Unlocking Agricultural Transformation through Commercialized Smallholders: Evidence from Rural Kenya

Milu Muyanga[1], John Olwande[2], Joseph Opiyo[2], T. S. Jayne[1,3]

[1] Michigan State University, [2] Tegemeo Institute, [3] Africa Network of Agricultural Policy Research Institutes- ANAPRI

Executive Summary

Smallholder farms dominate sub-Saharan Africa's agricultural landscape, yet a quiet shift is underway. In rural Kenya, commercialized medium-scale farms—as well as a growing group of high-performing commercialized smallholders—are emerging as pivotal actors in driving agricultural transformation. This study explores the extent to which these commercial farms enhance productivity and trigger positive spillovers within their surrounding communities, offering timely insights into how market-oriented farming can foster inclusive rural development.

Drawing on mixed-method evidence from four Kenyan counties, the study finds that medium-scale farmers (3+ hectares) are fundamentally different from traditional smallholders. They typically have higher education levels, greater asset wealth, and often acquire land through non-farm income sources. Most are "stepping-in" farmers—transitioning from non-farm sectors into agriculture—rather than smallholders who scaled up. Land markets have played a critical role in enabling this transition.

These farms are highly commercialized, generating more output per hectare and per labor unit, and selling a larger share of their produce than their smallholder peers. Crucially, commercialized medium-scale farms are significantly more productive and exert positive income spillovers on nearby smallholders, especially when they "stepped-in" rather than "stepped-up." These findings highlight a nuanced pathway to food systems transformation—one that blends economic inclusion, agricultural commercialization, and spatial productivity spillovers.

The study underscores the need for policies that catalyze both medium-scale and commercial smallholder growth, emphasizing:

- Investments in land-saving technologies and productivity-enhancing inputs
- Strengthened land tenure and market systems
- Diversified R&D and extension to support high-value crops beyond staples
- Enabling infrastructure and policy environments that link producers to markets
- Strategic inclusion of entrepreneurial farmers—both new entrants and scaled-up smallholders—in transformation agendas.

In a nutshell, commercialized farming—whether from above or from below—is reshaping Kenya's rural economy, and holds lessons for scaling inclusive food system transformation across Africa.

1. Introduction

Many studies exist showing the impacts of commercialized large-scale farms (i.e., farms generally operating above 50 hectares and often much more) to rural economic development in sub-Saharan Africa and potential channels through which they cause spillovers to small-scale farms around them (Deininger and Byerlee, 2011). Agricultural commercialization is broadly defined as the transition from growing crops for home consumption to growing some or all crops for sale in markets (van Asselt and Useche, 2022). Some studies have found a positive effect of proximity to large-scale farms on yields and/or input use or welfare. For example, in Mozambique, Deininger and Xia (2016) found evidence of positive short-term spillovers from large-scale farm on neighboring small-scale farms in terms of adoption of new practices, access to inputs, and labor demand. In this study, small-scale farms are defined as those that operated 10 hectares and below. Farms above 10 hectares were categorized as large-scale farms. The study also found evidence of job creation in areas with newly established crop farms. However, they did not find improved access to output markets by small-scale farms. Ali et al. (2016) and Deininger and Xia (2018) both found some positive effects of proximity to large-scale farms on small-scale input use and risk-coping in Ethiopia but did not find evidence of employment creation. Lay et al. (2018) found evidence that small-scale farmers near large farms were able to expand their acreage in Zambia.

Conversely, these studies also found a negative effect of proximity to large-scale farms on yields and/or input use or welfare of small-scale farms. Lay et al. (2018) found reduced fertilizer use among smallholders in areas with high concentrations of large farms in Zambia. In Mozambique, Deininger and Xia (2016) found that proximity to larger farms decreased the perceived well-being among local people due to disruptions in rural socio-economic structures. Large farms may also drive-up land prices making it harder for smallholders to obtain land and expand their scale of operation in sub-Saharan Africa (Smalley, 2013).

Most of this literature tended to classify farms into two distinct categories, the commercialized and highly mechanized large-scale and the less profitable and inefficient small-scale farms. However, with increasing population densities and shrinking farmland, large-scale farms are becoming fewer and thus may not play a significant role in the agriculture-led transformation in sub-Sahara Africa. For example, the 2015/16 Kenya Integrated Household Budget Survey (KIHBS) data shows that farms operating 10 hectares and above constituted 0.16 percent of the total farm households in Kenya. This group controlled 4.6 percent of the total operated farmland in the country. Muyanga, et al. (2020) reports that large scale farm households constitute about 0.11 percent of the total farm households in Malawi and control less than one percent of the total farmland in the country. Considering the small-scale farms, it is important to note that this group is not homogenous. First, there are commercialized small-scale farms that generate great value even though they may operate less than 5 hectares. For example, 2-hectare greenhouse vegetable and poultry farms that produce for sale locally and in nearby towns (Neven et al., 2009). Second, there are the commercialized medium-scale farms operating 5 to 50 hectares. Recent evidence shows that these farms are a nontrivial—and rapidly expanding—force in many African countries (Jayne et al., 2016; 2022). This trend is especially apparent in countries with at least moderate potential to expand area under farm production through the conversion of forest and grasslands to farming. Countries with limited potential for cropland expansion, such as Kenya and highland Ethiopia, were found to have only modest increases in the numbers of medium-scale farms (Jayne et al., 2019.

Prior to 2015, the rapid rise of medium-scale farms in sub-Saharan Africa rarely featured anywhere in the debate on Africa's agricultural transformation (Jayne et al., 2016; Muyanga et al., 2019). Even though much remains unclear, and the story is still unfolding, the initial indication is that medium-scale farms are an important driver of rural transformation in much of sub-Saharan Africa. For example, medium-scale farms have contributed up to 40 percent of the agricultural production growth in Ghana, Tanzania, Zambia, Nigeria, and Malawi between 2000 and 2015, even though there is most likely an under-representation of medium-scale farms in the data sets used to generate these findings (Jayne et al., 2019; Jayne et al., 2022). The aggregate value of crop production is growing faster among medium-scale farms and these farms account for a rising share of marketed crop output in those countries.

Only a few studies (Burke et al., 2019; Wineman et al., 2020; Liverpool-Tasie et al., 2020) have focused exclusively on spillover effects from medium-scale farms (operating 5ha to 50ha) yet. According to these studies, these are the farms that are more likely accessible to smallholders than the large and more commercialized farms. Medium-scale farms may be injecting important sources of capital and expertise into current underperforming farming systems. Evidence from several African countries points to potential positive spillover benefits from medium-scale cropping activities to adjacent small-scale communities that improve the access of these small-scale communities to agricultural technologies, credit, extension services, and marketing services and thus improving the food security and welfare of small-scale farmers in those communities (e.g., Wineman et al., 2019; Chamberlin and Jayne, 2019; Burke et al., 2019; Liverpool-Tasie et al., 2020). Chamberlin and Jayne (2020) find that commercialized medium-scale farms tend to raise the productivity of nearby small-scale farms and, because of their commercial orientation, improve market access for all farms in the area by attracting new commodity buyers and input suppliers into a community. Medium-scale farms are also a valuable source of off-farm agricultural wage employment, and thus additional income for the local community.

Specifically, Burke at al. (2019) found that the growth of medium-scale farms and large-scale traders seemed to have positive spillover effects on nearby small-scale marketing options in Zambia. In areas where medium-scale farms numbers were increasing, smallholder farms around them were more likely to sell maize, more likely to sell to the private sector and more likely to sell to larger traders. In Tanzania, Wineman et al. (2020) found evidence that small-scale farms located near medium-scale farms were more likely to use improved seed, to cultivate more of their landholdings, and to receive agricultural extension services, relative to small-scale farms further away from them. In Nigeria, Liverpool-Tasie et al. (2020) found evidence of knowledge and cost spillover effects of medium-scale farms on small-scale farms' behavior and welfare. The study also found that receiving training and purchasing inputs from a medium-scale farm increased smallholders' productivity (yields) and welfare via increased incomes and lower incidence and severity of poverty (ibid, 2020). Conversely, an influx of commercialized medium-scale farms to an area may also promote the commodification of land, raise land values, and potentially make it more difficult for local small-scale farmers to access land for farming (Jayne et al., 2022).

It is important to distinguish between medium-scale and large-scale farms when examining the spillover effects on nearby smallholder farms and communities because the social and economic ties between the families of smallholder and medium-scale farms tend to be more extensive than between smallholder and large-scale operations (Jayne et al., 2022). In Tanzania and Nigeria, for example, many medium-scale farmers were found to be members of their rural communities or at least resided in their rural communities earlier in their lives, are related to other families in their rural communities, and have

continuing social and economic ties with them (Chamberlin, Jayne, and Snapp, 2020; Liverpool-Tasie et al., 2022).

There are two main pathways into commercialized medium-scale farming. There is the 'farm-led' or *stepping-up* pathway which involves small-scale farmers acquiring additional land and expanding into medium-scale farming, and the "*stepping- in"* approach whereby individuals primarily engaged in non-farm employment invest in land and start new commercialized agricultural production. The impacts of the commercialized small-scale farms, and the *stepping-up* and *stepping-in* medium- scale farms on the non-commercialized small-scale farms around them have been only scantily addressed in the research literature. Initial work to date indicates that *stepping up* and *stepping in* medium-scale farms may have differential impacts on productivity of surrounding small-scale farms (Muyanga et al., 2022).

Several studies examine the relationship between farm size and productivity (e.g., Larson et al. 2013; Carletto et al. 2013; Dillon et al. 2016; Barrett et al. 2010; Foster and Rosenzweig, 2017) and several of them have upheld the inverse farm size-productivity relationship (IR) hypothesis that small farms are more productive than larger farms. However, most of these studies use data in which most observations are between zero and five hectares. Now that the share of farms that are medium-scale has increased over time and that these farms are responsible for an increasing share of the value of crop production, it becomes important to examine how their productivity compares with that of small-scale farms. Only two studies have examined farm productivity across a much wider range of farm sizes that we are aware of. These studies find a U-shaped relationship between farm and productivity in Kenya and Nigeria (Muyanga and Jayne, 2019; Omotilewa et al., 2021). In Kenya, the IR hypothesis holds on farms between zero and 3 hectares. The relationship is relatively flat between 3- and 5-hectares farms but turns positive thereafter (Muyanga and Jayne, 2019). In Nigeria, the IR holds between zero and about 22 hectares, turning positive afterwards (Omotilewa et al., 2021). The turning point for farmers who started their operation as smallholders and expanded their scale of operation (stepped up) into medium-scale was at 11 hectares, in contrast to 22 hectares for those who stepped into medium-scale farming from non-farm employment (ibid, 2021).

In summary, the full impact of increased land investments by the commercialized medium-scale farms is both complex and poorly understood. So is the impact of commercialized small-scale farms on their non-commercialized small-scale counterparts. Besides, the studies reach divergent findings on some types of spillover effects implying limited transferability of results from one country to another (Joseph, et al. 2023). If researchers and policy makers knew more about the factors enabling some small-scale farm households to become profitable and commercialize, and others to step up or step in into medium-scale farming, it might be possible to inform policies to assist small-scale farm households that are still stuck in low productivity agriculture and poverty.

This study seeks to shed light on the extent to which commercialized small- and medium- scale farms make contribution to farm productivity growth and spillover effects on local communities using data from Kenya. More importantly, the study is intended to guide Kenyan policy makers and development agencies as they consider strategies for promoting agricultural transformation. The specific objectives of the study are to (i) understand the characteristics of commercialized farms, both small- and medium- scale, and the importance of different pathways into commercialized farming; (ii) assess the broader effects of commercialized farms' agricultural operations on the economic welfare of rural households around them; and (iii) suggest concrete policy actions and investments that can be made by the national and county governments in Kenya to promote rural and agricultural transformation through land markets and the

promotion of emergent commercialized farms. The evidence generated by this study on these issues constitutes the study's contribution to the applied literature on agricultural transformation. We recognize that there might be unique conditions in the four counties of this study that might require caution in extending policy actions to other counties of Kenya.

2. Data source and methods

2.1 Sampling strategy

Given that the focus of this study was to assess the impacts of commercialized farms, both small- and medium- scale, in USAID Feed the Future (FtF) focal counties in Kenya, we selected four counties for our study in two FtF focal regions; two in the southeast and two in the west regions (Table 1). Because commercialized farmers tend to focus on established farms (not transient), we excluded from consideration counties in the north region where pastoralism dominates. We also excluded counties that are so densely populated that farms greater than three hectares in size are very few, such as Kisii County in the western highlands. Consequently, the study is limited to the counties in the western transitional and lowlands agroecological zones in the west region and eastern lowlands agroecological zone in the southeast region. Makueni and Taita Taveta counties in the southeast and Kisumu and Kakamega in the west region were selected for the study. The selection of these counties was done in consultation with USAID Kenya Mission.

Table 1. Study counties from the overall USAID FtF counties in Kenya

FtF Regions	Agroecological zone (AEZ)	FtF counties	To be considered in sampling	Counties selected
West	Western Transitional	Bungoma, Kakamega	Yes	Kakamega
	Western Lowlands	Busia, Homa Bay, Kisumu, Migori, Siaya	Yes	Kisumu
	Western Highlands	Kisii	No	None
Southeast	Eastern Lowlands	Kitui, Makueni, Taita Taveta	Yes	Makueni and Taita Taveta
North	Northern Arid	Garissa, Isiolo, Marsabit, Samburu, Turkana, Wajir	No	None

In consultation with county agricultural officers, two sub-counties in each county, and two wards in each of the selected sub-counties were purposively selected. Based on the agricultural officers' guidance, we purposively selected the sub-counties and wards with a higher concentration of commercially oriented farms, both small- and medium-scale. Then, from each ward and with the guidance of the ward agricultural officer, five (5) villages with relatively higher concentration of commercialized farms were sampled, for a total of 20 villages per county and 80 villages from the four counties. Using a household listing questionnaire, a team of enumerators conducted a complete listing of all farm households in the selected villages to generate a sampling frame.

The listing questionnaire captured information on household headship biodata (gender, age, main occupation, telephone numbers, etc.), agricultural production information (land access, operated land-land allocated to crops, trees, and livestock, types of crops grown in the last main season, whether the household grows crops specifically for sale, and if so the types of crops, proportions of crops that were sold out of the total harvested, whether any crops were grown under contract, etc.), investment in farming technology (use of purchased farm inputs, irrigation practices used, green houses, zero grazing, etc.) and soil and water conservation methods practiced. Households that indicated that they grew crops for sale

and indicated the crops they had sold in the previous main season were categorized as commercialized. Households that produced crops with no intention to sell were categorized as non-commercialized. This categorization of farm households was validated using actual crops sales data from the household level survey.

The last stage involved a stratified random sampling of 25 farm households in each of the selected villages for interviews. This resulted in a sample of 500 households in each county. Given that the objective of the study was to examine the attributes of commercialized farms and the spillovers from commercialized farms on neighboring small-scale farms, the stratification was based on household commercialization (if a household produced farm products for sale or not) and farm sizes (small- versus medium- scale). The idea was to strike a balance between commercialized versus non-commercialized farms while maintaining a reasonable proportion of medium-scale farms in each village.

In this study, small-scale farms were defined as households operating less than three hectares while medium-scale are those that operate three hectares and above. This is because this definition is in line with the Government of Kenya farms categorization and would make it possible for the results from this study to be compared with other studies in Kenya. Even though we wanted to oversample the medium-scale farms in this study, the low numbers of those farms in various villages stood in our way. Given the shrinking farm sizes in Kenya especially with the increasing population densities, some four villages didn't have medium-scale farms at all while others had very few. The average number of medium-scale farms per village ranged from three to four in the sampled villages in the relatively low population density counties of Taita Taveta and Makueni and one to two in the relatively densely populated counties of Kisumu and Kakamega. Consequently, no MSF were picked from four villages that didn't have them. In eight others, all MSF available in the villages were included in the sample owing to the low numbers present. Again, owing to the small number of MSF, we sampled over 50 percent of the MSF available in those villages.

Table 2 presents the distribution of farm households from the listing data by farm size categories in the sampled villages. Approximately 28 percent of the total small-scale farm household population in the sampled villages were included in the sample. Similarly, 39 percent of the total medium-scale farm household population were included in the sample; this proportion would have been about 29 percent if we used population-based sampling.

Table 2. Distribution of farm households' population and sample by farm size categories in the sampled villages

COUNTY	WARD	POPULATION		SAMPLE		%	%	%
		[A] Small-scale farms in sampled villages	[B] Medium-scale farms in sampled villages	[C] Small-scale farms in sampled villages	[D] Medium-scale farms in sampled villages	(C/A)	(D/B)	(D/[C+D])
Taita Taveta	Mboghoni	439	50	105	19	24%	38%	15%
	Challa	377	23	111	14	29%	61%	11%
	Werugha	372	43	107	19	29%	44%	15%
	Wumingu-Kishushe	306	28	108	17	35%	61%	14%
	Sub-total	1494	144	431	69	29%	48%	14%
Makueni	Ilima	301	19	116	8	39%	42%	6%
	Ukia	364	24	117	8	32%	33%	6%
	Nguu-Masumba	156	104	91	33	58%	32%	27%
	Kikumbulyu North	188	50	92	33	49%	66%	26%
	Sub-total	1009	197	416	82	41%	42%	16%
Kakamega	Ingotse-Matiha	577	17	120	5	21%	29%	4%
	Bunyala Central	687	12	123	2	18%	17%	2%
	Likuyani	500	20	118	6	24%	30%	5%
	Nzoia	573	15	120	5	21%	33%	4%
	Sub-total	2337	64	481	18	21%	28%	4%
Kisumu	Kabonyo-Kanyagwal	463	15	120	4	26%	27%	3%
	Ahero	522	15	120	5	23%	33%	4%
	Muhoroni-Koru	298	36	114	10	38%	28%	8%
	Chemelil-Tamu	327	51	112	13	34%	25%	10%
	Sub-total	1610	117	466	32	29%	27%	6%
	OVERALL	6450	522	1794	201	28%	39%	10%

2.2 Methods

We applied both descriptive and econometric methods. Descriptive analysis methods were used to compare commercial farmers with non-commercialized small-scale farmers on selected characteristics, and to identify the pathways into commercialized farming. Econometric analysis was used to investigate the effects of commercialized farms on the incomes of small-scale farm households around them.

Descriptive analysis

As a precursor to the econometric regressions, we conducted some descriptive analysis. The descriptive analysis focused on the characteristics of the farm households to highlight differences among the groups of farm households. The interviewed 1995 farm households were grouped into three categories based on farm sizes (operated hectares), namely, (i) commercialized small-scale, (ii) non-commercialized small-scale, and (iii) medium-scale[1] (Table 3). As already mentioned, medium-scale farm households are defined as households that operate at least three hectares of land, while small-scale farm households are those that operate less than three hectares. As mentioned earlier, households that reported that they grew crops specifically for sale and they indeed sold a proportion of their crop production in the 2021 main season were categorized as commercialized. Households that produced crops with no intention of selling (i.e., stated that they did not produce crops specifically for sale) were categorized as non-commercialized. This commercialized versus non-commercialized categorization was validated by actual crop sales data in the household survey (see household commercialization index, HCI, in Table 3). However, it should be noted that there were a few households that produced crops specifically for sale but didn't obtain marketable surplus probably due to crop failure. We also acknowledge that there were households that produced crops without the intention to selling but made some sales. We do not consider the latter category of households as commercialized in our definition because their decision to sell was likely influenced by factors other than market-oriented production.

The survey also elicited information from medium-scale farm households to determine their pathways into medium-scale farming. Those households that had farming as their primary occupation before they expanded their scale of production into medium-scale farming were categorized as *stepping-up* medium-scale farmers. These are successful farm households who were small-scale farmers initially but invested in more land and graduated to medium-scale farming status. Those that primarily engaged in non-farm income earning activities prior to attaining medium-scale farming status were categorized as *stepping-in* medium-scale farmers. These are households that used income generated outside farming to laterally enter medium-scale farming status. Considering these two sub-categories of medium-scale farms, we ended up with four farm categories, namely, (i) commercialized small-scale, (ii) non-commercialized small-scale, (iii) *stepping-up* commercialized medium-scale, and (iv) *stepping-in* commercialized medium-scale (Table 3). About 47% of the stepping-in households, the highest proportion across the various categories, reported that they migrated into their current village from somewhere else.

Table 3. Medium-scale farms by mode of entry to medium-scale farming status

[1]Virtually all the medium-scale farms were commercialized; only three were non-commercialized and thus were excluded from the analysis because their number was not enough to make a distinct category for meaningful analysis.

	Pathway into medium-scale farming	Sample N	Household commercialization index (HCI)* [mean]	% of households that migrated into the village from somewhere else
Small-scale (not commercialized)	--	632	12.8	30.1
Small-scale (commercialized)	--	1,268	48.5	25.1
Medium-scale (commercialized)	*Stepping-up*	18	70.3	16.7
	Stepping-in	74	66.9	47.3
Total		1,995		27.4

* HCI is defined as the proportion of the household's total crop production that is marketed, or (total value of crops sold by households in season t / total value of crops produced by household in season t)*100.

Econometric estimation strategy

Turning to econometric modeling, to determine the effects commercialized farms on the small-scale households' farm and non-farm incomes of nearby smallholder households, we estimate the following model:

$$inc_i = \alpha + \boldsymbol{X}\beta + \boldsymbol{Z}\gamma + \boldsymbol{C}\delta + \theta S_i + \varepsilon_i \quad [1]$$

where the dependent variable, inc_i, is household income (with alternative models for household (a) total income, (b) farm income only, and (c) non-farm income only) per adult equivalent, $\boldsymbol{X}$ is a vector containing household demographic characteristics (e.g., gender of household head, age of the household head, education attainment, household size), vector $\boldsymbol{Z}$ contains household experience in farming, assets, and land access variables (e.g., hectares owned when household started farming, years that the household head has been farming, household assets value, household head held another job other than as farmer), and $\boldsymbol{C}$ is a vector of community-level variables, including, ward daily wage rate, share of operated land that is rented-in within the ward, distance to all-weather roads, and population density and its squared term. The data for all these variables came from the survey data. S_i is the variable of interest, measuring the concentration of commercialized farming in the sampled villages aggregated at the ward level. The variable is drawn from the listing data. The Greek alphabets, α is the intercept, β, γ, δ and θ are the slope parameters to be estimated, and ε_i is the random error term. To estimate model [1], we use ordinary least square (OLS) estimator.

For each type of income, we estimated 5 alternative specifications, whereby we retain vectors $\boldsymbol{X}$, $\boldsymbol{Z}$ and $\boldsymbol{C}$ in each regression but change S_i, the concentration of commercialized farm measure. The following measures of concentration of commercialized farm are used each per specification: (1) share of operated area in the ward under commercialized medium- and small- scale farms; (2) share of operated area in the ward under commercialized medium-scale farms; (3) share of operated area in the ward under commercialized small-scale farms; (4) share of operated area in the ward under commercialized medium-scale farms and that entered into medium-scale farming via *stepping-up* pathway; and (5) share of operated area in the ward under medium-scale farms and that entered into medium-scale farming via *stepping-in* pathway. The analyses were weighted using sampling weights computed from the listing data. The summary statistics of the variables used in the econometric regressions are presented in Appendix Table A1.

3. Findings

3.1 Descriptive results

Demographic characteristics

In this Section, key descriptive results are presented and discussed, where we use medians for continuous variables and percentages for categorical variables. We examined the data across the counties and found no significant inter-county differences. Also, the sample size for medium-scale farms in the study counties is low for meaningful comparison across counties. Therefore, the main report presents results for all counties combined. Complete results disaggregated by county are presented in the appendix.

The median age of the household heads ranged from 53 to 61 years (Table 4). Commercialized small-scale households seemed to have relatively younger heads (by one year) compared to their non-commercialized small-scale counterparts. Households that laterally *stepped in* to medium-scale farming had much older heads compared to small-scale households, commercialized or not. Although Kenya has a relatively young population, the majority of farm households are headed by older generations – young people's involvement in farming is not widespread. The 2019 population census data indicates that 53 – 60% of farming households in the four counties of our study were headed by persons aged 45 years and above.[2]

Majority of the households in the entire sample were headed by males, with the proportion of male heads higher among commercialized small-scale and commercialized medium-scale and stepping in households (82-83%) compared to the non-commercialized small-scale and commercialized medium-scale and stepping up households (71-72%). The results also show that commercialized medium-scale and stepping in households had more experience in farming compared to the other categories of households. It is important to note that while stepping-in medium-scale farm households had their primary form of employment in off-farm work prior to acquiring the land that they currently operate, it does not mean that they were not at all doing any farming.

Commercialized medium-scale households, especially those who entered via "stepping-in", were headed by persons who were older and possessed relatively higher education level compared to small-scale households, commercialized or not.

Table 4: Demographic characteristics

Demographic Characteristics	A < 3 ha, not commercialized (n=632)	B < 3 ha, commercialized (n=1268)	D = > 3 ha, commercialized	
			Stepping-up (n=18)	Stepping-in (n=74)
Age of household head [median]	54.0	53.0	57.0	61.0
% men heads	71.1	82.2	72.1	82.7
Farming experience (years) [median]	22.0	23.0	21.5	27.0
Head's education (years) [median]	8.0	8.0	8.5	12.0

[2]Source: https://statistics.kilimo.go.ke/en/2_5/#

Demographic Characteristics	A < 3 ha, not commercialized (n=632)	B < 3 ha, commercialized (n=1268)	D = > 3 ha, commercialized	
			Stepping-up (n=18)	Stepping-in (n=74)
Average education of household members (years) [median]	8.4	9.3	11.3	10.5

Primary occupation of the household head

Regarding occupation, the majority of household heads were primarily engaged in farming, although a higher percentage of medium-scale farm households (31 – 34%) than small-scale farm households (24 – 28%) had heads holding another job in addition to farming (Table 5). Generally, only a few of the household heads were employed in the public sector, with the highest proportions among commercialized small-scale households (6%) and commercialized and stepping-in medium-scale households (5%). On average, a household head spent five months at home (where farming activities occurred) during the past twelve months prior to the survey. The main occupation for most of the household heads was farming, with the commercialized medium-scale having the highest percentages; 72% among stepping-up and 70% among stepping-in households. This important finding indicates that the vast majority of heads of commercialized medium-scale and stepping-in households are individuals who once they became commercialized switched over to farming as their main occupation. This may imply that once it is possible for individuals to acquire at least several hectares of land and intentionally produce for the market, farming appears to become profitable enough that many individuals switch from a combination of non-farm employment and low-commercialization farming to commercialized farming as their main occupation. Acquiring several hectares of land, however, is generally difficult and exceedingly expensive for most rural Kenyan households. The proportion of heads whose main occupation was in non-farm business and/or casual wage employment was highest among non-commercialized small-scale households. On the other hand, formal salaried/contract employment was most common among "stepping in" commercialized households.

Table 5: Occupation of household head

Occupation of household head	A < 3 ha, not commercialized (n=632)	B < 3 ha, commercialized (n=1268)	D = > 3 ha, commercialized	
			Stepping-up (n=18)	Stepping-in (n=74)
Head holds another job in addition to farming (%)	23.7		33.6	30.8
Head currently employed by the public sector (%)	1.8	5.6	0.0	5.4
Time spent at home by head (months) [median]	4.8	5.0	5.0	4.8
Main occupation by activity (%)				
None	6.0	3.4	0.0	5.4
Farmer	53.0	64.7	72.1	70.2
Formal salaried/contract employment	9.6	12.3	10.7	16.6
Business and wage employment	31.4	19.5	17.1	7.8

Land ownership and use

When[3] they started farming, small-scale households (both commercialized and non-commercialized) had much smaller landholdings (i.e., owned land) (0.4 ha) compared to their commercialized medium-scale counterparts (1.4 ha) (Table 6). The commercialized households (both small- and medium- scale) currently have larger landholdings than they initially had, while non-commercial small-scale households have not seen a change in the median landholding. These findings underscore the expected strong association between access to and acquisition of new land, operated farm size, and agricultural commercialization.

Commercialized medium-scale households are roughly three times more likely to have purchased land over the past 10 years than small-scale households (both commercialized and non-commercialized). Within the commercialized medium-scale category, stepping-up households were more likely to have purchased land than stepping-in households, suggesting that in addition to renting, purchasing land is a major pathway for stepping-up transition from small-scale production to medium-scale farming. Medium-scale households began operating as such between 5.5 and 12 years ago.

In terms of the size of land purchased among those that did purchase, the commercialized medium-scale and stepping-in households purchased larger pieces of land compared to the other groups of households.

Commercialized small-scale and medium-scale households were operating a larger share of their controlled landholding (77% to 91%) than non-commercialized small-scale households (68%), emphasizing the importance of intensity of land use in farm commercialization. Similarly, the median rented-in land was larger among commercialized small and medium-scale households than among non-commercialized small-scale households, suggesting that the ability to participate in agricultural land markets plays a major role in both the expansion of farm size and commercialization potential.

Most of the land parcels controlled by medium-scale farm households were acquired in 2010 or later (Table 7), after the sustained global rise in real food prices starting in 2007 and continuing to the present (Jayne et al., 2022). The data also indicate that 28% of the total land controlled by the households in the study sample was purchased and 28% of the purchased land was purchased in 2010 or later. The increase in food prices globally shifted the terms of trade toward agriculture, increased the demand for farmland, and has undoubtedly contributed to increased participation in, and development of, land rental and purchase/sales markets.

Table 6: Land ownership and use

Land ownership and use	A < 3 ha, not commercialized (n=632)	B < 3 ha, commercialized (n=1268)	D = > 3 ha, commercialized	
			Stepping-up (n=18)	Stepping-in (n=74)

[3] Households were asked the year they started farming and how much land they had owned when they started farming.

Initial landholding[4] size when started farming (ha)	0.4	0.4	1.4	1.4
Current landholding size (ha)	0.4	0.8	2.5	4.1
Current land controlled (ha)	0.5	1.2	4.7	5.6
Current land operated (ha)	0.3	0.8	4.3	4.4
Rented-in land (ha)	0.3	0.4	3.4	1.7
% of households that purchased land in the past 10 years	12.0	13.4	38.9	32.4
Hectares of land purchased over the past 10 years among those that purchased (median)	0.4	0.5	0.4	1.3
% of controlled land currently operated	67.7	76.6	90.6	84.4
Years since began operating => 3 ha of land (median)			5.5	12.0

Note: All land sizes reported in the table are median. Household landholding refers to land owned by the household; controlled land refers to land that the household has user rights, including owned and rented-in land; operated land refers to land that the household is using for crops and/or livestock production.

Table 7: Percentage of land parcels acquired by decade of acquisition and category of farm households

Decade when land parcel was acquired	A < 3 ha, not commercialized (n=931)	B < 3 ha, commercialized (n=2497)	D = > 3 ha, commercialized	
			Stepping-up (n=75)	Stepping-in (n=256)
	---------- (% of land parcels) ----------			
1969 or earlier	3.2	1.8	0.0	2.2
1970-79	7.0	5.7	2.4	4.6
1980-89	9.9	8.6	10.9	9.3
1990-99	15.1	15.5	7.9	15.3
2000-09	17.0	20.0	10.9	19.3
2010 or later	47.8	48.4	67.9	49.3

Farm input use

Agricultural production on small-scale farms is more labor-intensive than on medium-scale farms. Small-scale households (both commercialized and non-commercialized) used three to four times more labor per hectare cultivated compared to the commercialized medium-scale households (Table 8). Data in Table 8 also show that a higher proportion of medium-scale farm households than small-scale farm households utilized tractor (mechanization) for tillage.

Over 70% of commercialized small-scale and medium-scale households applied inorganic fertilizers compared to only 46% of non-commercialized small-scale households. However, the median fertilizer application rate (among users) for commercialized small-scale households was much lower than for the

non- commercialized small-scale households and commercialized medium-scale households (both stepping-in and stepping-up). Regarding expenditure on agrochemicals, commercialized medium-scale households spent about twice as much per hectare cultivated than commercialized small-scale households and much more than small-scale non-commercialized households.

The proportion of households that rented in land for agricultural production was much higher among commercialized medium-scale households (both stepping-up and stepping-in) compared to their small-scale counterparts, with only about 12% of non-commercialized small-scale households renting in land. This result combined with the fact that almost all of the commercialized medium-scale farm households in the study stepped into that status from non-farm income activities as the main occupation indicate that vibrant land markets are a major pathway into commercialized medium-scale farming. The reported agricultural land rental rate (median) per hectare was highest among the commercialized and stepping-in medium-scale households (KSh 25,000) and lowest among the commercialized and stepping-up households (KSh 17,500). The median daily wage rate was uniform across the four groups of farmers.

Table 8: Farm input use

Input use	A < 3 ha, not commercialized (n=632)	B < 3 ha, commercialized (n=1268)	D = > 3 ha, commercialized	
			Stepping-up (n=18)	Stepping-in (n=74)
Labor days per hectare cultivated [median]	110.0	80.0	26.4	25.2
Inorganic fertilizer kgs applied per ha cultivated [median]	192.3	171.9	254.6	198.7
Households using inorganic fertilizer (%)	46.4	71.1	90.0	70.5
Chemical expenditure (KSh/ha cultivated) [median]	0.0	1,273	2,552	2,167
Households renting in farmland (%)	11.5	26.0	60.6	32.6
Land rental rate per hectare (KSh/ha) [median]	20,000	20,000	17,500	25,000
Daily wage rate for farm labor (KSh) [median]	300.0	300.0	300.0	300.0
Households using tractor for tillage (%)	22.2	37.5	72.2	52.7

Farm production and productivity

We valued crop and livestock output for households that sold the output using the reported sale prices. If a household produced but did not sell a product, we used county-level median price for that product derived from the prices reported by households that sold that product. As would be expected, the median total value of crop output among commercialized small-scale and medium-scale households was much higher than among the non-commercialized small-scale households (Table 9). Further, commercialized medium-scale households had over five times higher total value of crop output compared to the commercialized small-scale households. Considering the types of crops, all the four categories of farmers derived most of the value of crop output from grains & legumes and fruits & vegetables in that order. However, commercialized medium-scale and stepping-in households derived more of their value of crop output from fruits & vegetables compared to the other three categories of households.

Both the value of crop output per hectare cultivated and the value of crop output per labor day (total of hired and family labor) were higher for commercialized small and medium-scale households than non-commercialized small-scale households. A comparison between commercialized small-scale and medium-scale households shows that the commercialized medium-scale households (both stepping-up and stepping-in) had higher productivity (both land and labor productivity) than their small-scale counterparts. Commercialized medium-scale and stepping-up households were the most productive and had three times more crop output per hectare than small-scale non-commercialized households and two times more than commercialized small-scale households.

The total value of livestock production (measured as the value of cow milk, value of other animal products, revenue from sale of live animals and value of animals consumed within the household) was higher for commercialized small-scale and medium-scale households than for non-commercialized small-scale households. Among the commercialized households, the total value of livestock production was higher among medium-scale/stepping-in households compared to medium-scale/stepping-up and small-scale households. In terms of value of production from various livestock enterprises, animals sold or consumed, including cattle, sheep, goats, and chicken, provided the highest value for all the categories of households, with the value highest for commercialized medium-scale and stepping-in households. Between the stepping-up and stepping-in households, the latter seemed to be much more intensively into livestock production most likely because it involves a more long-term steady build-up of animal assets over time compared to stepping-in farmers who were primarily involved in non-farm employment for most of their adult lives and may have only recently acquired land for farming.

As expected, total farm incomes were highest for the commercialized medium-scale farms, then the commercialized small-scale farms, and lowest for the non-commercialized small-scale farms. But the magnitude of these differences is quite stark. Commercialized medium-scale stepping-up and stepping-in households had over 30 times and 18 times, respectively, higher income than small-scale non-commercialized households, and eight times and five times, respectively, higher farm income than commercialized small-scale households. Among the small-scale households only, commercialized had almost four times higher farm income than their non-commercialized counterparts. Farm size and commercialization orientation (which are correlated) are major determinants of rural household differentiation.

In terms of farm productivity, Table 9 reports total value of crop output per hectare cultivated (a measure of partial land productivity), total value of crop output per labor day (a measure of partial labor productivity) and total value of farm output (total for crops and livestock) per hectare operated. For cropland productivity and labor productivity, medium-scale farms came out on top, especially for the stepping-up farms. Their land productivity was almost double that of commercialized small-scale farms and three times greater than non-commercial small-scale farms. Stepping-in medium-scale farms achieved cropland productivity measures that were less than stepping-up medium-scale farms but 20% more than commercialized small-scale farms and double that of non-commercial small-scale farms.

Medium-scale farms achieved substantially higher levels of labor productivity than small-scale farms. This is expected for two reasons: the value of output per hectare is higher on medium-scale farms, and small-scale farms utilize considerably more labor per hectare cultivated compared to medium-scale farms. These results indicate that the transfer of farmland from small-scale to medium-scale farms (at least in these four counties of Kenya), which is facilitated by the development of land rental and purchase/sales

markets can be expected to directly increase farm productivity (both per hectare and especially per unit of labor devoted to farming).

Table 9: Farm production and productivity

Farm production (thousand Ksh) [median]	A < 3 ha, not commercialized (n=632)	B < 3 ha, commercialized (n=1268)	D = > 3 ha, commercialized	
			Stepping-up (n=18)	Stepping-in (n=74)
Total value of crop output	18.6	78.2	905.3	433.9
Total value of crop output per ha cultivated	75.5	119.4	227.8	143.2
Total value crop output per labor day	0.6	1.3	7.5	4.7
Total value of livestock output	3.5	13.5	6.2	69.5
Total value of farm output	29.7	113.0	905.3	549.7
Total value of farm output per hectare operated	96.8	147.8	189.6	142.9

Note: value of crop output includes both crops retained for household consumption and for sale.

We analyzed agricultural commercialization through several measures, including the share of household agricultural gross income in total gross income and the share of marketed crop production. We also computed the shares of various agricultural enterprises in household agricultural gross income, as well as the percent of households engaged in those enterprises to tease out which enterprises are important for which categories of households. Results are provided on Table 10. Overall, commercialized households (both small-scale and medium-scale) derived a greater share of income from agriculture (53 – 88%) compared to their non-commercialized small-scale counterparts (27%). Among the commercialized households only, medium-scale (stepping-up and stepping-in) households had higher agricultural income shares (68%-88%) than the small-scale households (53%).

As with the agricultural income shares, the share of marketed production for crops was higher among commercialized households (49-70%) than non-commercialized small-scale households (13%). Again, commercialized medium-scale households sold a greater share of their crops production (67-70%) than their commercialized small-scale counterparts (49%).

Industrial crops were more important for the commercialized medium-scale (both stepping-up and stepping-in) households category compared to small-scale households in terms of the share of households that engaged in their production and the share of the enterprise in agricultural income. Notably, 45% of commercialized medium-scale and stepping-in households produced industrial crops, which contributed 62% of the agricultural income. For the stepping-up category, industrial crops contributed 79% of the agricultural income for the one third of the households that produced them. It is worth noting that sugarcane was the most common industrial crop in the study areas and found mainly in Kakamega and Kisumu counties.

The share of households producing fruits & vegetables was high (63-84%) across all the categories of households, and particularly among the commercialized group (both small-scale and medium-scale). However, small-scale households (both commercialized and non-commercialized) that produced fruits & vegetables compared to their medium-scale counterparts (both stepping-up and stepping-in) derived

greater shares of agricultural income from the enterprise (13-14% vs 4-7%). This is not surprising in Kenya where most of the horticultural production (except for flowers) occur on smallholder farms.

Grains & legumes were most important to non-commercialized smallholder households in terms of contribution to agricultural income (49%), indicating that the non-commercialized smallholder households are much more into staple foods compared to their commercialized counterparts (both small-scale and medium-scale). However, both commercialized smallholders and commercialized medium-scale and stepping-up categories also derived a substantial share of agricultural income from grains & legumes (38% and 44%, respectively).

Dairy production was more likely among stepping-in commercialized medium-scale households (20%) than the other categories of households and contributed about 17% of the agricultural income of the stepping-in households that engaged in the enterprise. None of the stepping-up medium-scale households in the sample reported producing cow milk. For the 13% commercialized and 8% non-commercialized smallholder households that engaged in dairy, the enterprise contributed 27% and 31% of the agricultural income, respectively.

Regarding livestock (including cattle, sheep, goats, and chicken), commercialized small-scale and medium-scale households compared to non-commercialized small-scale households were more likely to sell and/or consume. However, among those that sold and/or consumed, the share of the value of livestock sold and/or consumed in agricultural income was higher among the non-commercialized smallholder households (22%) and commercialized smallholder households (11%) than commercialized medium-scale households (2 – 4%).

Commercialized medium-scale and stepping-in households compared to the other categories of households were more likely to diversify into the production of all the five enterprises, which could indicate their greater access to land as well as market orientation. However, commercialized small-scale households were more likely to diversify into all the five enterprises than commercialized stepping-up households, even though the latter group operated larger land sizes.

Table 10: Agricultural commercialization and shares of crops and livestock enterprises in agricultural gross income

Commercialization	A < 3 ha, not commercialized (n=632)	B < 3 ha, commercialized (n=1268)	D = > 3 ha, commercialized	
			Stepping-up (n=18)	Stepping-in (n=74)
% share of agricultural income in household gross income	27.2	52.6	87.9	68.4
Household commercialization index (HCI)-crops (% of crop production value that was sold)	12.8	48.5	70.3	66.9
Industrial crops				
% of households producing industrial crops	6.2	22.9	33.3	44.6
% share of industrial crops in agricultural gross income	2.6	35.4	79.0	61.8

Fruits & vegetables				
% of households producing fruits & vegetables	63.1	80.2	83.3	83.8
% share of fruits & vegetables in agricultural gross income	13.6	12.8	3.7	7.4
Grains & legumes				
% of households producing grains & legumes	90.5	94.6	100.0	98.6
% share of grains & legumes in agricultural gross income	56.0	40.7	44.3	25.1
Dairy				
% of households producing dairy (cow milk)	7.9	12.8	0.0	20.3
% share of dairy in agricultural gross income	30.8	27.0		17.2
Live animals				
% of households that sold or consumed livestock (animals)	77.1	86.1	83.3	90.5
% share of livestock (animal) sold or consumed in agricultural gross income	22.4	10.8	1.8	3.8
All five products				
% of households that engaged in all the five activities (industrial crops, fruits & vegetables, grains & legumes, dairy, and sale or consumption of livestock)	0.9	2.4	0.0	4.1

Notes: 1) The shares were computed for each household then median of the shares reported in the table; 2) Industrial crops reported in the data were sugarcane, coffee, cotton, coconut, sunflower, and tobacco, with sugarcane the most common.

Resilience and sustainable land management practices

Irrigation, conservation tillage, intercropping, crop rotation, fallowing and incorporation of organic matter into the soil are among the important practices for resilience and sustainability in agricultural production. A higher percentage of commercialized small-scale and medium-scale households (29-38%) than the non-commercialized small-scale households (10%) practiced irrigation (Table 11). Within the commercialized category, a higher percentage of medium-scale than small-scale households practiced irrigation. These results taken together with the results on use of mineral fertilizer and agro-chemicals emphasize that commercialized farmers, and more so medium-scale commercialized farmers, invest more in modern farming technologies than non-commercialized farmers.

Although zero-tillage was practiced by only a few households, the percentage of those practicing it was higher among commercialized households (4-11%) than non-commercialized small-scale households (3%). Within the commercialized category, a higher percentage of medium-scale households than small-scale households practiced zero tillage.

Another practice that is important for soil fertility management is the incorporation of legumes in the rotation programme for cereal crops. This practice was more likely among commercialized small-scale and medium-scale households compared to non-commercialized small-scale households, and more likely among commercialized medium-scale households than commercialized small-scale households. General intercropping, however, was more likely among non-commercialized small-scale households compared to commercialized small-scale and medium-scale households.

As would be expected, fallowing was practiced by a higher percentage of commercialized medium-scale & stepping-in households compared to small-scale households (both commercialized and non-commercialized). In the small-scale category, a higher percentage of commercialized households than their non-commercialized counterparts practiced fallowing.

Organic matter application was more likely among commercialized households (medium-scale and small-scale) compared to non-commercialized small-scale households (60-72% vs 50%). Within the commercialized category, a higher percentage of medium-scale households (66-72%) than small-scale households (60%) applied organic matter.

Table 11: Adoption of resilience and sustainable land management practices

Resilience and sustainable land management practice	A < 3 ha, not commercialized (632)	B < 3 ha, commercialized (1268)	D = > 3 ha, commercialized	
			Stepping-up (n=18)	Stepping-in (n=74)
	----------% of households----------			
Irrigation	9.6	29.4	37.9	36.3
Zero tillage	2.5	4.3	10.7	5.8
Cereal-Legume rotation	22.0	33.5	37.9	36.6
Intercropping	80.7	74.7	61.4	76.7
Fallowing	11.9	16.2	15.0	29.6
Organic matter (e.g manure, compost) and organic fertilizer	49.8	60.0	66.4	71.8

4.2 Econometric analysis results

In this Section, we report the econometric results from the OLS regression model from Equation 1. As already mentioned, the objective of this analysis is to examine the effect of concentration of commercialized farming in the ward on small-scale farm households' incomes, with the aim of understanding whether there are spillover benefits from commercialized farming to smallholder farmers in the same ward. In Table 15, we present coefficients and standard errors of the variable of interest from five different specifications based on the definition of the variable of interest which is the measure of the concentration of commercialized farms at the ward level. The five different indicators of concentration intensity of commercialized farming are presented in rows. These include, (1) share of operated area in the ward under commercialized small-scale and medium-scale farms; (2) share of operated area in the ward under commercialized medium-scale farms; (3) share of operated area in the ward under commercialized small-scale farms; (4) share of operated area in the ward under commercialized medium-scale farms that entered medium-scale farming via stepping-up pathway; and (5) share of operated area in the ward under medium-scale farms that entered medium-scale farming via stepping-in pathway.

In Panel I, we examine the effect of commercialized medium-scale farms intensity on non-commercialized small-scale farm households' (a) total income, (b) agricultural income, and (c) non-farm

income using non-commercialized small-scale farms sub-sample data (Table 15 , Panel I). The results show that the share of operated land commercialized small- and medium- scale farms somehow reduce household total income. However, the finding is only significant at the 10 percent level.

There is a positive relationship between the share of operated area under commercialized medium-scale scale farms and non-commercialized small-scale households' farm incomes. A one percentage increase in the share of operated area under commercialized medium-scale farms is associated with a 1.85 percent increase in farm incomes of non-commercialized small-scale farms. This is an indication of some positive spillovers trickling from the commercialized medium-scale farms to non-commercialized small-scale farm households around them.

The farm incomes for the non-commercialized small-scale farms are also found to be an increasing and decreasing function of the share of operated area under *stepping-in* commercialized medium-scale farms and the share of operated land under commercialized small- scale farms, respectively. However, this finding is only significant at the 10 percent level.

Turning to the effect of concentration of commercialized farms on non-commercialized small-scale farms' non-farm incomes, only the coefficient of share of operated area in the ward under the *stepping-in* commercialized medium-scale farms is found to be statistically significant at the five percent level. A one percent increase in the share of operated land under stepping-in commercialized medium-scale farms reduce non-commercialized small-scale farms' non-farm incomes by 5.16 percent.

There are three plausible reasons for this negative relationship. First, the commercialized farms (medium- and small- scale), and specifically *stepping-in* medium-scale farms could be spending their money in ways that are not creating jobs in the areas where they operate. Second, probably the non-farm jobs that are being created through increased spending by the commercialized farms may be going to persons who are not directly involved in farming, thus outside the scope of this study. Third, may be the jobs being created could be extremely low income jobs that do not make significant contribution to household incomes.

Table 15: Log-linear OLS regression of the concentration of commercialized farms on income per adult equivalent for small-scale farms

	PANEL I			PANEL II			PANEL III		
	Non-commercialized small-scale farms only			Commercialized small-scale farms only			Small-scale farms (commercialized and non-commercialized)		
Share of operated area in sampled villages in a ward under:	(a) Log[TY]	(b) Log[FY]	(c) Log[NFY]	(a) Log[TY]	(b) Log[FY]	(c) Log[NFY]	(a) Log[TY]	(b) Log[FY]	(c) Log[NFY]
[1] Commercialized small- and medium- scale farms	-2.5171* (1.499)	1.4432 (1.613)	-9.3566 (5.942)	--	--	--	--	--	--
[2] Commercialized small- scale farms	-0.2180 (0.853)	-1.6540* (0.927)	-0.4427 (3.780)	--	--	--	--	--	--
[3] *All* commercialized medium-scale farms	-0.4976 (0.809)	1.8508** (0.846)	-2.3784 (3.892)	0.5418 (0.442)	1.2773** (0.547)	-2.3307 (2.591)	0.3431 (0.394)	1.7835*** (0.492)	-2.8508 (2.120)
[4] *Stepping-up* commercialized medium-scale farms	0.6555 (0.499)	-0.4954 (0.652)	3.4804 (2.130)	0.2365 (0.386)	-1.0280** (0.443)	0.5271 (1.534)	0.2808 (0.316)	-0.8948** (0.399)	1.7954 (1.292)
[5] *Stepping-in* commercialized medium-scale farms	-0.9753* (0.578)	1.2733* (0.720)	-5.1567** (2.449)	0.0711 (0.397)	1.5490*** (0.465)	-1.6978 (1.877)	-0.0947 (0.335)	1.7475*** (0.420)	-3.4219** (1.506)
Observations	631	621	572	1,268	1,266	1,113	1,899	1,887	1,685

Note:

TY=total household income; FY=farm income; NFY=non-farm income

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.10

Next, we examine the effect commercialized medium-scale farming intensity on commercialized small-scale farm households' total income, farm income, and non-farm income using commercialized small-scale farms sub-sample data (Panel II). The results show that the concentration of commercialized medium-scale farm households does not affect the commercialized small-scale farms' total and non-farm incomes in any way. However, the concentration of all medium-scale farms and that of the *stepping-in* medium-scale farms increase commercialized small-scale households' farm incomes. A one percent increase in the share of operated area under commercialized medium-scale farms increases commercialized small-scale farms' farm incomes by 1.28 percent. A similar increase in the share of operated area under the *stepping-in* medium-scale farms increase commercialized small-scale farms' farm incomes by 1.55 percent. Conversely, a one percent increase in the share of operated area under the *stepping-up* medium-scale farms reduce farm incomes of the commercialized small-scale farms by 1.03 percent.

These findings could be interpreted as follows. It is important to recognize that the *stepping-up* medium-scale farms were once small-scale farms that expanded their scale of production to graduate into commercialized medium-scale farming (*stepping-up*). This transition process from non-commercialized small-scale, to commercialized small-scale, and eventually to medium-scale farming probably involves some form of competition for resources (e.g., land, labor, and capital) within the small-scale farming communities. In this transition process, perhaps the *stepping up* medium-scale farms displace commercialized small-scale farms and hence the negative relationship between the share of operated land under stepping up medium-scale farms and commercialized small-scale households' farm incomes. This doesn't seem to be the case with *stepping-in* medium-scale farms. Perhaps this group brings in new farming innovations, farm inputs and output market networks, and is injecting new resources from non-farm employment to the local economies that are benefiting small-scale farm households in the areas where they operate.

In Panel III, we examine the effect of the commercialized farms concentration on both commercialized and non-commercialized small-scale farm households' incomes using both commercialized and non-commercialized small-scale farms sub-sample data. The results show that the intensity of commercialized medium-scale farms does not affect total household income. However, the share of operated land under all medium- scale farms and that under *stepping in* medium-scale farms increase farm incomes of both commercialized small-scale and non-commercialized small-scale farm households. A one percent increase in the share of operated land under all categories of medium-scale farms is associated with a 1.78 percent increase in household farm income. Similarly, a one percent increase in the share of operated land under the *stepping-in* commercialized medium-scale farms is associated with a 1.75 percent increase in household farm income.

Surprisingly, the increase in share of operated land under commercialized small-scale and that under *stepping-up* commercialized medium-scale farms are associated with reduced small-scale (commercialized and non-commercialized) farm incomes. A one percent increase in the share of operated land under *stepping-up* commercialized medium-scale farms is associated with a 0.90 percent decline in household farm income. The same explanation advanced in the case of a negative relationship between

commercialized small-scale households' farm incomes and the intensity of *stepping-up* commercialized farms (Panel II) perhaps applies in this case as well.

Lastly, we examine the effects of commercialized farm intensity on small-scale (both commercialized and non-commercialized) households' non-farm incomes. Just as observed in the case between non-commercialized small-scale farms on-farm income and the share of operated area under *stepping-in* medium-scale farms (Panel I), the share of operated area under *stepping-in* medium-scale farms reduces small-scale (commercialized and non-commercialized) farms' non-farm incomes. A one percentage increase in the share of operated area under the *stepping-in* medium-scale farms is associated 3.42 percent reduction in non-farm income for small-scale farms. The same line of argument explanation used to explain the negative relationship between non-commercialized small-scale farms non-farm income and the share of operated area under *stepping-in* medium-scale farms could also apply in this case. That is, either the *stepping-in* medium-scale farms could be spending their money in ways that are not creating jobs, or the non-farm jobs that are being created may be going to persons who are not directly involved in farming, or the jobs being created could be extremely low-income jobs that do not make significant contribution to household incomes.

4. Conclusion and Policy Suggestions

While small-scale farms dominate agricultural production in sub-Saharan Africa, recent evidence shows that medium-scale farms are a rapidly expanding force that is likely to profoundly influence the nature and pace of food systems transformation in many African countries. Besides the medium-scale farms, there are also productive small-scale farms that are involved in commercial agricultural production but which have often not received much attention regarding their potential role in Africa's food systems transformation. The full impact of these two groups of farming systems on the neighboring non-commercialized small-scale farms are both complex and poorly understood. This study aimed at shedding light on the extent to which commercialized medium- and small- scale farms make contribution to farm productivity growth and spillover effects on local communities around them.

Our study shows that commercialized small-scale farm households were headed by more educated persons compared to their non-commercialized counterparts, an indication that investment in education has a crucial role in rural agricultural transformation process. Also, small-scale farm households with diversified income sources were more likely to be commercialized compared to those with fewer income sources. Perhaps this could be driven by the difference in education attainment of the heads of households in the two small-scale farm categories.

Access to land also matters for smallholder commercialization. For example, commercialized small-scale farm households owned and controlled relatively larger landholdings and a higher proportion rented in land compared to non-commercialized small-scale farm households, implying that improving access to land through vibrant agricultural land markets can enhance agricultural commercialization among smallholder farming communities.

Virtually all the sampled medium-scale farm households were commercialized, indicating a positive relationship between scale of operation and commercialization. This relationship is validated by the relatively higher production volume and share of marketed crop output among commercialized medium-scale farm households compared to their commercialized and non-commercialized small-scale counterparts.

Majority of the medium-scale farm households stepped into medium-scale farming from non-farm economic activities, i.e., their primary economic activity prior to becoming medium-scale farmers was in the non-farm sector. This group used income generated from non-farm employment to acquire (buy and/or rent-in) land and expand their scale of production. Only a few commercialized medium-scale farm households attained that status through stepping-up from small-scale farming. This result implies that there exists considerable difficulty for a typical small-scale farm household to generate a surplus that can be invested in land acquisition to aid transition from small- to medium-scale farming. The result also suggests that a vibrant land market is critical to stimulating commercialized medium-scale farming, and that non-farm employment opportunities have a crucial role to play in providing capital for investment in entrepreneurial farming. Most farm households that stepped into commercialized medium-scale farming now have farming as their primary occupation. This could be an indication that they now find farming a more profitable economic venture than other alternatives available to them.

Both stepping-up and stepping-in medium-scale farm households were found to be more productive (in terms of output per hectare and output per labor-day) than small-scale commercialized and non-commercialized farm households. The medium-scale farm households were also more likely to use irrigation and apply organic matter, and use fertilizer and agro-chemicals more intensively compared to the small-scale farm households. This finding is similar to that by Muyanga and Jayne (2019) on the relationship between farm sizes and productivity when both small- and medium- scale farms are included in the sample. That study found that, regardless of whether productivity is defined in terms of gross output per hectare cultivated, gross output minus input costs (including labor costs) per hectare cultivated, or total factor productivity, the relationship between farm size and farm productivity was unambiguously positive for farms five hectares and beyond.

On the spillover effects, our results show that an increase in the share of operated area under commercialized farms (both small- and medium-scale) is associated with an increase in small-scale households' farm incomes but a reduction in their non-farm income. Similarly, an increase in the share of operated area under commercialized medium-scale farms is associated with an increase in small-scale households' farm incomes. There is also a positive relationship between the share operated area under the *stepping-in* medium-scale farms and small-scale households' farm incomes but a negative relationship between the share operated area under the *stepping-in* medium-scale farms and small-scale households' non-farm income . These results indicate the presence of some spillover benefits flowing from the commercialized farms to small-scale farm households around them. Contrary to our expectation, we found a negative relationship between the share of operated land under *stepping-up* medium-scale farms and farm incomes for small-scale households , a finding that is contrary to our expectations.

We highlight priority programmatic and policy thrusts that the national and county governments, and development organizations may consider for revitalizing small-scale farming in Kenya:

1. Strength agricultural research and development and extension system to develop, deploy and scale out land-saving technologies, innovations, and management practices (TIMPs) for sustainable agricultural productivity growth. Critical here are investments in TIMPs that enhance crop yields.
2. Strengthen land tenure arrangements that enable efficient transfer of agricultural land and protect owner and user rights. Such tenure arrangements will enable land access by entrepreneurial farmers who are able to use the land more productively through investments in TIMPs thereby accelerating agricultural productivity growth and transformation.

3. Repurpose public and private research and development and extension investments to promote the range of crops and animal products with high value, have great potential for commercialization, and able to accommodate a broad base of smallholder farmers. Most of the current research and development and extension investments are directed to just a small number of staple and industrial cash crops, e.g., maize, cassava, coffee, etc.
4. Prioritize investments in an enabling policy environment for trade in agricultural inputs to facilitate efficiency in the supply of inputs to farmers. The study finding that the medium-scale farm households were more likely to use irrigation and apply organic matter and use fertilizer and agro-chemicals more intensively compared to the small-scale farm households, indicates the key role efficient input markets will play in facilitating agricultural commercialization.
5. Prioritize investments in physical infrastructure for transport, i.e., roads, rails, ports, that connect agricultural production areas to processing, local trading, local consumption and export markets, and communication infrastructure and information and communications technology to promote the growing use of digital technologies in agricultural production and marketing.

References

Ali, D., Deininger, K., & Harris, A. 2019. Does large farm establishment create benefits for neighboring smallholders? Evidence from Ethiopia. *Land Economics*, 95(1), 71– 90.

Barrett, C.B., Bellemare, M.F. and Hou, J.Y. 2010. Reconsidering Conventional Explanations of the Inverse Productivity–Size Relationship. *World Development* 38(1): 88-97.

Burke, W.J.; Jayne, T.S. & Sitko, N J. 2019. Do Medium-Scale Farms Improve Market Access Conditions for Zambian Smallholders? *Journal of Agricultural Economics*, 71(2): 517–533).

Carletto, C., Savastano, S. and Zezza, A. 2013. Fact or artefact: the impact of measurement errors on the farm size-productivity relationship. *Journal of Development Economics* 103(0): 254-261.

Chamberlin, J. & Jayne, T. S. 2020. Does farm structure affect rural household incomes? Evidence from Tanzania. *Food Policy*, 90(101805).

Christiaensen, L., & Demery, L. 2018. Agriculture in Africa: Telling myths from facts. *Directions in Development*. Washington DC: World Bank.

Deininger, Klaus and Fang Xia. 2016. Quantifying Spillover Effects from Large Land-based Investment: The Case of Mozambique. *World Development,* Vol. 87, pp. 227–241.

Deininger, Klaus and Byerlee, Derek. 2011. Rising global interest in farmland: Can it yield sustainable and equitable benefits? The World Bank.

Dillon, A., Gourlay, S., McGee, K. and Oseni, G. 2019. Land measurement bias and its empirical implications: evidence from a validation exercise. *Economic Development and Cultural Change* 67(3): 595-624.

Foster, A.D. and Rosenzweig, M R. 2022. Are There Too Many Farms in the World? Labor Market Transaction Costs, Machine Capacities, and Optimal Farm Size. *Journal of Political Economy* 130(3): 636-680.

Larson, D.F., Otsuka, K., Matsumoto, T., and Kilic, T. 2014. Should African rural development strategies depend on smallholder farms? An exploration of the inverse-productivity hypothesis. *Agricultural Economics* 45(3): 355-367.

Lay, J., Nolte, K. & Sipangule, K. 2018. *Large-scale farms and smallholders: evidence from Zambia*. GIGA Working Papers.

Liverpool-Tasie, L.S.O., A.S. Nuhu, T. Awokuse, T. Jayne, M. Muyanga, A. Aromolaran, A. Adelaja. 2023. Can medium-scale farms support smallholder commercialisation and improve welfare? Evidence from Nigeria. *Journal of Agricultural Economics*, 74(1), pp 48-74.

Jayne, T.S., A. Wineman, J. Chamberlin, M. Muyanga, F.K. Yeboah. 2022. Changing Farm Size Distributions and Agricultural Transformation in Sub-Saharan Africa. *Annual Review of Resource Economics journal,* Volume 14.

Jayne, T.S., M. Muyanga, A. Wineman, H. Ghebru, C. Stevens, M. Stickler, A. Chapoto, W., D. van der Westhuizen, D. Nyange. 2019. Are medium-scale farms driving agricultural transformation in sub-Saharan Africa? *Agricultural Economics*, 50(S1).

Jayne, T.S, J. Chamberlin, and Rui Benfica. 2018. Africa's Unfolding Economic Transformation. The Journal of Development Studies, Volume 54: pp777-787.

Jayne, T.S., Chamberlin, J., Traub, L., Sitko, N., Muyanga, M., Yeboah, F. K., Anseeuw, W., Chapoto, A., Wineman, A., Nkonde, C., Kachule, R. 2016, Africa's changing farm size distribution patterns: the rise of medium-scale farms. *Agricultural Economics*, 47: 197–214.

Joseph, J., M. van Dijk, and T. Krisztin. 2023. Do Large Estates Benefit Smallholder Neighbours? Evidence from Malawi. *The Journal of Development Studies*, Vol.59(4): Pages 570-592.

Muyanga, M., A.B. Aromolaran, T.S. Jayne, S. Liverpool-Tasie, T. Awokuse, A. Adelaja, E. Obayelu, F.O. Issa, and Y. Lifeyo. 2022. Changing Farm Structure and Agricultural Commercialisation: Implications for Livelihood Improvements among Small-Scale Farmers in Nigeria. Agricultural Policy Research in Africa Working Paper No. 093, Institute of Development Studies, University of Sussex, Brighton.

Muyanga, M., Jayne, T. S. 2019. Revisiting the farm size-productivity relationship based on a relatively wide range of farm sizes: Evidence from Kenya. *American Journal of Agricultural Economics,* 101(4), 1140–1163.

Muyanga, M., David Tschirley, Thomas Reardon, T.S. Jayne, Ferdi Meyer, Saweda Liverpool-Tasie, and Tracy Davids. 2019. Rural and Agrifood Systems in Transforming Economies in Africa and Asia. Feed the Future Innovation Lab for Food Security Policy Synthesis Report III.

Omotilewa, O.J., T.S. Jayne, M. Muyanga, A.B. Aromolaran, L.S.O. Liverpool-Tasie, and T. Awokuse. 2021. A revisit of farm size and productivity: Empirical evidence from a wide range of farm sizes in Nigeria. *World Development*, Volume 146, October 2021.

Neven, David & Odera, Michael Makokha & Reardon, Thomas & Wang, Honglin, 2009. Kenyan Supermarkets, Emerging Middle-Class Horticultural Farmers, and Employment Impacts on the Rural Poor, World Development, 37(11), pages 1802-1811.

Smalley, R. 2013. *Plantations, contract farming and commercial farming areas in Africa: a comparative review*. FAC Working Paper 55. Land and Agricultural Commercialisation in Africa project. Brighton: Future Agricultures Consortium.

Wineman, A., Jayne, T. S., Modamba, E. I., & Kray, H. 2020. Characteristics and spillover effects of medium-scale farms in Tanzania, *The European Journal of Development Research*, 1-22. Published online 26 Oct. 2020.

Yeboah, Felix Kwame and Thomas S. Jayne. 2018. Africa's Evolving Employment Trends, *The Journal of Development Studies*, 54:5, 803-832.

Appendix

Table A1: Summary statistics of the explanatory variables

Variable	Mean	p25	p50	p75
Dependent variables				
Total income (‘000KSh)	406.56	97.25	198.63	430.97
Agricultural income (‘000KSh)	190.99	29.34	75.51	180.76
Non-farm income (‘000KSh)	215.57	24.00	86.00	234.00
Household demographic variables				
Proportion of male headed household	78.55	1.00	1.00	1.00
Age of the household head (years)	54.00	42.00	54.00	65.00
Head have held another job other than as farmer	25.50	0.00	0.00	1.00
Household years of schooling	8.55	7.00	8.00	12.00
Number of household members	5.68	4.00	5.00	7.00
Household land access and experience in farming				
Hectares owned when household started farming	1.13	0.20	0.50	1.20
Household years of farming experience	24.58	12.00	23.00	36.00
Community level variables				
Daily wage rate (‘00KSh)	3.08	2.00	3.00	3.50
Asset index	0.12	0.06	0.10	0.15
Share of operated land that is rented in	12.05	0.00	0.00	0.00
Ward population density (‘000)	0.30	0.10	0.24	0.50
The squared ward population density (‘000)	0.14	0.01	0.06	0.26
Distance to all-weather road (km)	0.51	0.00	0.20	0.50
Distance to marketplace for crops produce (km)	3.69	1.50	3.00	5.00
Share of operated area in the Ward under commercialized MSF & SSF	0.24	0.17	0.22	0.37
Share of operated area in the Ward under commercialized MSF	0.59	0.49	0.60	0.65
Share of operated area in the Ward under commercialized SSF	0.07	0.00	0.03	0.09
Share of operated area in the Ward under commercialized MSF and Stepping-up	0.16	0.08	0.16	0.25
Share of operated area in the Ward under commercialized MSF and Stepping-in	0.84	0.82	0.85	0.90

Table A 2: Household demographic characteristics, disaggregated by county

Demographic Characteristics	County	[A] SSF: non-commercialized (632)	[B] SSF: commercialized (1268)	MSF: commercialized	
				[C] SUP (18)	[D] SIN (74)
Age of household head	Taita Taveta	54.0	53.0	49.5	59.0
	Makueni	52.0	54.0	53.5	60.5
	Kakamega	56.0	56.0	54.0	63.0
	Kisumu	50.0	49.0	58.0	61.0
	Overall	54.0	53.0	57.0	61.0
% men heads	Taita Taveta	67.4	80.9	100.0	78.6
	Makueni	73.0	81.9	50.0	79.2
	Kakamega	75.5	87.6	100.0	80.0
	Kisumu	67.2	78.0	63.6	90.5
	Overall	71.1	82.2	72.1	82.7
Farming experience (years)	Taita Taveta	22.0	23.0	21.0	31.5
	Makueni	22.0	25.0	29.0	14.0
	Kakamega	27.0	24.0	22.0	27.0
	Kisumu	19.0	19.0	27.0	29.0
	Overall	22.0	23.0	21.5	27.0
Head's education (years)	Taita Taveta	8.0	8.0	7.5	11.0
	Makueni	8.0	8.0	15.5	11.5
	Kakamega	13.0	9.0	7.0	13.0
	Kisumu	8.0	8.0	12.0	12.0
	Overall	8.0	8.0	8.5	12.0
Average education of household members (years)	Taita Taveta	8.4	9.3	7.0	10.1
	Makueni	8.5	9.4	15.0	10.2
	Kakamega	11.4	9.7	10.5	11.4
	Kisumu	9.0	9.5	11.5	10.8
	Overall	8.4	9.3	11.3	10.5

Note: SSF-small-scale farm; MSF- medium-scale farm; SUP-stepping-up MSF; SIN- stepping-in MSF

Table A3: Occupation of household head, disaggregated by county

Occupation of household head	County	[A] SSF: non-commercialized (632)	[B] SSF: commercialized (1268)	MSF: commercialized	
				[C] SUP (18)	[D] SIN (74)
Head holds another job in addition to farming (%)	Taita Taveta	20.2	20.1	50.0	14.3
	Makueni	12.9	20.1	0.0	30.8
	Kakamega	27.8	32.4	33.3	53.3
	Kisumu	29.6	33.4	36.4	42.9
	Overall	23.7	27.8	33.6	30.8
Head currently employed by the public sector (%)	Taita Taveta	2.2	3.9	0.0	0.0
	Makueni	2.2	6.1	0.0	8.3
	Kakamega	1.3	6.7	0.0	13.3
	Kisumu	1.6	5.3	0.0	0.0
	Overall	1.8	5.6	0.0	5.4
Time spent at home by head (months)	Taita Taveta	4.0	4.9	5.5	4.6
	Makueni	5.0	4.8	2.0	3.8
	Kakamega	5.0	5.3	6.0	5.6
	Kisumu	4.5	5.0	5.0	5.0
	Overall	4.8	5.0	5.0	4.8

Note: SSF-small-scale farm; MSF- medium-scale farm; SUP-stepping-up MSF; SIN- stepping-in MSF

Table A4: Main occupation of household head by activity, disaggregated by county

Current main occupation of household head	County	[A] SSF: non-commercialized (632)	[B] SSF: commercialized (1268)	MSF: commercialized	
				[C] SUP (18)	[D] SIN (74)
	Taita Taveta				
None		3.9	2.0	0.0	0.0
Farmer		69.1	77.0	100.0	92.9
Formal salaried/contract employment		10.1	8.6	0.0	0.0
Business and wage employment		16.9	12.5	0.0	7.1
	Makueni				
None		9.6	4.4	0.0	8.3
Farmer		45.5	55.3	50.0	58.3
Formal salaried/contract employment		11.8	18.8	50.0	16.7
Business and wage employment		33.1	21.5	0.0	16.7
	Kakamega				
None		5.3	3.3	0.0	13.3
Farmer		51.7	60.9	66.7	60.0
Formal salaried/contract employment		10.6	13.6	0.0	26.7
Business and wage employment		32.5	22.1	33.3	0.0
	Kisumu				
None		5.6	3.8	0.0	0.0
Farmer		48.0	66.3	72.7	76.2
Formal salaried/contract employment		6.4	9.4	9.1	19.0
Business and wage employment		40.0	20.5	18.2	4.8
	Overall				
None		6.0	3.4	0.0	5.4
Farmer		53.0	64.7	72.1	70.2
Formal salaried/contract employment		9.6	12.3	10.7	16.6
Business and wage employment		31.4	19.5	17.1	7.8

Note: SSF-small-scale farm; MSF- medium-scale farm; SUP-stepping-up MSF; SIN- stepping-in MSF

Table A5: Land ownership and use, disaggregated by county

Land ownership and use	County	[A] SSF: non-commercialized (632)	[B] SSF: commercialized (1268)	MSF: commercialized	
				[C] SUP (18)	[D] SIN (74)
Initial landholding size when started farming (ha)	Taita Taveta	0.6	0.5	0.8	1.4
	Makueni	0.8	0.8	4.3	2.0
	Kakamega	0.4	0.4	1.0	2.0
	Kisumu	0.3	0.4	2.0	0.8
	Overall	0.4	0.4	1.4	1.4
Current landholding size (ha)	Taita Taveta	0.8	0.8	3.9	4.4
	Makueni	0.8	1.2	1.6	6.0
	Kakamega	0.3	0.8	0.4	5.6
	Kisumu	0.4	0.8	2.8	3.8
	Overall	0.4	0.8	2.5	4.1
Current land controlled (ha)	Taita Taveta	0.9	1.2	4.9	5.4
	Makueni	0.8	1.4	50.9	6.7
	Kakamega	0.4	1.0	4.6	6.0
	Kisumu	0.5	1.1	4.8	5.0
	Overall	0.5	1.2	4.7	5.6
Current land operated (ha)	Taita Taveta	0.4	0.8	4.8	4.6
	Makueni	0.4	1.0	50.4	4.8
	Kakamega	0.2	0.8	3.8	5.1
	Kisumu	0.4	0.9	4.4	4.0
	Overall	0.3	0.8	4.3	4.4
Rented-in land (ha)	Taita Taveta	0.4	0.4	0.0	2.0
	Makueni	0.3	0.8		3.7
	Kakamega	0.2	0.4	3.4	1.7
	Kisumu	0.4	0.5	3.7	1.2
	Overall	0.3	0.4	3.4	1.7
% of controlled land currently operated	Taita Taveta	60.6	69.2	97.0	94.3
	Makueni	65.1	71.3	87.5	75.7
	Kakamega	69.1	78.9	93.5	87.6
	Kisumu	73.4	82.9	89.2	85.0
	Overall	67.7	76.6	90.6	84.4

Note: SSF-small-scale farm; MSF- medium-scale farm; SUP-stepping-up MSF; SIN- stepping-in MSF

Table A6: Input use, disaggregated by county

Input use	County	[A] SSF: non-commercialized (632)	[B] SSF: commercialized (1268)	MSF: commercialized	
				[C] SUP (18)	[D] SIN (74)
Total labor days per hectare cultivated (Days)	Taita Taveta	114.5	151.2	78.2	83.9
	Makueni	120.0	107.5	26.2	53.8
	Kakamega	117.9	58.9	9.5	17.5
	Kisumu	98.6	64.6	26.4	20.2
	Overall	110.0	80.0	26.4	25.2
Total kgs of fertilizer per hectare cultivated (Kg)	Taita Taveta	0.0	8.4	29.8	10.0
	Makueni	0.0	0.0	209.9	0.0
	Kakamega	192.3	207.2	259.2	250.0
	Kisumu	0.0	120.0	250.0	178.8
	Overall	0.0	113.6	250.0	108.3
Households using inorganic fertilizer (%)	Taita Taveta	23.0	52.6		50.0
	Makueni	33.1	47.8	50.0	41.7
	Kakamega	74.8	91.2	100.0	100.0
	Kisumu	40.0	79.5	100.0	90.5
	Overall	46.4	71.1	90.0	70.5
Total cost of chemicals per hectare cultivated (Ksh)	Taita Taveta	558.3	2773.2	2833.3	2968.8
	Makueni	0.0	1125.0	18980.5	1323.2
	Kakamega	0.0	142.0	1881.6	767.5
	Kisumu	0.0	2022.1	2831.3	2325.6
	Overall	0.0	1272.7	2552.0	2166.7
Households that rented in land for agricultural production (%)	Taita Taveta	8.97	17.24	0.00	7.14
	Makueni	3.90	9.09	0.00	0.08
	Kakamega	8.6	26.8	100.0	60.0
	Kisumu	21.6	41.9	70.0	52.4
	Overall	11.5	26.0	60.6	32.6
Land rental rate per hectare (Ksh)	Taita Taveta	15,000	25,000	25,000	25,000
	Makueni	10,000	12,500	27,500	12,500
	Kakamega	25,000	25,000	30,000	30,000
	Kisumu	15,000	20,000	15,000	16,250
	Overall	20,000	20,000	17,500	25,000
Daily wage rate for general farm labour (Ksh)	Taita Taveta	400	400	450	300
	Makueni	300	300	575	350
	Kakamega	200	200	300	250
	Kisumu	300.0	300.0	300.0	300.0
	Overall	300.0	300.0	300.0	300.0

Note: SSF-small-scale farm; MSF- medium-scale farm; SUP-stepping-up MSF; SIN- stepping-in MSF

Table A7: Farm production, disaggregated by county

Farm production	County	[A] SSF: non-commercialized (632)	[B] SSF: commercialized (1268)	MSF: commercialized	
				[C] SUP (18)	[D] SIN (74)
Total value of crop output ('000 Ksh)	Taita Taveta	9.2	52.7	177.2	228.9
	Makueni	12.7	44.2	7223.8	209.9
	Kakamega	22.6	93.2	1335.6	1086.1
	Kisumu	29.7	112.6	905.3	837.0
	Overall	18.6	78.2	905.3	433.9
Total value of livestock output ('000 Ksh)	Taita Taveta	4.8	20.5	44.2	52.1
	Makueni	6.4	17.5	2.0	91.3
	Kakamega	3.6	17.4	26.2	134.8
	Kisumu	2.3	5.8	4.8	31.1
	Overall	3.5	13.5	6.2	69.5
Total value of farm output ('000 Ksh)	Taita Taveta	22.4	93.5	221.4	264.5
	Makueni	24.6	75.7	7225.9	304.2
	Kakamega	30.5	131.5	1361.8	1177.1
	Kisumu	34.3	132.2	905.3	839.0
	Overall	29.7	113.0	905.3	549.7

Note: SSF-small-scale farm; MSF- medium-scale farm; SUP-stepping-up MSF; SIN- stepping-in MSF

Table A8: Crop productivity, disaggregated by county

Crop productivity	County	[A] SSF: non-commercialized (632)	[B] SSF: commercialized (1268)	MSF: commercialized	
				[C] SUP (18)	[D] SIN (74)
Total value crop output per ha operated (000 Ksh)	Taita Taveta	28.9	104.9	84.6	106.5
	Makueni	31.7	56.9	104.7	81.3
	Kakamega	125.8	146.0	280.7	186.5
	Kisumu	83.5	138.0	239.8	186.9
	Overall	75.5	119.4	227.8	143.2
Total value crop output per labor day (000 ksh)	Taita Taveta	0.2	0.5	1.5	1.2
	Makueni	0.2	0.5	11.1	1.1
	Kakamega	1.0	2.2	34.5	9.8
	Kisumu	0.9	2.0	7.5	10.3
	Overall	0.6	1.3	7.5	4.7

Note: SSF-small-scale farm; MSF- medium-scale farm; SUP-stepping-up MSF; SIN- stepping-in MSF

Table A9: Commercialization, disaggregated by county

Commercialization	County	[A] SSF: non-commercialized (632)	[B] SSF: commercialized (1268)	MSF: commercialized	
				[C] SUP (18)	[D] SIN (74)
Share of agricultural income to net household income (%)	Taita Taveta	31.5	55.1	82.5	64.7
	Makueni	28.8	38.1	74.9	57.5
	Kakamega	37.7	51.3	83.0	60.6
	Kisumu	34.2	54.3	70.0	61.3
	Overall	33.9	50.4	74.2	60.6
Household commercialization index (hci)-crops (% of production that was sold)	Taita Taveta	15.8	54.8	45.6	68.8
	Makueni	11.8	41.3	89.4	56.3
	Kakamega	11.9	41.2	32.1	59.0
	Kisumu	12.6	56.0	82.7	82.1
	Overall	12.8	48.5	70.3	66.9
% of households growing high value crops (FFV)	Taita Taveta	49.4	78.0	50.0	100.0
	Makueni	5.8	7.3	100.0	66.7
	Kakamega	93.4	96.1	100.0	100.0
	Kisumu	75.0	79.8	81.8	90.5
	Overall	73.0	82.9	83.6	87.0
% value of crop output from FFV	Taita Taveta	17.8	39.5	20.5	49.3
	Makueni	13.7	29.4	38.8	31.1
	Kakamega	19.5	12.3	1.4	7.4
	Kisumu	13.8	15.7	5.9	6.5
	Overall	16.5	22.2	9.9	21.7
% of households practicing dairy farming	Taita Taveta	0.0	21.3	0.0	21.4
	Makueni	0.0	1.2	0.0	25.0
	Kakamega	0.0	17.3	33.3	66.7
	Kisumu	0.0	3.3	0.0	9.5
	Overall	0.0	12.9	5.7	28.7

Note: SSF-small-scale farm; MSF- medium-scale farm; SUP-stepping-up MSF; SIN- stepping-in MSF

Table A10: Adoption of resilience and sustainable land management practices, disaggregated by county

Resilience and sustainable land management practices (% of households)	County	[A] SSF: non-commercialized (632)	[B] SSF: commercialized (1268)	MSF: commercialized	
				[C] SUP (18)	[D] SIN (74)
Irrigation	Taita Taveta	24.9	60.5	50.0	85.7
	Makueni	7.3	30.0	100.0	45.8
	Kakamega	0.0	0.0	0.0	0.0
	Kisumu	4.8	28.7	27.3	14.3
	Overall	9.6	29.4	37.9	36.3
Zero tillage	Taita Taveta	4.5	6.3	0.0	0.0
	Makueni	3.4	2.0	50.0	0.0
	Kakamega	0.0	2.1	0.0	6.7
	Kisumu	3.2	6.5	9.1	14.3
	Overall	2.5	4.3	10.7	5.8
Cereal-Legume rotation	Taita Taveta	28.8	43.8	50.0	42.9
	Makueni	15.2	25.3	100.0	29.2
	Kakamega	24.5	36.4	0.0	53.3
	Kisumu	19.2	29.0	36.4	28.6
	Overall	22.0	33.5	37.9	36.6
Intercropping	Taita Taveta	62.1	59.5	100.0	57.1
	Makueni	84.3	75.4	0.0	62.5
	Kakamega	84.8	84.8	100.0	93.3
	Kisumu	87.2	74.8	54.5	90.5
	Overall	80.7	74.7	61.4	76.7
Fallowing	Taita Taveta	21.5	26.3	50.0	28.6
	Makueni	16.9	17.4	100.0	33.3
	Kakamega	5.3	8.2	0.0	20.0
	Kisumu	8.8	16.4	0.0	33.3
	Overall	11.9	16.2	15.0	29.6
Organic matter (e.g manure, compost) and organic fertilizer	Taita Taveta	40.7	61.2	100.0	42.9
	Makueni	71.9	80.5	50.0	83.3
	Kakamega	59.6	71.8	66.7	86.7
	Kisumu	28.0	34.3	63.6	66.7
	Overall	49.8	60.0	66.4	71.8

Note: SSF-small-scale farm; MSF- medium-scale farm; SUP-stepping-up MSF; SIN- stepping-in MSF