
Information

Agricultural Modernization in Tanzania: A Case Study on the Transition of Increasing Tractor-Hiring Services in the Rice-Producing Area of Kilombero Valley

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Abstract Expanding tractor use was expected to strengthen agriculture and improve welfare in rural African areas. However, there were various discussions on introducing tractors to African agriculture. Although some studies pointed out that introducing tractors caused increases in agricultural productivity and farmer's income, others indicated that the costs of using or maintaining tractors were expensive for local farmers and caused them economic burdens. This study aimed to grasp the dynamics of the tractor-hiring service in rural Tanzanian areas. Data related to hiring tractor services and farmer management were collected through interviews with local farmers and tractor owners in one of Tanzania's rice-producing areas for 17 years. The results showed an increase in the number of tractors and decrease in the study area's tractor-hiring charges. Additionally, the cost for rice cultivation also decreased. Furthermore, among some farmers, increases in the average farm size per household as well as the average income were noted. However, other farmers did not increase their farm sizes and did not receive benefits from sufficiently promoting tractorization.

Key words: Africa, Motorization of agriculture, Rice cultivation, Tractor

Introduction

There have been many discussions regarding the potential for introducing tractors in rural African areas. Senkondo and Ashimogo (1991) suggest that wage employment is more economically efficient than using machinery in Tanzanian agriculture. Piya and Kiminami (2011) asserted that tractors did not contribute to increased land productivity in low-income countries, such as sub-Saharan African countries during the 1980s and 1990s. In Nigerian rural areas, while introducing tractors helped increase the management efficiency of rice cultivation, it did not increase the management efficiency of non-rice crops (Takeshima *et al.*, 2020). According to Adu-Baffour *et al.* (2019), the expanded use of tractors has increased cultivated spaces and household incomes in rural Zambia. Daum and Birner (2020), who scrutinized such diverse discussions about agricultural mechanization in Africa, mentioned that it is necessary to accumulate empirical studies in African rural areas. In other words, more detailed information about the realities of rural villages needs to be collected. Thus,

through this study, we intended to understand the realities around tractorization in an African rural village by conducting long-term onsite fieldwork.

The United Republic of Tanzania is an African country with an agricultural population of more than 80%; agriculture is an important sector in the Tanzanian economy. Despite the increase in the number of tractors since the 2000s, tractors still have a low penetration rate. According to Mrema *et al.* (2020), the use of the largest number of tractors, around 18,500, was recorded in 1985. After 1985, the number of tractors decreased every year because the government, grappling with debt, decreased support for mechanization (Mrema *et al.* 2020). The number of tractors was about 7,200 in 2005. Numbers began to increase gradually after 2010 and reached around 13,000 in 2015. Another study shows the different peak years of the number of tractors. It fluctuated between about 7,000 and 21,000 from the 1970s to the 2000s (FAO and AUC, 2018). Furthermore, the share of cultivated area plowed by tractors remains at around 14% across Tanzania (Mrema *et al.*, 2020). Another report shows that only 2.3% of farmers used a tractor for cultivation in Morogoro, our research region, in 2007 (United Republic of Tanzania, 2012). Although these data showed that introducing tractors for Tanzanian rural areas is challenging, the reports concluded that tractorization will contribute to improve rural agriculture, and

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many farmers expect an increasing number of tractors in Tanzania (FAO and AUC, 2018; Mrema *et al.*, 2020).

This study was conducted in Kilombero Valley, a major rice-producing area located in southern central Tanzania. Although tractorization was not sufficiently promoted in Tanzania, Kilombero Valley was one of the areas where tractorization was promoted well. People in Kilombero Valley have used tractors for rice cultivation since the 1970s. Furthermore, the number of tractors has increased sharply since the 2000s, with many rice farmers now using them. Research on tractorization in Kilombero Valley will contribute to future discussions pertaining to tractorization in other local villages in Tanzania. In this context, our objectives in conducting this study were to understand the realities of tractorization at the rural village level by grasping the transition in tractor usage and rice cultivation management.

Methods

The study area

Kilombero Valley is located in the Morogoro Region (Fig. 1). It is an inland flood plain covering an area of about 11,600 km² with a total length of 250 km and width of up to 65 km (Jatzold and Baum, 1968). Rice and maize cultivation are the primary sources of livelihood in Kilombero Valley; most households cultivate rice as both a staple food and an important cash crop. Maize is cultivated only as a staple food. Many farmers used tractors to plough only paddy fields and not the maize fields, because maize was not regarded as a profitable crop in this area. Paddy fields were located approximately 5 to 15 km away from the village (Kato, 2010). Therefore, the farmers hired trucks or tractors to carry rice bags from the paddy fields to their homesteads in the village after harvesting. Farmers used tractors for their rice cultivation one or two times per year. Tractors were essential

for rice cultivation in Kilombero Valley (Kato, 2011). The reasons behind selecting this area for the study were that Kilombero Valley was regarded as one of the areas where tractorization was promoted well. Further, the region has a long history of tractor use, with its rice-growing farmers' dependence on tractors (Kato, 2007). Onsite fieldwork for this study was conducted over 35 months between 2003 and 2020 in the Itete ward, a rice-producing village in Kilombero Valley. In 2012, this ward had a population of about 10,000 people in 1,700 households, and its primary source of income for villagers was rice production.

Research methods

The data collected included the number of tractors, history of tractor use, cost to hire tractors, land preparation methods per household, rice planted area per household, and rice producer price in the Itete ward. These data were obtained through interviews with local farmers and tractor owners. The research purpose and objectives were explained to all participants before commencing the interviews. They were also informed that the data would not be used for any purposes other than those originally agreed upon and would be published anonymously. All data were obtained with consent from all participants. Participants were chosen randomly and included 55 rice farmers and 11 tractor owners. Among the 55 farmers, 41 and 44 rice farmers in 2004 and 2019, respectively, were re-selected as participants and interviewed in detail. We used questionnaires to conduct interviews with the households and recorded participants' open-ended answers. The tractor-hiring charges in the Itete ward was recorded using nominal prices. Further, the real price of tractor-hiring charges was calculated by dividing the nominal price by the consumer price index. The base year of the real price was 2003 or 2004. The



Fig. 1. Study area location.

monthly exchange rate between U.S. dollars and Tanzanian shillings was obtained to calculate the area's tractor-hiring charges in U.S. dollars. This information was primarily collected from the monthly records of Japan Tanzania Tours Ltd. The nominal prices of tractor-hiring charges in Tanzanian shillings were converted into U.S. dollars. The real prices in U.S. dollars were calculated by dividing the Tanzania consumer price index by the dollar volume. Data of the consumer price index in Tanzania were obtained from International Monetary Fund (IMF). Amounts of harvested rice per household were estimated through average planted area multiplied by the average of rice yield per ha in the Morogoro region. Rice yield data, obtained from the Agricultural Census of Tanzania, was reported to be 2.2 t ha⁻¹ (United Republic of Tanzania, 2012). In this study, we assumed that all informant farmers harvested 2.2 t ha⁻¹ rice and calculated their estimated amounts of harvest per household. The household estimated produce was derived from estimated amounts of harvested rice per household multiplied by the average nominal rice price of each year. Farmers sold their harvested rice in small proportions over time. Furthermore, rice production prices fluctuated throughout the year. However, in this study, household produce was estimated based on farmers' rice sales using the average price.

Results and Discussion

Tractor use for rice cultivation and hiring tractor services in Kilombero Valley

Table 1 shows the paddy field cultivation methods used in the Itete ward. Although rice farmers were

forced to cultivate using hand hoes in 2007 since heavy rain restricted the operation of tractors, most of the farmers had used tractors to cultivate their paddy fields for many years.

Most tractors being used in Kilombero Valley were four-wheel riding tractors with about 4,000 to 4,500 cc displacement and 75 horsepower. Tractors with about 2,500 cc displacement engines and 40 horsepower were also used, but very rarely. Tractors were introduced in Kilombero Valley in the 1960s by the Indian population to cultivate cotton; however, these tractors were not meant for rice cultivation done by local people. After the 1970s, missionaries, a monastery, and a village council introduced tractors, and local farmers cultivated their paddy fields by paying tractor-hiring charges. After the 2000s, along with the increase in the market value of rice, wealthy urban people started bringing tractors to the rice-growing area (Fig. 2). According to the customary land tenure system in this area, anyone can be granted ownership by opening unused lands, even if an exploiter is not a resident of this village. These tractor owners also established paddy fields in villages. The results of an interview conducted in 2005 show that 4 out of 6 private tractor owners reclaimed paddy fields that were more than 10 ha in size from vast grasslands. They allotted the profits from selling the rice grown in these vast paddy fields to maintaining their tractors. Today, some tractor owners who did not cultivate paddy fields or came from urban cities during the cultivation season are also engaging in business in the Itete ward. This indicates that the demand for the tractor business has become higher in the local village and that the exist-

Table 1. Cultivation methods in paddy fields in the Itete ward, Kilombero Valley.

	Tractor (%)	Bullock plowing (%)	Hand hoe (%)
2006	100	0	0
2007	11	15	74
2008	87	13	0
2009	87	13	0
2010	87	13	0
2011	89	11	0
2012	100	0	0
2013	96	4	0
2014	89	11	0
2015	88	12	0
2016	89	9	5
2017	89	11	0
2018	87	13	0
2019	85	13	2

(n=55)

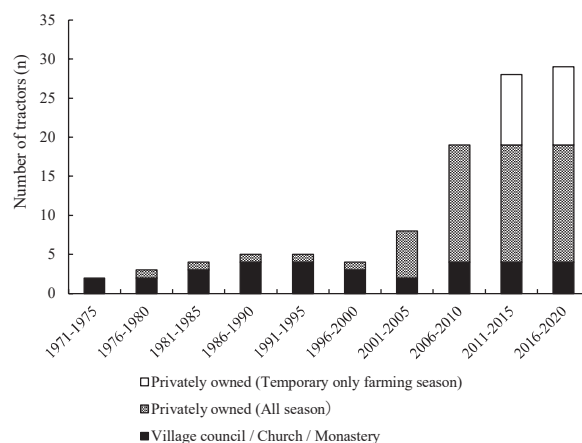


Fig. 2. Number of tractors in the Itete ward, Kilombero Valley. Data were collected in the Itete ward through interviews with rice farmers and tractor owners.

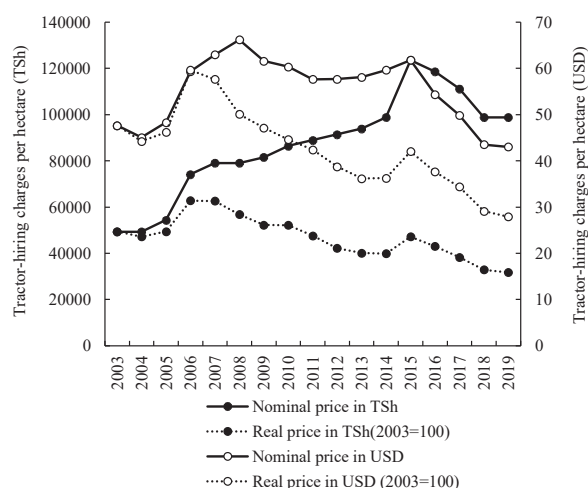


Fig. 3. Cost per hectare to hire a tractor in Tanzanian shillings (TSh) and U. S. dollars (USD). Data on nominal prices were collected in the Itete ward, Kilombero Valley. The data on real prices were based on the 2003 standard.

ing tractor service became more important for local rice cultivation.

Fig. 3 shows the tractor-hiring charges per hectare to plow. The nominal price gradually increased until 2015, witnessing a slight decline after 2015. On the other hand, the real price had been on a decreasing trend since its peak in 2006. We also calculated the cost of hiring a tractor in U.S. dollars to gain a more global understanding. The nominal and real prices of tractor-hiring charges in U.S. dollars also decreased. In particular, the real price in Tanzanian shillings and U.S. dollars decreased sharply after 2006 (Fig. 3). The real price of the tractor-hiring charges in 2019 decreased by 64% and 58% in Tanzanian shillings and U.S. dollars, respectively, compared to that in 2003 (Fig. 3).

Farmers' management after promoting tractorization of increasing tractors in Kilombero Valley

Table 2 shows the summarized size of the paddy field, rice yield, estimated produce, and ratio of tractor-hiring charges to estimated produce per household in

Kilombero Valley in 2004 and 2019. Although the average size of the paddy field per household was 1.3 ha in 2004, it increased to 2.2 ha in 2019. The nominal and real average increases in the price of 1 kg of rice from 2004 to 2019 were 310% and 116%, respectively. Expanding the paddy field increased the estimated amount of harvested rice and estimated produce per household. In the case where farmers sold all harvested rice at once, the nominal estimated produce in 2019 increased approximately five times compared to that in 2004, and the real estimated produce in 2019 increased approximately two times compared to that in 2004. The nominal increase in tractor-hiring charges was 200% and real increase was 67% from 2004 to 2019. Although nominal tractor-hiring charges in 2019 were slightly higher than in 2004, this change may not have been significant—the increase from 2004 to 2019 in nominal tractor-hiring charges was smaller than that in the nominal rice price. Therefore, while better farm management led to an increase in farmers' income, when seen in relation to rice prices, tractor-hiring was cheaper in 2019 (in real terms) than in 2004. As expected, therefore, the ratio of tractor-hiring charges to estimated produce per household decreased from 9.7% in 2004 to 5.8% in 2019.

Under such a situation, did the decreasing tractor-hiring charges benefit all rice farmers equally in Kilombero Valley? Although the standard deviation of the paddy field size of 2004 was 0.8 ha, it increased to 1.9 ha in 2019 (Table 2). This indicated an increased gap related to farm size between households in the Itete ward. Fig. 4 shows the frequency of paddy field size per household in 2004 and 2019. In 2004, farmers who cultivated paddy fields of 0.6–1 ha were in the majority, comprising 18 among the 41 households. Farmers who cultivated paddy fields of 3.1–3.5 ha and 3.6–4.0 ha included those from only one household, in 2004. However, farmers who cultivated 0.1–1 ha paddy fields decreased to 11 households, and the number of farmers who cultivated 1.6–2.0 ha paddy fields increased to 10 households among 44 informants in 2019. Furthermore, the number

Table 2. Paddy field size, rice yield, estimated produce income, and ratio of the tractor-hiring charges to the estimated produce per household in the Itete ward, Kilombero Valley.

	Number of surveyed households	Size of paddy field per household (ha) (Mean $\pm$ S.D.)	Estimated amounts of harvested rice per household (kg)	Average 1kg rice price (TSh)		Estimated produce per household (TSh)		Tractor-hiring charges per ha (TSh)		Tractor-hiring charges per household (TSh)		Ratio of tractor-hiring charges to estimated produce per household (%)
				Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real	
2004	41	1.3 $\pm$ 0.8	2,135	313	313	669,446	669,446	49,421	49,421	65,123	65,123	9.7
2019	44	2.2 $\pm$ 1.9	3,975	972	363	3,864,227	1,442,737	98,842	33,304	223,378	83,400	5.8
Increase rate (%)		170	186	310	116	577	216	200	67	343	128	

Real price: Reference year is 2004

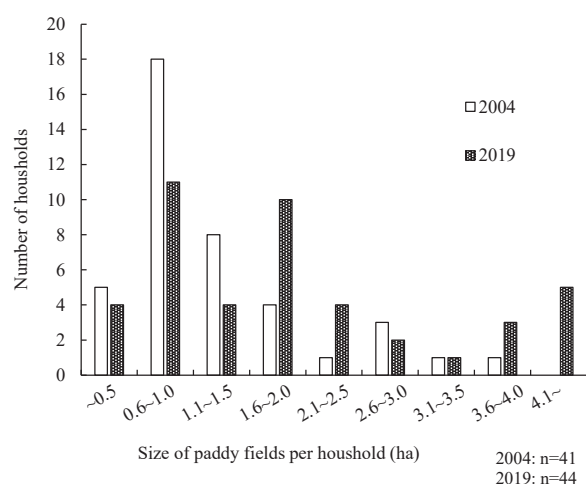


Fig. 4. Dispersion of paddy field size in the Itete ward, Kilombero Valley in 2004 and 2019.

of farmers who cultivated paddy fields of 3.6–4.0 ha and above 4.1 ha also increased in 2019. This result showed that many farmers increased the size of their paddy fields. However, while the number of farmers with large-scale paddy fields increased, farmers who cultivated smaller fields below 0.5 ha were also present in 2019.

Table 3 shows the estimated ratio of the tractor-hiring charges to the farmers' estimated produce per household based on each farm size in 2004 and 2019. Comparing data from 2004 and 2019 revealed that all ratios of the tractor-hiring charges decreased, suggesting that farmers of each farm size benefited from decreasing the tractor-hiring charges. However, the ratio of tractor-hiring charges to the farmers' estimated produce (those who cultivated 0.5 ha of paddy field) was still 10%. This means that large-scale farmers benefitted more than small-scale farmers. For small-scale farmers, the tractor-hiring charges remained expensive.

Eight households cultivated paddy fields above 3.6 ha in 2019. All of them comprised local people who were born in the Itete ward. Six farmers among the eight were interviewed in both 2004 and 2019. They cultivated 0.6–2.0 ha paddy fields in 2004 and they increased the size of their paddy fields between 2011 and 2013. During this term, the tractor-hiring charges began to decrease. According to the customary land tenure system in this area, people were granted ownership by opening unused lands. If a farmer ordered a tractor owner to plough a grassland with the tractor, the farmer acquires ownership of the new field. Therefore, in this manner, they opened new paddy fields using tractors between 2011 and 2013.

The results of this study revealed that the tractor-hiring service became more reasonable, perhaps due to

Table 3. Estimated ratio of tractor-hiring charges to estimated produce per household in 2004 and 2019.

Size of paddy field (ha)	Ratio of tractor-hiring charges to estimated produce per household (%)	
	2004	2019
0.5	15.8	10.2
1.0	10.5	6.8
1.5	9.5	6.1
2.0	9.1	5.8
2.5	8.8	5.6
3.0	8.7	5.5
3.5	8.6	5.5
4.0	8.5	5.4
4.5	8.5	5.4

a decrease in the tractor-hiring charges. However, while some farmers that cultivated larger fields benefitted from the decreased tractor-hiring charges, the farmers that cultivated smaller fields did not sufficiently benefit.

Previous research that dealt with tractorization in developing countries pointed out the following main reasons for the stagnation of tractorization. Akinola (1987) stated that low cost consciousness during the time was one of the reasons behind the failure to promote African tractorization until the 1990s. Although governments and public corporations introduced tractors to African local villages during this term, operations of these public tractors tended to be saddled with debt. According to Sikhwari (2008), who studied tractors used in the rural areas of South Africa, inadequacies pertaining to the operator's capacity, in-depth knowledge of mechanics, and service availability were problems of tractorization in rural African villages. Furthermore, another study concluded that the high maintenance cost and high tractor-hiring charges for local farmers were putting pressure on their agricultural management (Latmany *et al.*, 2009).

However, while some studies indicated that a higher tractor-hiring charges tended to cause economic burdens for farmers in developing countries, this study showed that the tractor-hiring charges tended to decrease in Kilombero Valley. Moreover, farmers' income increased in the study area. Adu-Baffour *et al.* (2019) stated that promoting tractorization caused increases in cultivation area and farmer income in Africa. Loon *et al.* (2020) concluded that introducing tractors to African villages has the potential to promote rural development when schemes that promote tractorization are carried out effectively. Daum and Birner (2020) asserted that the political failure regarding rural tractorization that

was pushed through the top-down approach by governments or public corporations until the 1990s created a negative image of African tractorization. They concluded that the recent tractorization of the private sector was effective for African rural development.

In Kilombero Valley, tractorization was also promoted. The decreasing costs of the tractor-hiring charges reduced farmers' economic burden related to the tractor-hiring service. Against this background, some rice farmers increased their paddy fields, and their incomes also increased. However, the results also showed that the costs of tractor-hiring services were still heavier for small rice farmers.

On the other hand, the environmental issue is an important matter for discussion related to African tractorization. Searchinger *et al.* (2015) pointed out that increasing farmland degraded the savanna wetlands. In Kilombero Valley, paddy fields expanded into grassland savanna inhabited by wild animals (Kato, 2007). Under such a situation, the local government promoted these environmental conservation policies and imposed restrictions on expanding the subsistence activities of local farmers (Kato and Inoue, 2015). It is thus necessary to parallelly and continuously discuss approaches to expand agriculture and address environmental issues.

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