aims to find the optimal clustering of analogous households, which shows a high degree of natural association within clusters and a high degree of natural disassociation between clusters (Pienaar and Traub 2015). The principal components obtained from PCA then became the input for CA analysis. The first step in performing CA is determining the similarity of the entities under study. In this study, a distance measures approach in the form of Euclidean distance was used. Entities that have the smallest Euclidean distance are said to be the most similar. The next step is cluster determination. In this research, iterative partitioning methods in the form of k-means clustering are used. Analysis of variance (ANOVA) in the form of Bartlett's Test and Bonferroni Post-hoc Test is also conducted to validate the clustering results. The research framework can be seen in Figure 1.

Utilizing ST2013 SKB data, this research categorized the variables into four distinct groups to delve into the intricacies of sugarcane farming. Employing Principal Component Analysis (PCA), the variables were streamlined to ensure conciseness and facilitate interpretation. The resultant principal components were then subjected to Cluster Analysis (CA) to unveil patterns and groupings within the dataset. A deeper understanding of sugarcane farmers and the underlying structure of contract farming was attained through CA. The managerial implications of these findings are substantial, offering actionable insights for optimizing current contract farming operations and informing strategic decisions regarding the expansion of contract farming initiatives within the sugarcane sector.

RESULTS

Determination of principal components

The KMO (Kaiser, 1970) test used to measure sampling adequacy shows that each of all themes has a KMO value of more than 0.5 so that the four themes are feasible and able to be used for PCA (Kuswardhani et al. 2014; Pienaar and Traub, 2015; Staal et al. 1997; Staal et al. 2001) low quality of product and ensuring off season availability of vegetables, pose serious challenges for smallholder farmers to adopt efficient and appropriate technologies. Technology adoption is a complex process depending on several factors mainly including the socio-economic status of individual farmers. The differentiation on adopting technology could be explained by farm typology. The aim of this research was to classify groups of farm households in the West Java Province of Indonesia based on identification of factors influencing new technology adoption. A survey of farmers was carried out during January-December 2010 in Sukabumi (medium and highland. The main component with an eigenvalue of more than 1.0 in each theme is retained to obtain nine main components. A varimax rotation is performed to facilitate interpretation, which maximizes a variable's correlation on one component only (Miller and Whicker 1999; Kuswardhani et al. 2014). The factor loadings that are more than 0.3 are bolded and are considered sufficiently correlated with a variable. The results of PCA for each theme can be seen in Table 3.

The results suggest that PCA with the varimax rotation can yield distinct principal components that are easy to interpret and involve fewer variables. For example, in PC 1 (capability), which comprises age and education, there are high loading factors on age (-0.71) and education (0.71), whereas household size (-0.02) and gender (0.02) variables have minimal influence. Conversely, PC 2 (household resources) is associated with household size (0.72) and gender (0.70), contrasting with age (0.00) and education (0.00). However, it should be noted that in this research, PCA is a method for necessary data reduction and parsimony creation (Miller and Whicker, 1999; Makate et al. 2018; Chipfupa and Tagwi, 2021). This implies that interpreting the derived dimensions may not be as crucial in PCA as in other organizing analyses, such as factor analysis (Miller and Whicker, 1999).

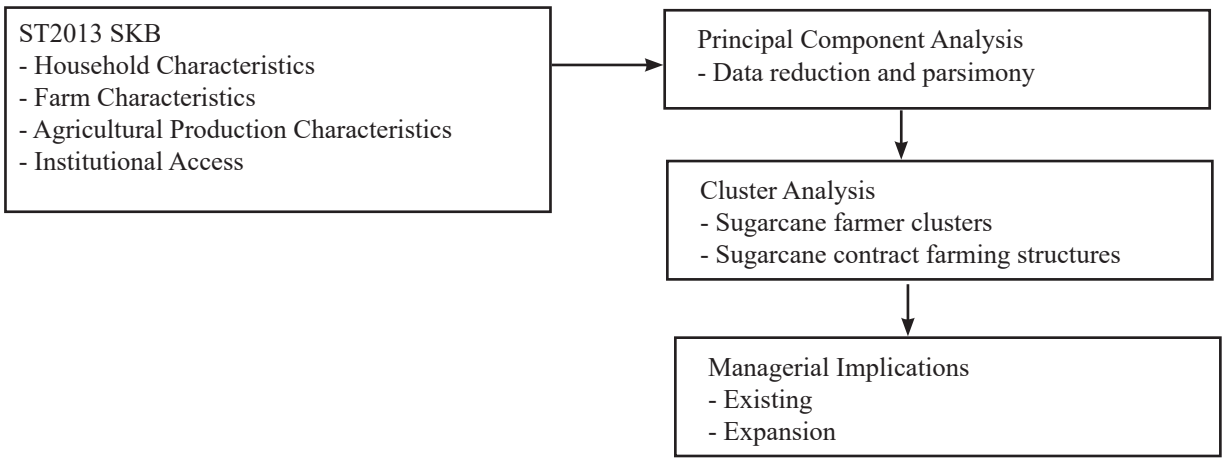

Figure 1. Research framework

Table 3. Loading factors for each variable related to household (HH), farming system, production characteristics, and institutional access

Variables	Principal Component (PC)		
	HH characteristics		
	PC 1 (Capability)	PC 2 (HH Resources)	
HH size	-0.02	0.72	
Gender	0.02	0.70	
Age	-0.71	0.00	
Education	0.71	0.00	
	Farming system characteristics		
	PC 3 (Rented Land)	PC 4 (Cultivation)	PC 5 (Seed)
Farmed land	0.26	0.17	0.45
Owned-farmed land	-0.67	0.05	0.06
Rented-farmed land	0.68	0.00	0.00
Irrigated land	0.13	0.50	-0.19
Farming system	-0.05	0.58	0.00
Farming technique	-0.08	0.61	0.06
Certified seed	-0.05	-0.03	0.87
	Agricultural production characteristics		
	PC 6(Labor Factors)	PC 7(Yield Factors)	
Production cost	0.06	0.69	
Revenue	-0.05	0.73	
Labor	0.61	0.00	
Paid men labor	0.57	0.03	
Paid women labor	0.55	-0.04	
	Institutional access		
	PC 8 (Access)	PC 9 (Grant)	
Mechanization	0.25	0.19	
Credit	0.31	0.37	
Aid/grant	-0.03	0.83	
Extension	0.35	-0.24	
Cooperative	0.40	-0.15	
Farmers group	0.42	-0.13	
APR	0.32	-0.06	
Contract farming	0.41	0.07	
Transportation	0.32	0.16	

Farmer Clusterization

After PCA produced the principal components of each predetermined theme, CA used the output as input for clustering sugarcane farmers. The results of clustering with the k-means clustering method, along with the average value of the variables used in this study, can be seen in Table 4. Clustering in the four clusters was chosen after clustering experiments with three, four, five, and six clusters. The four-cluster clustering results can provide a better solution in producing easily recognizable clusters with significant differences ($p<0.01$) and meaningful classification (Bidogeza et al. 2009). Each cluster was defined by key characteristics related to the four predefined themes: household, farming system, agricultural production characteristics, and institutional access.

Table 4 Mean of variables from selected cluster and statistic test of one-way ANOVA and the Bonferroni post-hoc

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster means	Cluster SD	P-Value ANOVA
	N=3,929 (44.6 %)	N=2,080 (23.6 %)	N=1,696 (19.2 %)	N=1,111 (12.6%)			
Household Characteristics							
Household Size	4.06^{a}	3.34^{abc}	4.11^{b}	4.06^{c}	3.90	1.46	0.00
Gender	0.95^{ab}	0.78^{acd}	0.91^{bc}	0.95^{d}	0.90	0.30	0.00
Age	47.05^{abc}	62.14^{ade}	50.31^{bd}	49.87^{ce}	51.59	11.82	0.00
Education	0.97^{abc}	0.20^{ade}	0.75^{bd}	0.78^{ce}	0.72	0.45	0.00
Farming System Characteristics							
Farmed land	0.54^{ab}	0.44^{cd}	1.14^{ace}	2.67^{bde}	0.90	3.16	0.00
Owned-farmed land	0.92^{ab}	0.95^{acd}	0.91^{ce}	0.00^{bde}	0.81	0.39	0.00
Rented-farmed land	0.00^{ab}	0.00^{cd}	0.03^{ace}	0.94^{bde}	0.12	0.33	0.00
Irrigated land	0.35^{ab}	0.31^{c}	0.28^{ad}	0.47^{bcd}	0.34	0.47	0.00
Farming system	0.99^{a}	0.99^{b}	0.99^{c}	0.97^{abc}	0.99	0.10	0.00
Farming technique	0.95^{a}	0.95^{b}	0.95^{c}	0.88^{abc}	0.94	0.23	0.00
Certified seed	0.14^{a}	0.12^{b}	0.29^{abc}	0.14^{c}	0.16	0.37	0.00
Agricultural Production Characteristics							
Labor	25.58^{a}	29.07^{b}	82.59^{abc}	25.72c	37.39	70.26	0.00
Paid men labor	14.52^{a}	16.65^{b}	48.31^{abc}	15.31c	21.62	42.77	0.00
Paid women labor	3.87^{a}	4.24^{b}	20.03^{abc}	5.64c	7.29	23.37	0.00
Production cost	25197.56^{ab}	24677.07^{cd}	36463.22^{ace}	29666.86^{bde}	27805.24	23331.57	0.00
Revenue	32918.26^{ab}	32619.14^{cd}	43428.98^{ace}	37702.6^{bde}	35472.64	32569.28	0.00
Institutional access							
Mechanization	0.09^{ab}	0.08^{cd}	0.42^{ace}	0.18^{bde}	0.16	0.37	0.00
Credit	0.10^{ab}	0.12^{cd}	0.61^{ace}	0.34^{bde}	0.23	0.42	0.00
Aid/grant	0.47^{ab}	0.38^{acd}	0.47^{ce}	0.53^{bde}	0.45	0.50	0.00
Extension	0.06^{ab}	0.06^{cd}	0.43^{ace}	0.25^{bde}	0.16	0.36	0.00
Cooperative	0.03^{ab}	0.04^{cd}	0.54^{ace}	0.21^{bde}	0.15	0.36	0.00
Farmers group	0.15^{ab}	0.15^{cd}	0.85^{ace}	0.31^{bde}	0.31	0.46	0.00
APTR	0.00^{ab}	0.01^{cd}	0.22^{ace}	0.06^{bde}	0.05	0.22	0.00
Contract farming	0.16^{abc}	0.21^{ade}	0.88^{bdf}	0.42^{cef}	0.34	0.47	0.00
Transportation	0.38^{ab}	0.41^{cd}	0.91^{ace}	0.65^{bde}	0.52	0.50	0.00

^{a,b,c,d,e,f} means within a row with the same superscript letters are statistically different ($\alpha = 0.05$ The Bonferroni posthoc test). SD is the standard deviation

This cluster has the highest number of sugarcane farming households at 44.6 percent. This cluster comprises farmers with an average age of relatively younger and more well-educated than the other clusters. Regarding land, farmers in this cluster own their land, although the average size is only 0.54 hectares. The analysis also shows that the small land area does not make farmers cultivate their land intensively. The number of laborers per hectare in this cluster is the lowest among the other clusters, at 26 people per hectare. This condition is also consistent with the relatively poor institutional access. Extension services reach few farmers in this cluster or are members of cooperatives or associations of plantation farmers.

Cluster 2: older female farmers - small landholding - non-intensive - poor institutional access

Unlike Cluster 1, Cluster 2 is mostly composed of older farmer households with an average age of 62 years and relatively low education compared to the other clusters. This old age and relatively low education are expected to lead to low adaptability. In addition, this cluster is also rather more populated by households with a female head of household and a relatively small family size of three people on average. Regarding land, cultivation intensity, and institutional access, this cluster is similar to Cluster 1. Most farmers in Cluster 2 have their own narrow land, which is not intensively cultivated, and their ability to access institutions could be better.

Cluster 3: adult farmers - own medium land - intensive - good institutional access

Farmer households in this cluster are generally adult farmers with an average of four family members. In contrast to the previous two clusters, this cluster has relatively more significant land holdings, averaging 1.14 hectares. Most of the land used is their land, but relatively few have access to irrigation, also known as moorland. Despite cultivating relatively marginal moorland, this cluster is characterized by intensive production. The number of workers in this cluster averages 83 per hectare. This large amount of labor is consistent with the relatively large total costs and revenues. Despite being intensive, this cluster's revenue-cost ratio (R/C) is the lowest at 1.19. The highest ratio was in the second cluster (1.32), followed by Cluster 1 (1.31) and Cluster 4 (1.27). This shows the potential for cost efficiency, especially in the labor aspect. The institutional access of this cluster is relatively good. This cluster is the most numerous in terms of the use of farm mechanization; financing with interest; recipients of extension visits; membership of cooperatives, farmer clusters, and associations of plantation farmers; involvement in contract farming; and transportation of crops.

Cluster 4: adult farmers - large landholdings on lease - not intensive - sufficient institutional access

Like Cluster 3, this cluster mostly comprises adult farmers with an average of four family members. The striking difference in this cluster is the average cropping area of 2.67 hectares and its status as rented land. This cluster is suspected to comprise farming households with a good entrepreneurial attitude, as they can take the risk of cultivating more significant land through leasing. However, farmers in this cluster cultivate their land sparingly. This cluster is also relatively adequate regarding institutional access and receives the most assistance/grants compared to other clusters.

The study outcomes reveal the effective differentiation of farmers into four distinct groups based on various variables, with age and education emerging as significant indicators of capability in Makate et al.'s (2018) research, highlighting the importance of demographic factors in understanding agricultural dynamics and farmer behavior. These demographic dimensions reflect individual capacity and offer insights into resource accessibility, training opportunities, and adaptive capacities within the farming community (Abdul-Razak and Kruse 2017). Understanding farm characteristics, as emphasized by scholars like Kuivanen et al. (2016), Priegnitz et al. (2019), and Mutyasira (2020), contributes to a holistic comprehension of the multifaceted factors influencing agricultural practices, aiding in identifying patterns, trends, and constraints shaping agricultural production systems. The intensification level, explored by Musafiri et al. (2020), Priegnitz et al. (2019), and Mutyasira (2020), is crucial for sustainable agricultural development, influencing resource efficiency, environmental sustainability, and livelihood outcomes. Mutyasira (2020) and Kuswardhini et al. (2014) demonstrate that institutional factors are central in agricultural research, highlighting the significance of institutional variables in policy formulation and interventions. Understanding institutional dynamics aids in identifying opportunities to bolster support systems and foster equitable agricultural development agendas (Reinders et al. 2019).

While the clustering outcomes diverge from those documented by Kuswardhini et al. (2014), who categorized two, three, and four vegetable farmer clusters based on altitude in West Java – Indonesia, and Makate et al. (2018), who delineated six clusters of smallholder maize farmers in Zimbabwe, the foundational tenets of this study remain unwavering. Firstly, the findings resonate with empirical realities, and secondly, the clustering bears statistical significance. Upholding these principles, this study offers a framework spotlighting the diverse nature of farm households, a pivotal resource for shaping contract farming initiatives within the sugarcane agribusiness sector.

Research-for-development programs that foster sustainable agricultural intensification in targeted communities must integrate identified opportunities and constraints across various farm types into their strategies, interventions, and policies. By tailoring initiatives to each farm typology's specific needs and dynamics, these programs can optimize their effectiveness and promote enduring agricultural development outcomes while recognizing the nuanced characteristics and challenges inherent in different agricultural settings. Acknowledging the heterogeneity among farm households enables development programs to design context-specific interventions that address distinct needs and potentials, resonating with local realities to foster meaningful and sustainable improvements in agricultural productivity and livelihoods. Integrating insights from clustering analyses and acknowledging the diverse array of farm typologies enhances the relevance, efficacy, and impact of research-for-development initiatives to advance agricultural intensification and sustainability.

Structure of contract farming farmers

Having identified the clusters of Indonesian sugarcane farmers, this section analyzes the structure of contract farming farmers, which is the second objective of this study. Sugarcane farmers are compared in structure between those who are members of contract farming and those who are not (Table 5).

The largest proportion of farming households involved in contract farming, belonging to Cluster 3, comprises 49.3 percent. Conversely, the majority of farmers not engaged in contract farming, at 56.9 percent, are affiliated with Cluster 1.

With an understanding of the structure, the impact of contract farming can be evaluated and developed within each cluster. Some previous studies on contract farming impact evaluation have yet to cater to this structure despite acknowledging the validity of the studies and the possibility of survival biases (Bellemare dan Bloem 2018; Ton et al. 2018). Additionally, clusterization based on four variable groups can be used to understand each cluster's weaknesses and opportunities. The next section will explain suggestions for developing contract farming in the sugarcane agribusiness.

Managerial Implications

The increased involvement of smallholders by agribusiness companies in this study is evident through the establishment of contract farming agreements between sugarcane farmers and PG. The analysis results, showing the heterogeneous clustering of sugarcane farmers into four distinct groups, provide a basis for PG to enhance the performance of existing contract farming arrangements. Improving sugarcane farmers' productivity can be achieved by PG through increased counseling, particularly in Clusters 1 and 2, where counseling levels are currently low. This aims to address the low levels of technology adoption observed in Cluster 2. In Cluster 4, PG can contribute to enhanced productivity by providing certified seeds or land cultivators, addressing a current deficiency in this cluster. In contrast, in Cluster 3, production is already conducted intensively; however, excessive labor usage poses a challenge. Therefore, this cluster can enhance labor efficiency by reducing labor or mechanizing harvesting.

In addition to improving the performance of existing contract farms, PG can increase its raw material supply by expanding the scope of contract farming. This coverage expansion can focus on Clusters 1 and 2, who still need to join contract farms. These two clusters are characterized by farmers with small land and less intensive cultivation. Improving land efficiency can go hand in hand with increasing sugarcane farmers' participation in contract farming through the aggregation of land to be managed by PG managers (Chinsinga 2017; Dubb et al. 2017; Lazzarini 2017; Matenga 2017) or through a nucleus-plasma scheme (Pintakami et al. 2013; Azmie et al. 2019).

Table 5. Structure of Indonesian sugarcane contract farming farmers

Cluster	Contract Farming		Non Contract Farming		Total	
	n	Percentage	n	Percentage	n	Percentage
1	638	21.1	3291	56.9	3929	44.6
2	436	14.4	1644	28.4	2080	23.6
3	1493	49.3	203	3.5	1696	19.2
4	462	15.3	649	11.2	1111	12.6
Total	3,029	100 %	5,787	100 %	8,816	100 %

Pearson chi2(3) = 2.9e+03 Pr = 0.000

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The clustering of Indonesian sugarcane farmers was successfully achieved using PCA and CA methods. The four selected variable themes, each containing 25 variables, were suitable for PCA analysis. From this analysis, nine principal components were derived and used as inputs for CA, resulting in the identification of four clusters of farmers with distinct, recognizable characteristics. The largest cluster consists of adaptive adult farmers who own their land, although it is narrow, and manage it with low intensity, facing challenges in institutional access. Structurally, these farmers dominate among sugarcane farmers not engaged in contract farming. Another group comprises adult farmers participating in contract farming, who own medium-sized land plots managed intensively, with better institutional access. Recognizing the heterogeneity among farm households allows development programs to design interventions tailored to address specific localized needs and potentials.

Recommendations

First is contract farming performance improvement in general. Suppose it is assumed that there is no change in the structure of sugarcane contract farming in Indonesia. In that case, improving the performance of contract farming can focus on the Cluster 3 farmers through farm input efficiency. However, if there is a change in structure and there is an increase in farmers who are members of contract farming, then improving performance through intensification can be done with two schemes, namely 1) focus on non-intensive narrow land farmers (Cluster 1), or 2) focus on non-intensive large land farmers (Cluster 4).

Second is contract farming performance improvement for each cluster. In Cluster 1, farmers are considered more adaptive, so they can be encouraged to intensify independently and join contract farming by improving their institutional access. With a relatively small land size, Clusters 1 and 2 can increase their productivity by hiring a manager to manage their lands as a block. This way, the land can be managed more efficiently, and farmers can earn profit sharing and land rent. As mentioned in the results section, improving the performance of Cluster 3 can be done by making farming inputs, especially labor, more efficient. Finally, Cluster 4 farmers have relatively well-irrigated land. This can be optimized using certified seeds, which farmers in this cluster still need to use widely.

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REFERENCES

Abdul-Razak M, Kruse S. 2017. The adaptive capacity of smallholder farmers to climate change in the Northern Region of Ghana. *Climate Risk Management* 17:104–122. https://doi.org/10.1016/j.crm.2017.06.001

Akzar R, Umberger W, Peralta A. 2023. It is understanding heterogeneity in technology adoption among Indonesian smallholder dairy farmers. *Agribusiness* 39(2):347–370. https://doi.org/10.1002/agr.21782

Azmie U, Dewi RK, Sarjana IDGR. 2019. Pola Kemitraan Agribisnis Tebu di Kecamatan Jetis Kabupaten Mojokerto. *Agrisocionomics: Jurnal Sosial Ekonomi Pertanian* 3(2):119–130.https://

doi.org/10.14710/agrisocionomics.v3i2.5062

Bellemare MF, Bloem JR. 2018. Does contract farming improve welfare? A review. *World Development* 112:259–271. https://doi.org/10.1016/j.worlddev.2018.08.018

Bidogeza JC, Berentsen PBM, De Graaff J, Oude Lansink AGJM. 2009. A typology of farm households for the Umutara Province in Rwanda. *Food Security* 1(3):321–335. https://doi.org/10.1007/s12571-009-0029-8

BPS. 2022. *Statistik Tebu Indonesia 2021*. Jakarta: Badan Pusat Statistik Indonesia.

Bruinsma J. 2009. The resource outlook to 2050: how much do land, water, and crop yields need to increase by 2050? Expert meeting on how to feed the world in 2050.

Chinsinga B. 2017. The green belt initiative, politics and sugar production in Malawi. *Journal of Southern African Studies* 43(3):501–515. https://doi.org/10.1080/03057070.2016.1211401

Chipfupa U, Tagwi A. 2021. Youth's participation in agriculture: A fallacy or achievable possibility? Evidence from rural South Africa. *South African Journal of Economic and Management Sciences* 24(1):1–12. https://doi.org/10.4102/sajems.v24i1.4004

Christen RP, Anderson J. 2013. Segmentation of smallholder households: Meeting the range of financial needs in agricultural families. The World Bank.

Dania WAP, Xing K, Amer Y. 2019. An Integrated Collaboration Framework for Sustainable Sugar Supply Chains. 8(3).

Dubb A, Scoones I, Woodhouse P. 2017. The political economy of sugar in Southern Africa - Introduction. *Journal of Southern African Studies* 43(3):447–470. https://doi.org/10.1080/03057070.2016.1214020

Fischer RA, Byerlee DR, Edmeades GO. 2009. Can technology deliver on the yield challenge to 2050?

Hambloch C. 2022. Contract farming and everyday acts of resistance: Oil palm contract farmers in the Philippines. *Journal of Agrarian Change* 22(1):58–76. https://doi.org/10.1111/joac.12462

Helfenstein J, Diogo V, Bürgi M, Verburg P, Swart R, Mohr F, Debonne N, Levers C, Herzog F. 2020. Chapter Five - Conceptualizing pathways to sustainable agricultural intensification. Di dalam: Bohan DA, Vanbergen AJ, editor. *Advances in Ecological Research*. [Internet] Vol. 63. Academic Press. (The Future of Agricultural Landscapes, Part I). hlm. 161–192.

Ikeda S, Natawidjaja RS. 2022. The sustainability of contract farming with specialized suppliers to modern retailers: insights from vegetable marketing in indonesia. *Agriculture* 12(3):380. https://doi.org/10.3390/agriculture12030380

Ittersum MK. 2011. Future harvest: the fine line between myopia and utopia. *Expert Opinion on Investigational Drugs - EXPERT OPIN INVESTIG DRUGS*.

Janssen S, van Ittersum MK. 2007. Assessing farm innovations and responses to policies: A review of bio-economic farm models. *Agricultural Systems* 94(3):622–636. https://doi.org/10.1016/j.agsy.2007.03.001

Kaiser HF. 1970. A second generation is a little jiffy. *Psychometrika* 35(4):401–415. https://doi.org/10.1007/BF02291817

Kaiser HF, Rice J. 1974. Little Jiffy, Mark Iv. *Educational and Psychological Measurement* 34:111–117. https://doi.org/10.1177/001316447403400115

Kansiime MK, van Asten P, Sneyers K. 2018. Farm diversity and resource use efficiency: Targeting agricultural policy interventions in East Africa farming systems. *NJAS - Wageningen Journal of Life Sciences*. 85:32–41. https://doi.org/10.1016/j.njas.2017.12.001

Kosim M, Aji JMM, Hapsari TD. 2021. The impact of agricultural extension on productivity of smallholder sugarcane farmers in East Java. *IOP Conference Series: Earth and Environmental Science* 892(1):012009. https://doi.org/10.1088/1755-1315/892/1/012009

Kostrowicki J. 1977. Agricultural typology concept and method. *Agricultural Systems* 2(1):33–45. https://doi.org/10.1016/0308-521X(77)90015-4

Kuivanen KS, Alvarez S, Michalscheck M, Adjei-Nsiah S, Descheemaeker K, Mellon-Bedi S, Groot JCJ. 2016. Characterizing the diversity of smallholder farming systems and their constraints and opportunities for innovation: A case study from the Northern Region, Ghana. *NJAS - Wageningen Journal of Life Sciences* 78:153–166. https://doi.org/10.1016/j.njas.2016.04.003

Kuswardhani N, Soni P, Shivakoti G. 2014. Cluster Analysis for Classification of Farm Households Based on Socio-Economic Characteristics for Greenhouse Technology Adoption: A Case Study of West-Java Province, Indonesia. *Journal of Food Agriculture and Environment* 12:238–247.

Lazzarini AH. 2017. Gendered labour, migratory labour: reforming sugar regimes in Xinavane, Mozambique. *Journal of Southern African Studies* 43(3):605–623. https://doi.org/10.1080/03057070.2016.1197695

Makate C, Makate M, Mango N. 2018. Farm household typology and adoption of climate-smart agriculture practices in smallholder farming systems of southern Africa. *African Journal of Science, Technology, Innovation and Development* 10(4):421–439. https://doi.org/10.1080/20421338.2018.1471027

Martiniello G, Owor A, Bahati I, Branch A. 2022. The fragmented politics of sugarcane contract farming in Uganda. *Journal of Agrarian Change* 22(1):77–96.doi:10.1111/joac.12455.

Matenga CR. 2017. Outgrowers and livelihoods: the case of magobbo smallholder block farming in mazabuka district in Zambia. *Journal of Southern African Studies* 43(3):551–566. https://doi.org/10.1080/03057070.2016.1211402

Miller G, Whicker ML, editor. 1999. *Handbook of Research Methods in Public Administration*. New York: M. Dekker. (Public administration and public policy).

Minot N, Sawyer B. 2016. Contract farming in developing countries: Theory, practice, and policy implications. Di dalam: *Innovation for inclusive value chain development: Successes and challenges* IFPRI. hlm. 127–155.

Musafiri CM, Macharia JM, Ng'etich OK, Kiboi MN, Okeyo J, Shisanya CA, Okwuosa EA, Mugendi DN, Ngetich FK. 2020. Farming systems' typologies analysis to inform agricultural greenhouse gas emissions potential from smallholder rain-fed farms in Kenya. *Scientific African* 8:1–17. https://doi.org/10.1016/j.sciaf.2020.e00458

Mutyasira V. 2020. Prospects of sustainable intensification of smallholder farming systems: A farmer typology approach. *African Journal of Science, Technology, Innovation and Development* 12(6):727–734. https://doi.org/10.1080/20421338.2019.1711319

Pienaar L, Traub L. 2015. *Understanding the Smallholder Farmer in South Africa: Towards a Sustainable Livelihoods Classification*.

Pintakami LB, Primingtyas DN, Yulianti Y. 2013. Analisis kemitraan antara PG. Candi Baru dengan petani tebu rakyat kerjasama usaha (TRKSU) di Kecamatan Candi Kabupaten Sidoarjo. *J. SEPA*. 10(1):27–39.

Priegnitz U, Lommen WJM, Onakuse S, Struik PC. 2019. A farm typology for adoption of innovations in potato production in Southwestern Uganda. *Frontiers in Sustainable Food Systems* 3:1–15. https://doi.org/10.3389/fsufs.2019.00068

Reardon T, Barrett CB, Berdegué JA, Swinnen JFM. 2009. Agrifood industry transformation and small farmers in developing countries. *World Development* 37(11):1717–1727. https://doi.org/10.1016/j.worlddev.2008.08.023

Reinders S, Dekker M, van Kesteren F, Oudenhuijsen L. 2019. *Inclusive Development in Africa.* Synthesis Report Series Inclusive development

Rokhani R, Asrofi A, Adi AH, Khasan AF, Rondhi M. 2021. The effect of agricultural extension access on the performance of smallholder sugarcane farmers in Indonesia. *AGRARIS: Journal of Agribusiness and Rural Development Research* 7(2):142–159.

Rokhani R, Fauziyah D, Supriono A, Hariyati Y, Raharto S, Hapsari T, Adi A, Khasan A, Rondhi M. 2021. Factors affecting the participation of sugarcane and tobacco farmers in farmer groups, associations, and cooperatives in Indonesia. *Caraka Tani: Journal of Sustainable Agriculture* 36:340.

Rokhani R, Rondhi M, Kuntadi EB, Aji JMM, Suwandari A, Supriono A, Hapsari TD. 2020. Assessing determinants of farmer's participation in sugarcane contract farming in Indonesia. *AGRARIS: Journal of Agribusiness and Rural Development Research* 6(1):12–23. https://doi.org/10.18196/agraris.v7i2.11224

Rosidah A, Irham, Masyhuri, Perwitasari H. 2023. Sugarcane production efficiency: a case study on ptpn x partner farmers. *Jurnal Manajemen & Agribisnis* 20(1):56–67. https://doi.org/10.17358/jma.20.1.56

Scoones I. 2015. *Sustainable livelihoods and rural development*. Practical Action Publishing Rugby.

Sjauw-Koen-Fa AR, Blok V. 2016. Critical success factors for smallholder inclusion in high value-adding supply chains. *Food & Agribusiness Multinational Enterprises* 19(1).

Staal SJ, Chege L, Kenyanjui M, Kimari A, Lukuyu BA, Njubi D, Owango MO, Tanner JC, Thorpe WR, Wambugu M. 1997. Characterization of dairy systems supplying the Nairobi milk market: A pilot survey in Kiambu District for the identification of target groups of producers.

Staal SJ, Owango MO, Muriuki H, Kenyanjui M, Lukuyu BA, Njoroge L, Njubi D, Baltenweck I, Musembi F, Bwana O. 2001. *Dairy systems characterisation of the greater Nairobi milk shed. Smallholder Dairy (R&D) Project report.* Nairobi (Kenya): ILRI.

Suprehatin. 2016. Adoption of high-value horticultural crops in Indonesia: determinants and impacts [Doctoral Thesis]. The University of Adelaide.

Suwandari A, Hariyati Y, Agustina T, Kusmiati A, Hapsari TD, Khasan AF, Rondhi M. 2020. The impacts of certified seed plant adoption on the productivity and efficiency of smallholder sugarcane farmers in Indonesia. *Sugar Tech* 22(4):574–582. https://doi.org/10.1007/s12355-020-00821-2

Temesgen Gelata F, Han J, Kipkogei Limo S. 2024. Impact of dairy contract farming adoption on household resilience to food insecurity evidence from Ethiopia. *World Development Perspectives* 33.

Tilman D, Balzer C, Hill J, Befort BL. 2011. Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences* 108(50):20260–20264.

Timmer CP. 1988. The agricultural transformation. *Handbook of Development Economics* 1:275–331. https://doi.org/10.1016/S1573-4471(88)01011-3

Ton G, Vellema W, Desiere S, Weituschat S, D'Haese M. 2018. Contract farming for improving smallholder incomes: What can we learn from effectiveness studies? *World Development* 104:46–64. https://doi.org/10.1016/j.worlddev.2017.11.015

Twongyirwe R, Fisher E, Karungi C, Ndugu N. 2022. Projected land use change in an oil-rich landscape in Uganda: A participatory modeling approach. *The Extractive Industries and Society* 10:101071. https://doi.org/10.1016/j.exis.2022.101071

Umberger WJ, Reardon T, Stringer R, Mueller Loose S. 2015. Market-channel choices of indonesian potato farmers: a best–worst scaling experiment. *Bulletin of Indonesian Economic Studies* 51(3):461–477. https://doi.org/10.1080/00074918.2015.1108389

Xie Z, Yuan S, Zhu J, Li W. 2023. Contract farming led by a seed enterprise and incentives to produce high quality: Which contract design performs best? *Agribusiness* 39(4):1173–1198. https://doi.org/10.1002/agr.21823