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Strategies For Improving Oil Palm Productivity In North Konawe

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Abstract: The current study was conducted to assess to assess the productivity of oil palm plantations in North Konawe, Indonesia, that are run through partnership with oil palm smallholders. Data were gathered through surveys and interviews. The study found that the productivity of the plantations was still low, ranging from 4 to 8 metric tons of fresh fruit bunch (FFB) ha–1 year–1, while the yield potential for the grown cultivars could reach 15 metric tons ha–1 year–1. Increasing the oil palm productivity could be done through improved soil capacity to provide nutrients for oil palm plants, for instance, through fertilization and/or the use of organic matter. Since the oil palm plantations were mostly developed on lands with slopes of 15-25%, activities during land preparation, cultivation, and FBBs harvest and transportation should be done properly to reduce land degradation due to erosion. Practices to minimize the sloppy land degradation include terracing and growing cover crops, multiple cropping or intercropping the main crop (oil palm) with either annual crops or perennial crops. Another strategy is through the integration of livestock farming into the oil palm plantations.

Keywords: agroecology, productivity, strategy, management

Introduction

Oil palm is one of the most important commodities in Indonesia due to its relatively high economic value. Fresh fruit bunches (FBBs) of the oil palm could be processed to produce *crude palm oil* (CPO) and *palm kernel oil* (PKO) (Obidzinksi, 2013). Oil palm has become one of the Indonesian economy pillars. CPO export has reached 14.19% of the total non-fossil oil and gas export (Kompas.com, 2021). Demand for CPO both in Indonesia and abroad continues to increase. Sixty-eight percent of oil palm products are used for food and feedstuffs, 27% for industrial applications (e.g. chemicals, cosmetics, detergents), and 5% for biogas and bioenergy (e.g. biodiesel and bio-gasoline) (WWF, 2014). Oil palm is an efficient oil-producing crop. It can produce 3.3 metric tons of oil ha^{-1}, while soybean, coconut, sunflower, and rapeseed only produce 0.4, 0.7., 0.7 and 0.7 metric tons of oil, respectively (WWF, 2016). Therefore, oil palm has a better prospect, and efforts to sustainably increase its FFB and oil production must be continually done.

North Konawe is the largest oil palm plantation area in Southeast Sulawesi and was the first to cultivate oil palm. Since being started in 2004, the oil palm plantations in North Konawe have spread to 7 districts with a total area of 15,000 ha and run by 3 (three) companies, i.e. PT. Sultra Prima Lestari (PT. SPL), PT. Damai Jaya Lestari (PT. DJL) and PT. Perkebunan Nusantara 14 (PTPN 14). The plantations are run in partnership with the local oil palm smallholders. Rianse et al. (2020) reported that the partnership model of the oil palm plantations in North Konawe had not made a significant contribution to the local welfare mainly due to the still very low oil palm productivity. The productivity of the plantations only reached 4-8 tons of FFBs ha^{-1} $year^{-1}$, far below the nation productivity of 15 tons of FFB ha^{-1} $year^{-1}$ (Rianse et al., 2020) and the oil palm potential yield of 30 metric tons of FFBs ha^{-1} $year^{-1}$ (Corley, 2003). The global average palm oil yield is 3.5 metric tons ha^{-1} with yield potential estimated at 11–18 metric tons (Barcelos et al., 2015). Such poor productivity was caused by sub-optimal agroecological management. Therefore, Therefore, it is necessary to identify the agroecological and technical characteristics of the oil palm plantations in North Konawe that could be used to increase their productivity.

Methods

The study was conducted from April to November 2020. The oil palm plantations chosen for the study site were those located in the central parts of the oil palm production in North Konawe Regency with a total area of 15,000 ha. The plantations were run by three companies, i.e. PT. Sultra Prima Lestari (PT. SPL), PT. Damai Jaya Lestari (PT. DJL), and PT. Perkebunan Nusantara 14 (PTPN 14). in partnership with the local oil palm smallholders. Data gathered through interviews were analysed to assess the productivity of the plantations. To elucidate the agroecology of the plantations, interviews and laboratory analyses of the soil samples within the study area were conducted. Secondary data of the climate (2015-2019) were also collected from the Meteorology Station of Kendari. Thematic maps of the land use in Southeast Sulawesi were also collected. The primary data were collected through two steps, i.e. field observations and laboratory analysis. The field observations were conducted using a free survey system to assess the study area's physiographic conditions. The laboratory analysis was conducted at the soil science laboratory of the Department of Soil Science of Halu Oleo University to analyse the soil samples for their mineral nutrient contents, i.e. pH, organic-C (%), total N (mg/100 g), total P (mg/100 g). The data produced were then used as a reference for assessing and improving the productivity of the oil palm plantations.

Result and Discussion

Oil Palm Productivity

The oil palm plantations in North Konawe are the largest in Southeast Sulawesi and the first to grow oil palm crops. The crops were first cultivated in 2004 and up-to-date the plantations were located in seven districts with a total area of around 15,000 ha run by three companies (PT. SPL, PT. DJL and PTPN 14).

Table 1. Production and Productivity of FFBs in North Konawe

Year	PTPN 14		PT DJL		PT SPL	
	Production(kg)	Productivity (kg ha^{-1} year^{-1})	Production (kg)	Productivity (kg ha^{-1} year^{-1})	Production (kg)	Productivity (kg ha^{-1} year^{-1})
2010	3,264,891	4,071	1,732,850	288.75	-	-
2011	3,098,699	3,864	5,632,543	938.56	-	-
2012	5,468,878	6,819	15,692,990	2,61.,02	-	-
2013	6,685,267	8,336	33,218,141	5,53.,10	4,552,367	685.63
2014	6,352,084	7,920	53,206,685	8,65.,36	22,042,287	3,318.70
2015	6,091,094	7,595	36,150,924	9,34.61	35,373,530	5,327.46
2016	5,682,280	7,085	46,803,343	7,783.15	39,006,240	5,874.57
2017	4,186,447	5,220	44,422,949	7,386.80	28,104,232	4,247.72
2018	4,152,252	5,177	36,006,164	5,995,33	29,805,540	3,503.95
2019	5,710,145	7,120	37,170,357	6,189,18	26,894,660	4,050.49
2020	7,000,000	8,028	24,949,892	4,154.37	26,976,250	4,062.78

The production and productivity of the FFB of the oil palm plantations are two important indicators of the management quality of the oil palm plantations. If production and productivity are high, the plantations may have used cultivation techniques well, and vice versa. In general, the performance of the assessed plantations was still poor. Their productivity (Table 1) was far lower than that of the same companies PTPN 14 of 21.94 metric tons ha^{-1} of FFB in 2018 and around 24.08 metric tons ha^{-1} in 2019 in Riau Province. Therefore, their productivity needs to be increased through the application of better oil palm cultivation techniques.

Agro-ecological characteristics of the oil palm plantations in North Konawe

The climatic conditions in North Konawe are quite suitable for oil palm cultivations. The area had an annual rainfall of 2,120.68 mm (Table 2). The productivity of oil palm in areas with moderate to heavy rainfall is better than those in areas with very heavy rainfall (> 5,000 mm) or in areas with dry to semi-dry (<1,500 mm) (Paramananthan, 2013; Kallarackal et al., 2004). The ideal annual rainfall for oil palm is 2,000 mm. The rainfall is well distributed throughout the year with no severe drought period or dry months less than one month throughout the year (Adiwiganda et al., 1999). Rainfall is one of the environmental factors that have a significant effect on the growth and development of oil palm plants. During the dry season, the absorption of water is limited or impaired, and this subsequently impairs the absorption of N and P (Albari et al., 2018) and other plant nutrients, as well. The study area had 7 wet months and 3.8 dry months (Table 3). Based on this, the Q value was 54.26%, which according to the Schmidt and Ferguson classification fell into type C. This climatic condition is relatively optimum for oil palm growth.

Table 2. Rainfall in North Konawe (2015-2019)

Year	Monthly rainfall (mm)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Des**
2015	239.90	274.50	90.20	0	0	0	41.90	1.10	0	4.50	0.70	263.90
2016	99.40	330.30	329.70	207.60	108.40	268.90	163.50	44.60	42.70	187.90	32.60	164.00
2017	163.60	228.30	258.40	172.70	702.30	526.80	300.00	69.10	29.20	66.00	233.10	163.80
2018	225.20	191.00	366.80	98.40	460.00	410.60	279.80	3.20	19.70	0	130.10	203.40
2019	267.30	301.20	261.30	239.80	341.30	350.40	101.20	5.70	2.50	0	0	98.30
Mean	199.08	265.06	261.28	143.70	322.40	311.34	177.28	24.74	18.82	86.13	132.17	178.68
Annual rainfall	2,120.68											

Source: Meteorology stations of Kendari

Table 3. The number of Wet, Moderate, and Dry Months in North Konawe (2010-2019)

Year	Rainfall (mm)	Wet months	Moderate	Dry months
2015	916.70	3	1	8
2016	1,979.60	8	1	3
2017	2,913.30	9	2	1
2018	2,388.20	8	1	3
2019	1,969.00	7	1	4

Source: Meteorology station of Kendari

Besides the sufficient rainfall, in the study area, two big rivers (i.e. the Lalindu River and the Lasolo River) exist that could help maintain the hydrology of the plantation area. However, some parts of the area have high elevations, therefore, the rain was the only source of water irrigation that could interfere and reduce the productivity of the oil palm when exposed towater deficit during the dry month spells (Carr, 2011; Backoume et al., 2013). When sufficient water availability exists, oil palm would produce FFBs up to 28 metric tons ha^{-1} $year^{-1}$ in Southeast Asia. For every 100 mm shortage of water, oil palm would lose yields of about 2.88 metric tons ha^{-1} $year^{-1}$, an FBBs reduction of about 10% although other cultivation inputs have been well implemented. The productivity of oil palm plantations in the North Konawe area was still very low, ranging 4–8 metric tons ha^{-1} $year^{-1}$. Higher productivity could be obtained by increasing water availability through irrigation and improving soil water holding capacity (Kallarackal et al., 2004; Murtilaksono et al., 2007; Backoume et al., 2013). The Lalindu River and the Lasolo River can be utilized for irrigation sources. A development of damps in those rivers would be a beneficial investment, not only to supply water for the plantations but also other crops, and to reduce the flow of floods frequently occurring at the peak of the rainy season (May–June; Table 2).

Soil reaction (pH) is another important external factor that affects plant growth and yield. It affects soil nutrient retention capacity and thus the soil capacity to provide nutrients for plants. Oil palm plantations in North Konawe were generally developed on soils with low soil reaction (pH 5.66–6.11; Table 4). This is presumably due to the soil types in the study area belong to Inceptisols, Entisols, and Ultisols (Figure 1). The soil pH in PT. SST was, however, slightly higher than that of in PTPN 14 and PT. DJL.

Table 4. Soil Properties of the Study Area

No.	Location	Soil pH		Organic-C (%)		Total-N (%)		Total-P (mg/100 g)	
		Value	Rating	Value	Rating	Value	Rating	Value	Rating
1.	PT. SPL	6.11	Slightly acidic	0.19	Very low	0.22	Moderate	12.44	Moderate
2.	PT. DJL	5.66	Slightly acidic	0.58	Very low	0.13	Low	12.93	Moderate
3.	PTPN 14	5.85	Slightly acidic	0.60	Very low	0.43	Moderate	12.58	Moderate

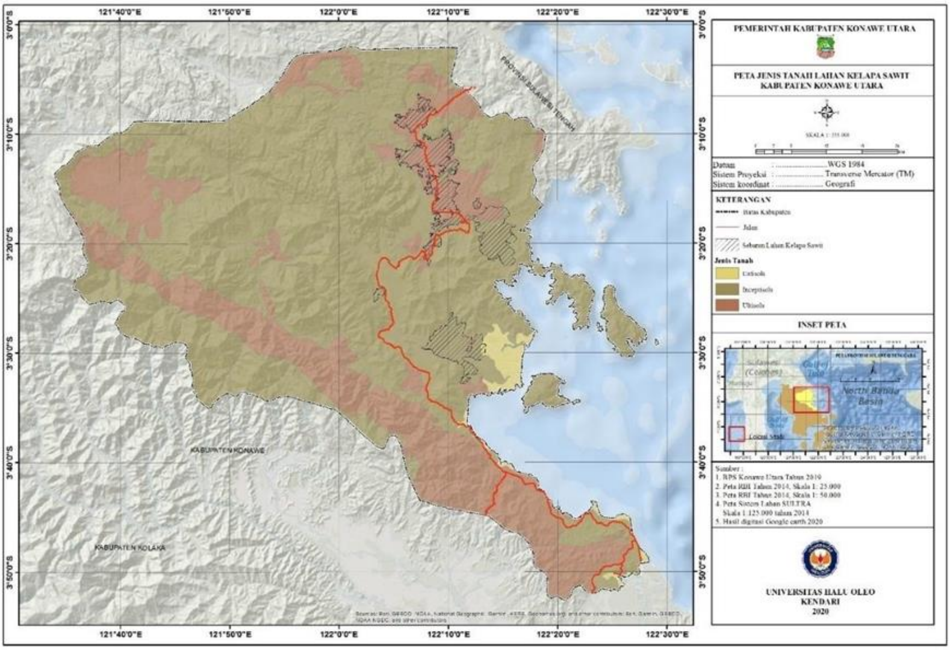

Figure 1. Distribution of soil types in the study area

Inceptisols have low to moderate, and sometimes moderate to high, organic matter content. The organic content at the upper layer is always higher than that at the lower layers, with the C: N ratio classified as low (5–10) to moderate (10–18) (Puslittanak, 2000). The exchangeable base content throughout the Inceptisols soil layer is moderate to high. The adsorption complex was dominated by Mg and Ca ions, with a relatively low K ion content. Medium to high cation exchange capacity (CEC) was found in all layers. Its base saturation is low to high (Damanik et al., 2011). It has low soil fertility and its effective depth varies from shallow to deep. The soil solums at low elevations are generally thick, but thin at areas having steep slopes.

The Entisols in North Konawe were found at lower elevation areas. This soil type has poor consistency, low level of aggregation, prone to erosion, and low available nutrient contents. Entisols contain low levels of clay and organic matter, thus have low water holding capacity and loose structure (Tan et al., 1986), therefore, water was easily lost due to percolation (Jamilah, 2003). Entisols generally have a limited N content. Although the soils have sufficient P and K elements, they are mostly complexed and not readily absorbed by plant roots (Darmawijaya, 1990). Entisols have varied base saturation, pH varies from acidic to alkaline, CEC also varies both for horizon A and C, and has a C: N ratio $< 20\%$ particularly the soil having a coarser texture and lower organic matter and nitrogen content. This is due to the lower moisture content and presumably the higher oxidation rate in soils having coarser texture (Munir, 1996).

The soil organic-C content in the study area was very low (0.19–0.60%). Organic-C plays a key role in improving water holding capacity, nutrient retention, and nutrient supply for plants. Soil organic-C or soil organic matter is a soil element that has multiple roles and works comprehensively in increasing soil fertility and also the capacity of the soil to store water. The soil N content varied from low to moderate (0.13-0.43%), and the soil P content was moderate (12.44–12.93 mg/100 g). Deficiency of N and P were the main soil limiting factors. The deficiency of the two nutrients was due to two main causes, i.e. (1) the low nutrient content of the soil parent material, and (2) nutrient loss through erosion and leaching (especially N) and adsorption and/or complex formation with Fe, Al or Ca and, thus, become unavailable for plants (Prasetyo, 2009). Both N and P are essentialmacronutrients for plants. N is a very important element for plant growth, especially during vegetative growth, such as leaves, stems and roots (Djajadirana, 2000). P can stimulate root development, increase production and yield quality, and accelerate maturity (Nyakpa et al., 1988).

Land topography (slope) is another agroecological aspect that becomes a limiting factor for oil palm plantations. The higher the slopes, the less the land suitability for plant cultivation is due to more prone to erosion and nutrient and organic matter loss. The steeper and the longer the slope is, the higher the run-off velocity and the greater the water volume become, resulting in more soil sediments being eroded (Martono, 2004). Besides, a land with a slope greater than 15% is prone to landslides during the rainy season (Kartasapoetra, 1990). The land in the study area have slopes ranging from 15–25% (Figure 2), which fell into land suitability class marginally suitable (S3) for oil palm plantation (Djaenudin et al., 2011).

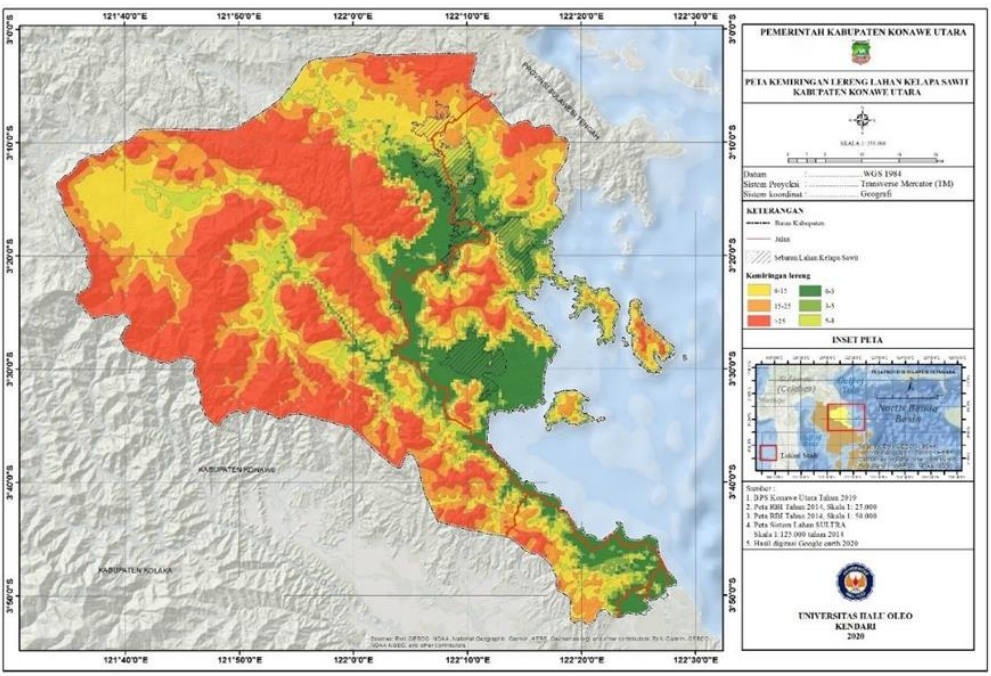

Figure 2. Land slope distribution in the study area

Strategies for Improving Oil Palm Plantation Productivity in North Konawe

Soil analysis showed that the soil fertility in the study area is poor. Besides, the plantation was mostly located in lands having slopes ranging from 15-25%, resulting in reduced soil productivity and FFB production. To mitigate this, soil ameliorants such as organic matter incorporation (e.g. organic fertilizers, green manures, cattle manures, composts) into the soil could be implemented. Palm oil processing wastes could also be used as material for organic fertilizer. The waste has a high organic matter content. The use of such waste would also reduce environmental pollution (Susilawati and Supijatno, 2015). Besides, 20% of the FBBs are empty, but rich nutrient fruit. The incorporation of the empty fruit would improve soil physics, chemistry, and biology and subsequently oil palm productivity (Darmosarkoro *et al.*, 2003). Liquid waste of an oil processing plant referred to as POME (Palm Oil Mill Effluent) contains a high amount of organic matter and N, P, K, Ca, and Mg (Budianta, 2005), which is potential for organic fertilizer. Kushairi et al., (2001) reported that besides via plant genetic improvement, productivity could be achieved through sufficient and balanced fertilizer applications.

Oil palm plants require high nutrients, and therefore, fertilization is one of the key factors in improving oil palm plant productivity. The additional supply of nutrients would meet the sufficient and balanced nutrient requirement energy source (Darmosarkoro *et al.*, 2007) and increase FBB production and CPO quality (Saputra, *et al.,* 2018). Deficiency in one of the required nutrients would cause deficiency symptoms and impaired vegetative growth and reduced yield (Saputra, *et al.,* 2018).

Since most of the oil palm plantations have slopes 15–25%, conservational practices should be implemented to reduce land degradation due to erosion. Multiple cropping or intercropping could be implemented. Annual crops, such as corn, upland rice, peanut, soybean, cassava, are suitable for this cropping system. Those annual crops could be cultivated on the oil palm plantation area throughout the first five years of the plantation. Iswandi (2019) explained that in addition to these benefits, the exploitation of various ground cover crops and food plants between oil palm plants can reduce radiation Perennial crops, such as pineapple, banana, cacao, and even *gaharu*, rubber tree, and white teak (*Gmelina arborea*) are also suitable for this system because of no significant competition for solar radiation with the main crop (oil palm). However, Sutarta *et al.,* (2012) reported that the cropping system is best implemented during the first two years of the oil palm plantation since the main crop canopy is still small and the main crop maintenance is still less intensive. The use of this system would make the soil surface fully covered by vegetation, and would reduce erosion during the rainy season. The inclusion of cocoa, for instance, into the cropping system would not interfere or compete for solar radiation with the main crop since the former crop has alower upward growth than the latter and adaptive to being understory (less sun light). Gaharu could be planted with proper spacing between the main crop, while white teak and rubber tree could be planted surrounding the main crop to help reduce erosion (Sebayang and Winarto, 2014).

Reducing land degradation due to run-off could also be done through the use of cover crops. *Mucuna bracteata* has been frequently used for soil and water conservation. *M. bracteata* is highly effective in producing biomass, even more effective than legume cover crops, because of its fast-vegetative growth, tolerance to being under shade and water deficit stress, and impairment to weed growth (Susetyo & Sudiharto, 2006). Other cover crops that could be introduced are *Centrosema pebescens, Pueraria javanica, Colopogonium mucunoides, Psopocarphus polustrins, Colopogonium caeruleum, Desmodium ovalifolium, Mucuna conchinchinesis, and Pueraria phascoloides*. Growing cover crops and crops could increase soil fertility, and be used as feedstuffs for livestock, and a source of income, as well (Iswandi, 2019). Reducing land degradation is concomitant with Roundtable on Sustainable Palm Oil (RSPO) and Indonesian Sustainable Palm Oil (ISPO) standards.

Reducing erosion hazards on sloppy lands could also be done through terracing. Planting on steep slopes has a high risk of erosion and, thus, topsoil and nutrient loss. Oil palm plants on the slopes were found to have lower flower growth and fruit sets, and subsequently, lower productivity (Harjowigeno, 1993).

Another strategy that could be implemented is oil palm plantation-livestock integration. Livestock farming, such as bees and cattle could be done through creative economic activities and integrated with oil palm plantations (Bain, 2020). Honey bee business can be carried out through entrepreneurship for young farmers, while cows, buffaloes, or goats could be carried out using a semi-intensification system according to the land conditions. Buffaloes could be grown in swampy areas, while cows would be in areas where no waterlogging exists.

The model for the integrated agro-livestock farming system should be chosen in accordance with the local wisdom. The local farmers' capacity for the integrated system is to be improved to ensure that the activities would be economically, ecologically, socially, and institutionally sustainable. Adoption of a better technology would ensure a more efficient and productive organic fertilizer (from oil palm processing wastes, empty FFBs, and oil palm plant biomass litters), and livestock feed. The liquid and solid livestock secretion is a well-known source of organic fertilizer, and renewable energy, as well. It is highly strategic if all these actions are well integrated into the oil palm plantation especially during the first years of their establishment and during replanting.

Conclusion

The productivity of the oil palm plantations in North Konawe was still low, ranging from 4-8 metric tons of FFBs ha^{-1} $year^{-1}$. There are a lot of rooms for productivity improvement. The improvement could be achieved through, for instance, better fertilization, reduction in nutrient loss and erosion, multiple cropping or intercropping, cover crops, and a better irrigation system. Since the oil palm plantations were mostly developed on lands with slopes of 15-25%, activities during land preparation, cultivation, and FBBs harvest and transportation should be done properly to reduce land degradation due to erosion. Practices to minimize the sloppy land degradation include terracing and growing cover crops, multiple cropping or intercropping the main crop (oil palm) with either annual crops (e.g. corn, upland rice, cassava, soybean, peanut) or perennial crops (e.g. cocoa, gaharu, white teak, rubber tree). Another strategy that could be implemented to increase the oil palm productivity is through the integration of livestock farming into the oil palm plantations: oil palm plantation could provide feedstuffs for the livestock and the plantation could be benefited from the manure the livestock would produce. Such integration is in accordance with the local wisdom. However, farmers' capacity needs to be improved so that the increased productivity and sustainability could be achieved.

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