Sustainable Transition to Entrepreneurial Production
in Agriculture through Upgrading

Work Package 2

Food Value Chain (FVC) Analysis of Banana and Mango (ZALF)

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Task 2.2: Farming systems analysis (WUR)

Analysis of mango farming systems in Kitui, Kenya

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1. Introduction

Sustainable intensification of agriculture provides a potential pathway to meet the growing demands for food on a global level. However, in practice adoption of many promising SI solutions remains disappointing, amongst others due to poor linkages to input and output markets and high investment risks. In the STEP-UP project, we aim to implement and assess sustainable intensification (SI) and market linkage (ML) strategies to enable small farm enterprises (SFEs) to step up towards food and nutrition security, sustainable development and income generation. The project focuses on banana and mango food value chains in Uganda and Kenya. Kenya is one of the leading mango producers in East-Africa with current annual production of 600.000 – 800.000 tons. However, the bulk of the mangos, primarily of old fibrous cultivars, are wasted because of the lack of processing facilities, bad quality and poor infrastructure. STEP-UP aims to identify and implement strategies to upgrade production, processing and marketing of mangoes.

The overall aim of the project is to contribute to food security and sustainable development in sub-Saharan Africa through equitable commercial relationships between SFEs and markets within the frame of sustainable agricultural production. The focus of the project is on the heterogeneous groups of smallholder farmers with an entrepreneurial ambition. Specific objectives are:

1. Achieve sustainable intensification of SFEs and the transition of diverse farms to commercial enterprises that contribute to food and nutrition security while minimizing trade-offs in other sustainability dimensions;
2. Provide key actor groups, local authorities and decision-makers with instruments and information for discussion and decision support based on participatory ex-ante and ex-post impact assessments;
3. Inform policy implementation towards a supportive public-policy environment based on locally-relevant sustainability principles, criteria and indicators.

The project recognizes the diversity of smallholder farmers and aims to look for different strategies for smallholders to 'step-up' along the value chain. To understand the diversity of farmers, a detailed farm characterization and farm typologies were envisaged. The characterization of farming systems should contribute to an understanding of current mango and banana cultivation, and the interaction with other farm components (e.g. cultivation of other crops, livestock) and other sources of income. The insights gleaned from the farming systems characterization provide the socio-ecological context for tailoring of promising 'stepping-up' innovations.

This report provides the analysis of a baseline survey on mango farming systems in Kitui county, Kenya. The baseline targeted 101 households and dealt with general household characteristics, mango cultivation (production, income, management practices, labour, marketing), other crops and livestock on the farm, food security, and other sources of income. The report provides an understanding of mango farming systems, based on a selected number of indicators that were to be considered to be relevant in relation to the interventions implemented in Kenya (a pilot for the export of dried mango flakes to Europe and a training on good agronomic management practices in mango cultivation). The report forms the basis for an ex ante appraisal of the potential effects of these interventions for different types of farmers.

2. Methodology

Summary of internship report Rashidatu Abdulai, Wageningen University, 2019:

2.1 Study area

The baseline survey was conducted in Kitui county, Kenya. Kitui is one of the main leading mango production areas in Kenya. Both grafted and indigenous mangoes are grown, and the county has two main mango processing plants in Kitui and Migwani town. The climate in Kitui County is semi-arid with temperatures between 14°C to 34°C. February and September are the hottest months of the year. There are two rainy seasons in Kitui: one from March to May (long) and another from October to December (short). The short rainy season is considered to be the most reliable, and farmers grow their major food crops during this season. Rainfall is irregular with the period and the amount of rainfall varying from year to year. Mean annual rainfall is about 1000 mm per year (https://en.climate-data.org/africa/kenya/kitui/kitui-11147/).

Almost 90% of people in Kitui earn their income from farming, owning an average of two hectares of land. Main crops grown are maize, green grams, cowpea and pigeon pea. These are mostly rain fed. Few people rear livestock. The manure is generally used as fertilizer for farms. Mineral fertilizer is hardly applied because of the high cost.

Mango is the main fruit crop in Kitui county. In 2018, Kitui had a total of about 345,200 mango trees, with a total production of almost 22,000 MT and a value of 4.4 million USD (Table 1). Challenges in the mango value chain, reported by the crop officer in Kitui county at the start of the study in 2018, relate to inadequate and poor access to good quality planting materials, low productivity and quality of mangoes, erratic and unreliable rainfall, inadequate skills in mango cultivation, high incidence of diseases and pests, high cost of inputs (especially pesticides), inadequate and inefficient processing infrastructure, poor organization of producers, high perishability and spoilage of the produce after ripening (short shelf life), the seasonality of mango production, high transport costs due to the bulky nature of the produce, inadequate market structures and linkages, inadequate value addition facilities and a low quality of mangoes for processing.

2.2 Data collection and analysis

The research was conducted in two sub-counties of Kitui: Kitui Central and Mwingi West. These two study areas were selected purposely due to the differences in marketing potentials. Both study areas have a processing plant, but the main difference is that the processing plant in Kitui Central is larger than the one in Mwingi West. A baseline survey conducted by the National Environmental Trust Fund (NETFUD) in 2014 formed the basis for the selection of villages in these two sub-counties, to build on previous work of NETFUND on mango in this area. A total of nine villages were selected.

A list of mango farmers and the number of trees that these farmers owned was obtained from sub-county agriculture offices and from the processing plants. Farms were classified into three types (based on experts' knowledge), depending on the number of trees: small scale (5 - 50 trees), medium scale (51 - 200 trees) and large scale mango farmers (more than 200 trees). Based on this classification, a total of 101 farmers were selected from the two sub-counties for interviews (50 farmers in Kitui Central and 51 farmers in Mwingi West). The selection of farmers was done randomly within each farm type in each village. Only the large-scale farmers were selected on purpose as it turned out they were smaller in number and did not always appear in the random selection. An approximately equal number of farmers from each type was selected in each village where possible (Table 2):

Table 2: Distribution of households in sub-counties and farm types (large, medium and small-scale mango farmers based on their number of trees)

	Kitui Central	Mwingi West	Total
Large scale (> 200 trees)	9	14	23
Medium scale (51-200 trees)	23	19	42
Small scale (5-50 trees)	18	18	36
Total	**50**	**51**	**101**

During the interviews, basic information on the following were collected: (1) household composition and education of household members, (2) land holding, (3) detailed information about mango production (number of trees, management practices, mango yields, prices of mangoes, marketing, etc.), (4) livestock ownership, (5) food security, (6) sources of income and (7) resource endowment.

An android mobile device preloaded with structured questionnaires modified from RHoMIS (www.rhomis.org) was used for data collection. The software used for data collection was the Open Data Kit (ODK) mobile application that enhances the collection and entry of both qualitative and quantitative information from respondents. The ODK application had a GPS receiver which is inbuilt and was used to capture coordinates of the respondents' household/location. This was done to ensure that those same households would be traceable for follow-up research during the period of the STEP-UP project. Data collected were uploaded to a survey web hosted by an online server. This data was exported into a .csv format for data analysis.

Data was analysed in R version 3.5.0. It turned out that the collection of data on mango yields was difficult. Farmers reported the total value of their mango harvest, and could not mention the quantity in kg. Therefore, data on mango yield is only expressed as the total value of mango sales, for the farmers who mentioned a total price for the whole year. Farmers who did report a price per piece, a price per kg or a quantity in kg were too few to be considered reliable.

Table 1: Mango production data for sub-counties in Kitui, 2018

Sub-county	No. of trees (grafted)	No. of trees (indigenous)	Total no. of trees	Total ha	Total no. of farmers	Grafted fruit bearing trees (ha)	Indigenous fruit bearing trees (ha)	Total production (MT)	Value USD (x 1000)
Mwingi North	6,056	2,754	8,810	88	678	16	13	289	60
Mwingi Central	67,483	25,513	92,996	930	3,579	272	99	4,064	810
Mwingi West	25,288	3,301	28,589	286	5,718	204	20	2,600	520
Kitui West	19,381	6,473	25,854	259	5,171	126	32	1,764	350
Kitui Central	71,940	27,298	99,238	992	16,540	500	128	7,021	1,400
Kitui Rural	24,896	6,906	31,802	318	5,300	184	31	2,453	490
Kitui East	25,855	7,461	33,316	333	6,663	198	40	2,693	540
Kitui South	14,080	10,522	24,602	246	4,430	71	31	1100	220
Total Kitui county	**254,979**	**90,228**	**345,207**	**3452**	**48,079**	**1,570**	**393**	**21,984**	**4,400**

Source: Crop Officer Kitui county

3. Results

3.1 Mango cultivation

The majority of farmers in Kitui Central and Mwingi West grew grafted mango trees, or a combination of grafted and indigenous trees (Table 3). Only one farmer in Mwingi West grew exclusively indigenous trees.

Table 3: Percentage of farmers growing indigenous and grafted mango trees in Kitui Central (n=50) and Mwingi West (n=51)

	Kitui Central (n=50)	Mwingi West (n=51)
Grafted only	60%	62%
Both	40%	38%
Indigenous only	0%	2%
Total	100%	100%

Both indigenous and grafted mangoes were consumed and sold (Table 4). For both types of mangoes, the percentage of farmers reporting to consume their mangoes was larger than the percentage selling mangoes. In Kitui Central, all farmers growing indigenous mangoes also consumed them. The sale of mangoes was more common in Kitui Central than in Mwingi West. In both sub-counties, a larger proportion of farmers sold grafted rather than indigenous mangoes. Livestock feed was a relatively common use of mangoes after harvest in Mwingi West. Post-harvest losses were reported by about two thirds of farmers for indigenous mangoes, and by 40 to 80% for grafted mangoes in Mwingi West and Kitui Central respectively.

Table 4: Percentage of farmers reporting use of indigenous and grafted mangoes after harvest Kitui Central (n=50) and Mwingi West (n=51)

	Indigenous		Grafted	
	Kitui Central	Mwingi West	Kitui Central	Mwingi West
Own consumption	100%	85%	96%	82%
Sell fresh	70%	35%	85%	60%
Fed to livestock	5%	30%	0%	5%
Saved for seed	5%	0%	0%	0%
Got lost/ rotten	70%	60%	82%	42%

NB: Farmers could give multiple answers

3.2 Indigenous mangoes

Farmers reported to consume on average about one third of their indigenous mangoes, and to sell almost 60% in Kitui Central, and 37% in Mwingi West (Table 5). The mangoes fed to livestock in Mwingi West accounted for about a quarter of the harvest. In both locations, losses of indigenous mangoes averaged 50% of the harvest.

The total number of indigenous trees, and consequently the total income from sales of indigenous mangoes was larger in Mwingi West than Kitui Central. The income per tree was slightly lower in Mwingi West, though. Overall, the total income per farm earned from indigenous mangoes was very low.

Table 5: Average number of indigenous mango trees, total income per farm per year from those trees, and average income per tree in Kitui Central (n=50) and Mwingi West (n=51)

Indigenous mango trees	Kitui Central	Mwingi West
Number of trees	13	19
Total income per farm per year (USD)	5	8
Income per tree (USD)	0.9	0.6

3.3 Grafted mangoes

The percentage of grafted mangoes consumed was only 12% of the harvest in Kitui Central, and 44% in Mwingi West. The farmers who sold their mangoes reported to sell an average of 57% in Kitui Central adn 72% in Mwingi West. Losses were reported to average 43% of the harvest in both sublocations.

3.3.1 Mango varieties

The most popular grafted mango variety cultivated in Kitui Central was Apple with 96% of the farmers growing the variety and an average of 91 trees per farm (Table 6). In Mwingi West, Van Dyke, Tommy Atkins and Apple were the most popular varieties. The average number of trees was generally larger than in Kitui Central.

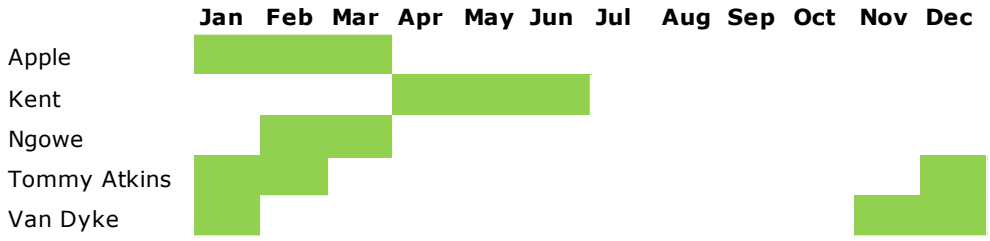
Table 6: Percentage of farmers growing and average number of trees for grafted mango varieties in Kitui Central (n=50) and Mwingi West (n=50).

	Kitui Central		Mwingi West	
	% of farmers growing	Nº of trees per farm	% of farmers growing	Nº of trees per farm
Apple	96%	91	96%	102
Baribo	6%	19	0%	
Dodo	0%		2%	1
Haden	2%	10	0%	
Keitt	0%		4%	26
Kent	30%	16	51%	63
Ngowe	32%	13	29%	8
Tommy Atkins	14%	12	33%	310
Van Dyke			20%	514

3.3.2 Harvest time of different varieties

Varieties Tommy Atkins and Van Dyke are normally harvested early in the season, starting in November/ December, whereas variety Kent is harvested late, from April onwards.

Figure 1: Five main mango varieties and their main harvesting months (Kitui central and Mwingi West combined)



3.3.3 Income for different grades and varieties

The combined income of the sale of different grades per variety resulted in the largest values per tree and per ha for varieties Kent, Haden and Apple in Kitui Central, and Apple, Kent and Tommy Atkins in Mwingi West.

In both Kitui Central and Mwingi West, the majority of farmers sold their mangoes as grade 2 (Table 7a+b).

Table 7a: Number of farmers selling, percentage of mangoes sold and average annual income per farm, tree and ha (USD) for mango varieties at grade 1, 2 and 3 in Kitui Central*. The income per tree and per ha is corrected for the % of mangoes sold at a particular grade.

	Grade 1					Grade 2					Grade 3				
	# farmers selling	% sold at grade	USD per farm	USD per tree	USD per ha	# farmers selling	% sold at grade	USD per farm	USD per tree	USD per ha	# farmers selling	% sold at grade	USD per farm	USD per tree	USD per ha
Apple	9	81	2638	12	1734	32	94	499	10.5	3456	3	75	77	5.5	2051
Baribo						2	100	108	3.5	380					
Haden											1	100	100	10.0	4000
Keitt															
Kent	5	85	206	27.5	4847	5	96	275	9.0	1675					
Ngowe	1	100	NA	NA	NA	8	94	57	3.0	717	1	100	10	3.5	1333
Tommy Atkins	2	100	75	4	469	4	100	113	5.5	729					
Van Dyke															

* Only farmers who reported the total price per season were taken into account. These figures were considered the most reliable for the calculations

Table 7b: Number of farmers selling and average annual income per farm, tree and ha (USD) for mango varieties at grade 1, 2 and 3 in Mwingi West*. The income per tree and per ha is corrected for the % of mangoes that was sold at a particular grade.

	Grade 1					Grade 2					Grade 3				
	# farmers selling	% sold at grade	USD per farm	USD per tree	USD per ha	# farmers selling	% sold at grade	USD per farm	USD per tree	USD per ha	# farmers selling	% sold at grade	USD per farm	USD per tree	USD per ha
Apple	4	100	4,95	2.0	1104	27	85	766	7.0	3171	1	100	150	6.0	
Baribo															
Haden															
Keitt	1	75	2,00	5.5	237										
Kent	7	82	2,37	4.0	2615	12	90	104	3.5	2629	3	5	10	14.5	2232
Ngowe						4	94	20	1.5	838					
Tommy Atkins	1	50	NA	NA	NA	9	92	1132	6.0	1746	1	25	NA	NA	NA
Van Dyke	1	50	NA	NA	NA	6	88	87	2.5	1216	1	25	NA	NA	NA

** Only farmers who reported the total price per season were taken into account. These figures were considered the most reliable for the calculations*

Farmers in Kitui Central selling a variety at a particular grade usually sold most of their mangoes at this grade, whereas in Mwingi West farmers also reported to sell only 5, 25 or 50% at a particular grade, hence the rest at a different grade.

The largest amount of money earned per farm in Kitui Central was with variety Apple, sold at grade 1, with an average of 2638 USD per farm. This included one farmer reporting an income of 19,000 USD from this variety. Kent and Apple had the largest value per tree and per ha, both when sold at grade 1 and grade 2. The prices per ha for varieties sold at grade 3 were also relatively large, but these all only had a limited number of observations.

In Mwingi West, the largest average amounts of USD per farm were achieved with varieties Tommy Atkins and Apple, sold at grade 2. The value per tree was largest for variety Kent sold at grade 3, but again these were only a limited number of observations. Apple, Kent and Tommy Atkins generally resulted in the highest prices per ha.

3.3.4 Total income from sale of fresh mangoes

The annual income from mango sales (indigenous and grafted combined) for large scale mango farmers averaged almost 980 USD per farm per year (Figure 2). (This excludes two outliers earning more than 15000 USD per farm per year. If these were included, the average income would be almost 2500 USD per farm per year.) Medium scale mango farmers earned an average of about 375 USD per farm, and small scale farmers only 60 USD. The average income per farm per year was slightly higher in Kitui (415 USD) than in Mwingi West (360 USD).

The average income per ha was similar for large (580 USD) and medium scale farmers (640 USD), but considerably lower for small scale farmers (190 USD). In Kitui Central the income per ha was about 555 USD per ha, and in Mwingi West 400 USD per ha. The income per tree averaged 3 USD for large, 4 USD for medium and 2 USD for small scale farmers. With 4 USD per tree, the income from mango sales in Kitui Central was double the income per tree in Mwingi West (2 USD).

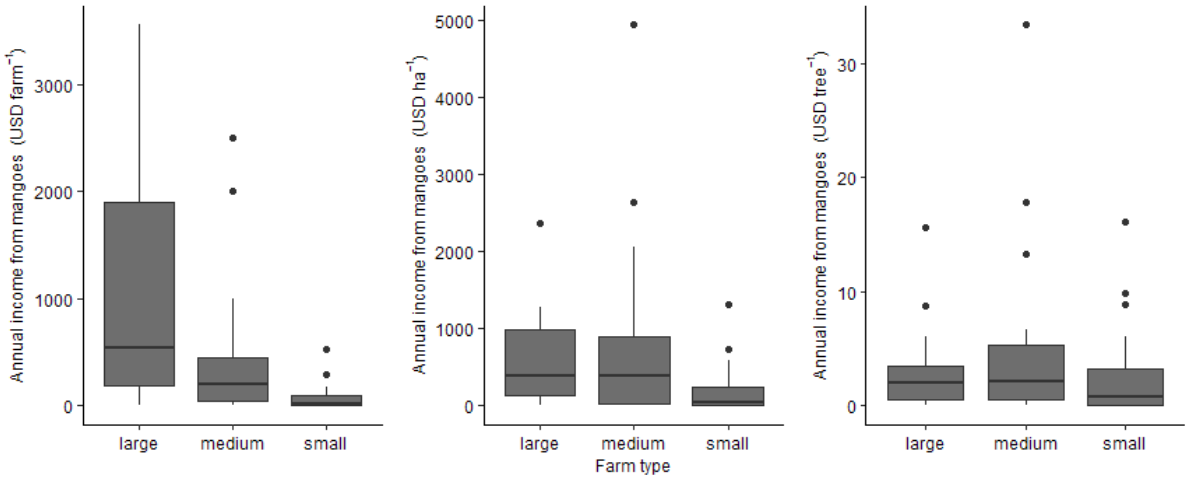


Figure 2: Annual income from mango sales per farm, per ha and per tree for large, medium and small-scale mango farmers (Kitui Central and Mwingi West combined)

NB: Two outliers were removed for large-scale farmers who would earn more than 15,000 USD per farm per year from mangoes. Although the data may be correct, the values were removed for easier comparison with the other farm types.

3.3.5 Income from other mango products

Indigenous mangoes were sold fresh only, and almost all grafted varieties as well. One farmer in Mwingi West, owning 5000 mango trees of this variety, sold juice from variety Van Dyke.

This was only a small portion of his total mango harvest. The reported annual income gained from this activity amounted to 1500 USD.

3.4 Management practices applied in mango cultivation

The main management practices applied in mango cultivation were pruning, weeding and pest and disease management (Table 8). Manure application was done by half of the farmers in Mwingi West, and only one third of the farmers in Kitui Central. In contrast, four farmers applied mineral fertilizer in Kitui Central, but none of the farmers in Mwingi West. Irrigation was only practiced by one farmer in Mwingi West. Some farmers did not apply any of the practices. One of these farmers only grew indigenous mangoes, the other two also had grafted mangoes.

Table 8: Percentage of farmers applying a certain practice in mango cultivation in Kitui Central (n=50) and Mwingi West (n=51)

	Kitui Central	Mwingi West
Plant new seedlings	12%	12%
Pruning	90%	84%
Mineral fertilizer application	8%	0%
Manure application	32%	53%
Weeding	94%	96%
Pest and disease management	96%	90%
Irrigation	0%	2%
Harvest	0%	0%
None of the above	4%	2%

Most practices were applied by the same percentage of large, medium and small-scale farmers (Table 9). Only pruning was applied to a lesser extent among small-scale mango farmers.

Table 9: Percentage of farmers applying a certain practice in mango cultivation for large (n=23), medium (n=42) and small scale (n=36) mango farmers (Kitui Central and Mwingi West combined)

	Large	Medium	Small
Plant new seedlings	9%	12%	14%
Pruning	100%	91%	77%
Mineral fertilizer application	5%	5%	3%
Manure application	45%	42%	43%
Weeding	100%	98%	91%
Pest and disease management	86%	100%	91%
Irrigation	0%	2%	0%

3.5 Labour in mango cultivation

3.5.1 Labour spent on the different practices

The largest share of labour spent on mango cultivation went to weeding and manure application (Table 10).

Table 10: Average labour spent on management practices for mango cultivation in days per farm, days per ha and hours per tree (Kitui Central and Mwingi West combined)

	Days per farm	Days per ha	Hours per tree
Plant new seedlings	9	9	0.6
Pruning	19	26	1.4
Weeding	157	203	20.5
Fertilizer application	9	10	1.7
Manure application	109	158	7.8
Pest and disease management	16	18	1.0
Total	**319**	**424**	**33**

The amount of labour spent on the different practices varied widely between farms (Figure 3). The labour spent on weeding per ha was similar for the different farm types, but manure application costed relatively little time for small-scale mango farmers. Per tree, the costs for weeding were relatively larger for medium and small-scale farmers.

3.5.2 Division of labour for the different practices

The majority of practices applied in mango cultivation were done by men and hired labourers (Table 11). Women played a relatively large role in the planting of new seedlings, weeding and manure application. Pruning and weeding were done by a range of people within the household. Buyers of mango had a little role in pruning, weeding and pest and disease management, but were largely involved in harvesting the mangoes (see table 13).

Table 11: Division of labour for practices applied in mango cultivation (Kitui Central and Mwingi West combined)

	Plant new seedlings	Pruning	Weeding	Fertilizer application	Manure application	Pest and disease management
Male adult	47%	49%	24%	33%	33%	38%
Female adult	40%	14%	23%	17%	20%	10%
Male youth (15-30yrs)	0%	6%	12%	17%	4%	7%
Female youth (15-30yrs)	0%	4%	4%	0%	0%	0%
Male child (<15 yrs)	0%	1%	1%	0%	0%	0%
Female child (<15 yrs)	0%	0%	2%	0%	0%	0%
Hired labour	13%	26%	33%	33%	43%	41%
Buyer	0%	1%	1%	0%	0%	3%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

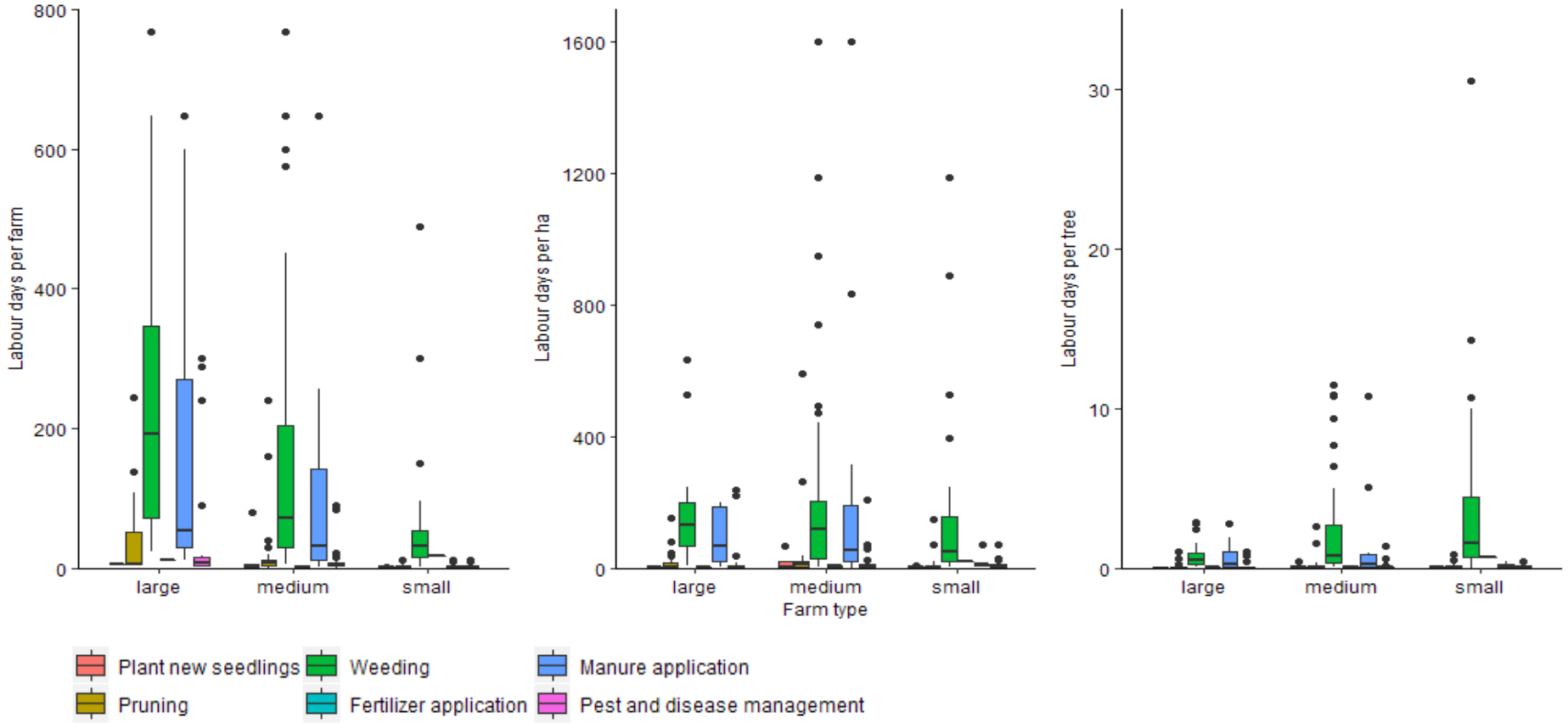


Figure 3: Labour days per farm (A), ha (B) and tree (C) in mango cultivation for large, medium and small-scale mango farmers

[NB: one outlier of a farmer who reported 3600 days per farm for manure application was removed from these graphs for ease of comparison]

3.6 Application rates and costs of inputs for mango cultivation

Farmers who applied mineral fertilizer all applied this to mature, grafted trees, and to all the trees on their farm. Two farmers applied NPK, two CAN. Application amounts ranged from 0.25 to 10 kg per tree or 15 to 333 kg per ha (Table 12). Reported application costs ranged from 20 to 164 USD per farm, but it is unclear whether these costs applied to mango cultivation only or to fertilizer use on the total farm. If the costs were for mango only, these costs would translate into 25 to 50 USD per ha.

The amount of manure applied averaged 27 kg per tree. Manure was applied to both seedlings and mature grafted trees. Five farmers also applied manure to indigenous trees. Costs for application ranged from 20 to 1000 USD per farm, with an average of 208 USD per farm. This translates into an average price of 5 USD per 100 kg of manure.

About 90% of the farmers sprayed their mangoes, and around 60% used traps. Farmers used an average of 60 20-liter spray pumps per year, translating into 85 pumps per ha or 0.6 pumps per tree. Total costs for spraying amounted to 114 USD per farm, for traps up to 67 USD per farm.

Table 12: Application rates and costs of inputs used in mango cultivation

Type	Application rate		Costs (USD)			
	Per ha	Per tree	Per input unit	Per farm	Per ha	Per tree
Mineral fertilizer	128 kg	4 kg	30 USD per 100 kg	54	24	0.6
Manure	5414 kg	27 kg	5 USD per 100 kg	208	175	1.2
Spray pumps (20 liter)	85 pumps	0.6 pumps	5.5 USD per pump	114	157	1.3
Trap	22 traps	0.2 traps	3.9 USD per trap	67	65	0.5

3.7 Income minus input costs for mango cultivation

The total income, input costs and hence the total mango income minus costs was largest for large scale mango farmers, and smallest for small scale farmers, per farm and per ha (Figure 4). Some farmers had larger input costs than income from mango cultivation, whereas others managed to get a profit of (more than) 1000 USD per ha. Mean profits for the farm types were almost 1100 USD per ha for large, 500 for medium and 160 USD for small scale mango farmers.

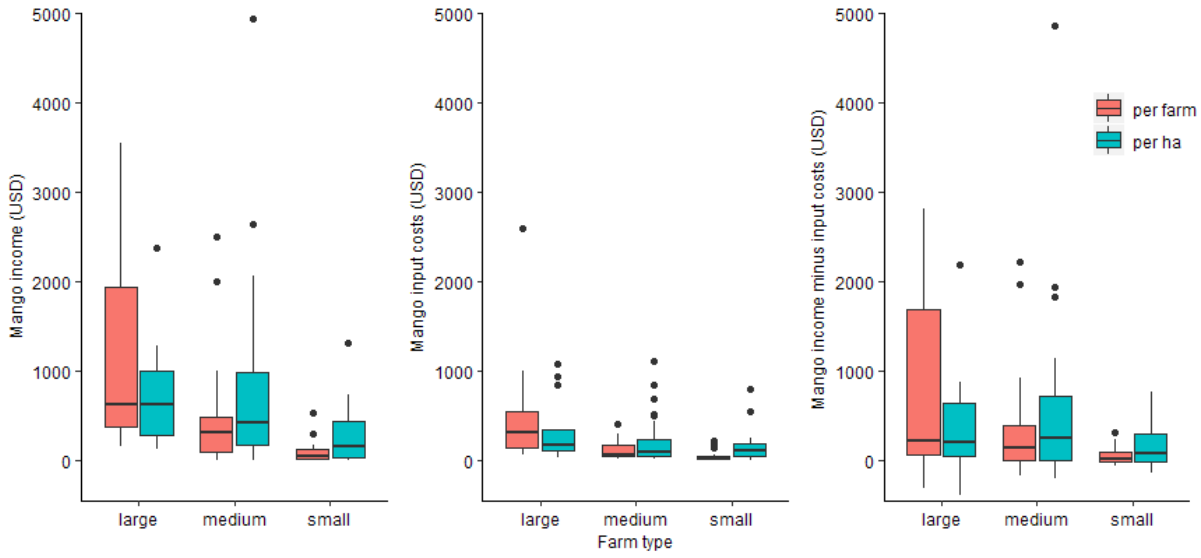


Figure 4: Mango income, input costs and income minus costs in USD per farm and per ha (Kitui Central and Mwingi West combined)

NB: Two outliers removed for large-scale farmers earning more than 15,000 USD per farm per year from mangoes.

3.8 Awareness and access to inputs in mango cultivation

Farmers were asked if they knew which mango varieties would fetch the highest price on the market. About 90% of the farmers in Kitui Central and Mwingi West mentioned that Apple is the variety with the highest price. Variety Kent was mentioned by 13%. Only one farmer would not know which variety this would be. The main source of access to these varieties were other farmers, the local market, and the own farm. In Kitui Central community-based seed producers (8%) and extension workers (4%) were also mentioned, whereas in Mwingi West rural agro-dealers played a relatively important role (26% of respondents). All but one farmer in Kitui Central had ever grown the variety with the highest price. The farmer who had not grown the variety (Apple), mentioned that the seedlings were not available.

This picture is quite different for the application of mineral fertilizer. None of the farmers in Mwingi West would know which fertilizer to apply on mango. In Kitui Central, CAN, DAP and NPK were mentioned by one to five farmers, and 82% of the farmers mentioned they would not know which fertilizer to apply. From the farmers who applied fertilizer in Kitui Central, all bought their fertilizer at a rural agro-dealer. And all of them had also ever applied this fertilizer.

For pest and disease management, one farmer in Kitui Central and one in Mwingi West indicated they did not know what to do to prevent pests and diseases in mango. About two third of the farmers mentioned they knew of traps and spraying, and one third mentioned spraying only. Spray pumps and traps were all obtained from rural agro-dealers. Only two farmers in Kitui Central mentioned the local market. All of the farmers who knew how to prevent pests and diseases had also applied these methods.

3.9 Sources of information on mango cultivation

The most frequently mentioned sources of information on mango cultivation were fellow farmers, farmer field schools or agricultural fairs and extension agents. In Mwingi West, agro-dealers and farmer groups were also relatively important sources of information, and demonstrations and radio in Kitui. None of the farmers mentioned leaflets or text messages as information source. One farmer mentioned social media as other information source, and one farmer reported to have no information sources at all.

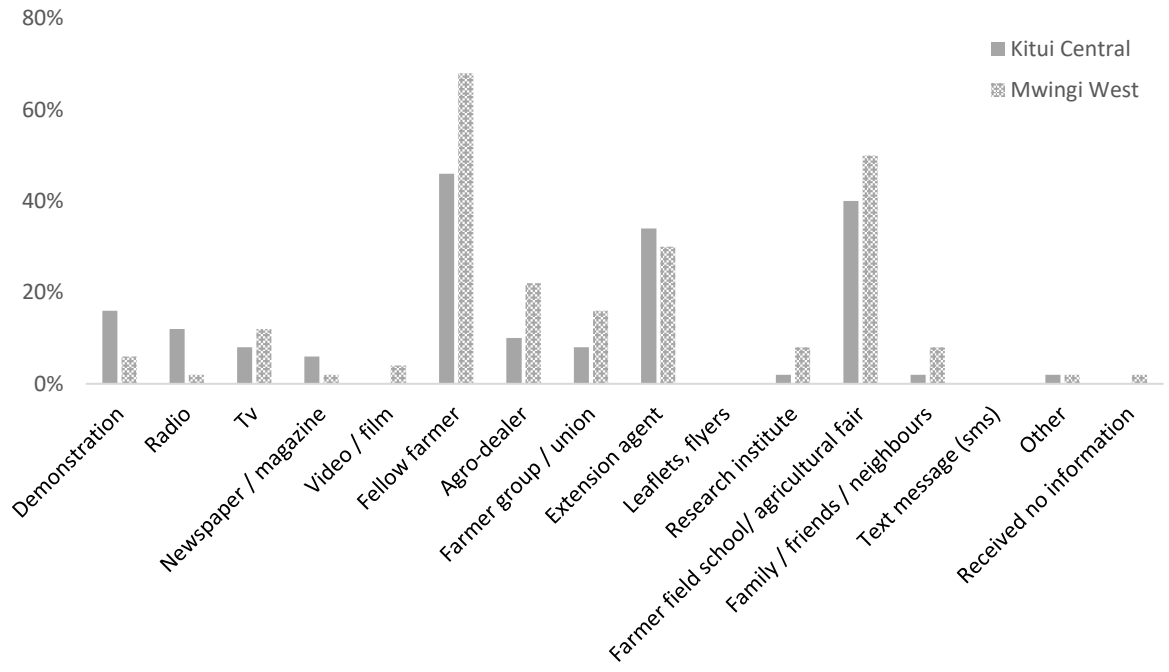


Figure 5: Farmers' sources of information on mango cultivation in Kitui Central and Mwingi West (farmers could mention multiple sources)

3.10 Common pests and diseases

The most common pests in Kitui Central and Mwingi West were fruit flies and mango seed weevil (Figure 6). In Kitui Central, aphids and thrips were also mentioned by a large proportion of farmers, and bugs and mites more frequently in Mwingi West. Powdery mildew, anthracnose and post-harvest rots were the most common diseases. All farmers indicated that the pests and diseases they mentioned occurred multiple times per season on their farm.

3.11 Marketing of mangoes

3.11.1 Cooperative membership

About 60% of the farmers in Kitui Central, and 50% of the farmers in Mwingi West reported to be member of a cooperative. Mango and passion fruits were the most frequently mentioned crops that these cooperative dealt with. Main activities conducted were training and collective marketing. Better access to markets and to information were the main advantages mentioned of being a cooperative member, next to better prices, improved access to credit and access to specific markets. Among the disadvantages of a cooperative membership were the poor prices received for the produce, issues related to marketing (sales not better than individually, poor collection at the processing centre, too many mangoes, late arrival of customers) and to communication (lack of communication and time wasted during meetings). One mentioned the large distances from his farm.

3.11.2 Main markets for grafted mangoes

Despite the cooperative membership of about half of the farmers, all farmers except one reported to sell their mangoes individually. The main marketing channel for grafted mangoes was to sell to buyers coming to the farm (Table 13). More than 40% of the farmers in Mwingi West also sold their grafted mangoes on local village markets, versus 20% in Kitui Central. Together, these two markets take the largest share of the mango harvest. Almost 15% of the farmers in Kitui Central sold their grafted mangoes to the collection centre at the processing plant. Many farmers combined the sale of mangoes on local markets with one of the other marketing channels. Most of the farmers selling to the collection centre in Kitui Central also sold part of their mangoes on local markets, or to buyers coming to the farm. Five percent of farmers in Mwingi West sold all of their mangoes to a market outside the village.

Table 13: Percentage of farmers selling grafted mangoes at different marketing channels and average percentage of grafted mango harvest sold at this market

	Kitui Central		Mwingi West	
	Farmers selling	Harvest sold	Farmers selling	Harvest sold
Buyers coming to the farm	62%	84%	52%	78%
Local village market	21%	73%	43%	61%
Collection centre at the processing plant	14%	57%	0%	-
Market outside the village	1%	25%	5%	100%
Export market	2%	38%	0%	-

NB: farmers could mention multiple marketing channels

3.12 Mango cultivation in relation to other farm and off-farm activities

In both Kitui Central and Mwingi West, about two-thirds of the farmers indicated that their income from mangoes contributed half of their total income or more (Table 14). For 35% of farmers in Kitui Central this was less than half, but none of the farmers reported that it was very little. In Mwingi West, farmers also reported that mangoes contributed little to nothing.

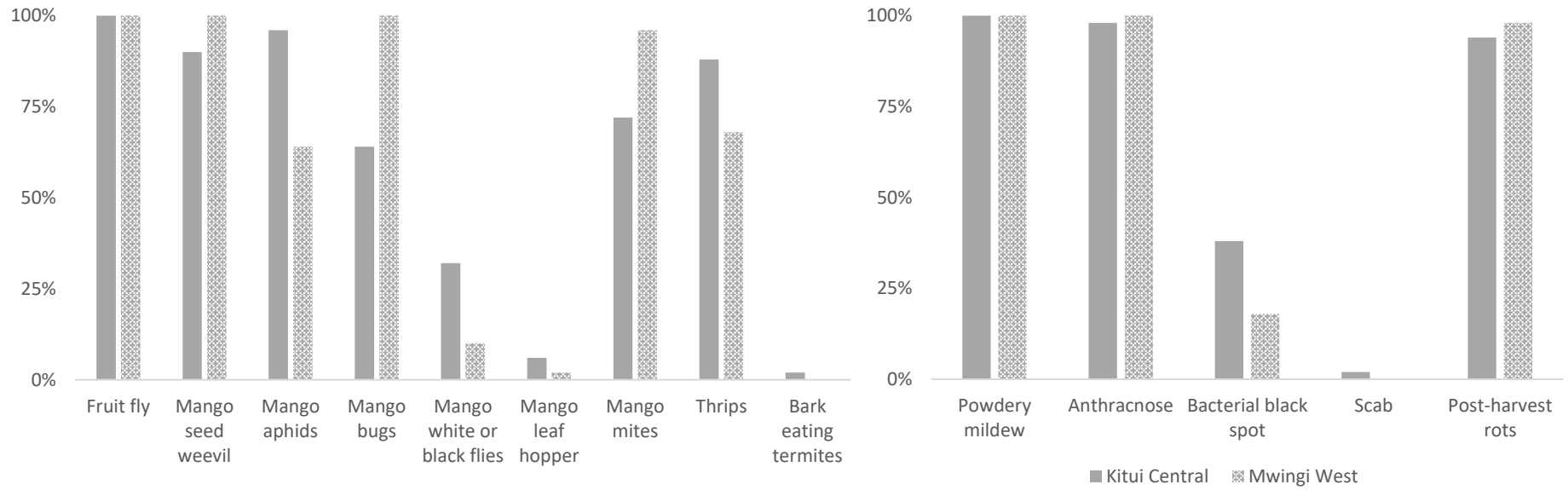


Figure 6: Common pests (left) and diseases (right) in mango cultivation in Kitui Central and Mwingi West, mentioned by % of farmers (farmers could mention multiple pests and diseases).

Table 14: Income from sales of mango in relation to total income (farm + off-farm income) in Kitui Central (n=17) and Mwingi West (n=36)*

	Kitui Central	Mwingi West
All	18%	14%
Most	29%	25%
Half	18%	28%
Less than half	35%	17%
Little	0%	17%
None	0%	3%
Total	100%	100%

** Data only available for farmers who reported having income from off-farm sources next to their farm income*

In terms of the crop land cultivated, many farmers reported the same size for their total land cultivated as the area cultivated with mangoes, even though these farmers also reported growing other crops (Figure 7 left). Therefore, the total land *owned* rather than *cultivated* was considered. Large-scale mange farmers tended to devote a relatively larger share of their land to mangoes than medium and small-scale farmers, although the ranges largely overlap (Figure 7 right).

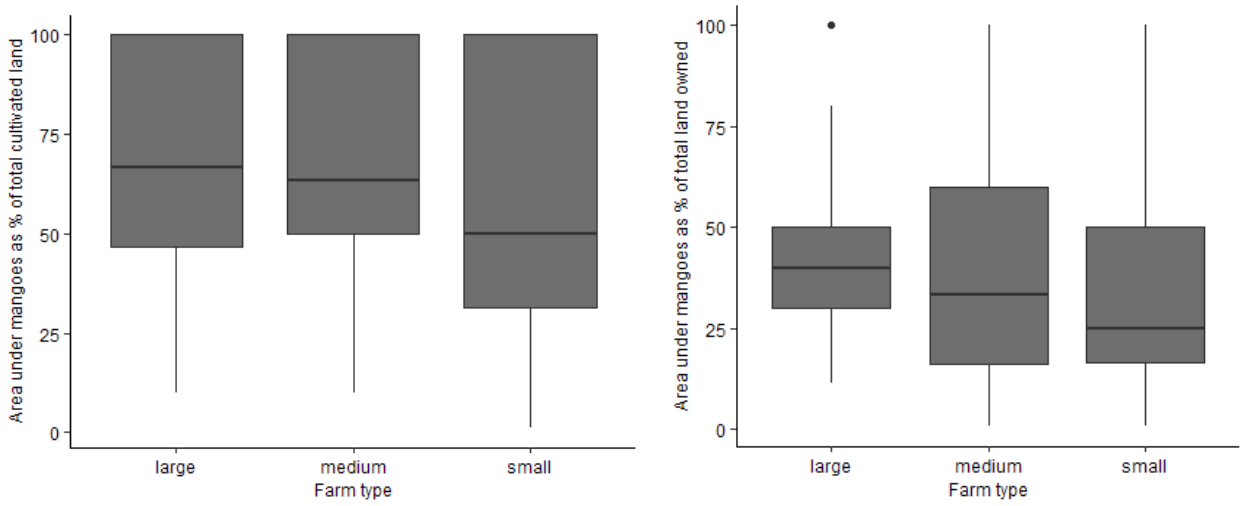


Figure 7: Area under mango cultivation as percentage of total cultivated land (left) and total land owned (right)

LABOUR ALLOCATION IN OTHER CROPS TO BE ADDED (TO COMPARE WITH LABOUR ALLOCATION IN MANGO CULTIVATION)

3.13 Yield of other crops grown on the farm

Farmers in the survey were selected for growing mango, so all of them grew mango. Next to mango, maize and beans were grown by almost all farmers, followed by pigeonpea and cowpea (Table 15). Banana, avocado, papaya and passion fruit were frequently grown fruits. Other, less frequently cultivated crops were (in order of importance) sorghum, tomato, oranges, millet, onions, sweet potato, barley, sugarcane and cotton.

Table 15: Percentage of farmers cultivating different crops in Kitui Central (n=50) and Mwingi West (n=51)

Crop	Kitui Central	Mwingi West
Maize	98%	100%
Bean	98%	98%
Pigeonpea	76%	92%
Cowpea	72%	47%
Banana	38%	41%
Avocado	60%	37%
Green gram	18%	33%
Cassava	18%	27%
Papaya	32%	20%
Passion	20%	18%

From the three most important crops that respondents selected, the majority of crops was cultivated in intercropping (Table 16). Especially in Kitui Central almost all crops were grown in intercropping.

Table 16: Number of farmers growing the most important crops and their percentage grown as sole and intercrops

	Kitui Central	Mwingi West	Kitui Central		Mwingi West	
	n	n	Intercrop	Monoculture	Intercrop	Monoculture
Maize	49	47	98%	2%	85%	15%
Bean	48	46	94%	6%	85%	15%
Pigeonpea	28	44	93%	7%	89%	11%
Cowpea	12	4	100%	0%	75%	25%
Green gram	3	2	100%	0%	100%	0%

Mean crop yields of most frequently mentioned crops are all relatively low: for maize about 1800 kg ha^{-1} and for the legumes all less than 1000 kg ha^{-1} (Figure 8). This is likely the result of intercropping.

3.14 Diversity of crops

On average, farmers in Kitui Central and Mwingi West grew about six different crops on their farm (ranging from 1 to 13) in addition to mango.

Farmers reported the field sizes of their three main crops, as well as the land devoted to mango cultivation. The total land under these four crops averaged 66% of the total land owned for large-scale mango farmers, 68% for medium and 73% for small-scale farmers (Figure 9). For 30% of farmers, these four crops accounted for less than 50% of their total land owned.

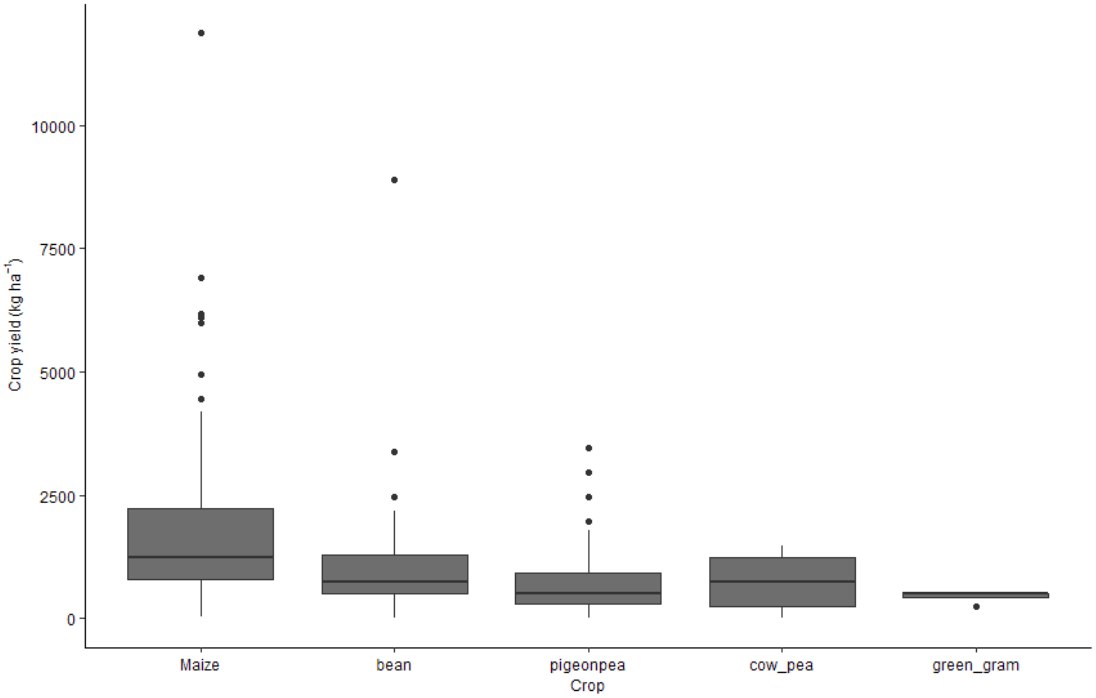


Figure 8: Crop yields of the most frequently mentioned crops (Kitui Central and Mwingi West combined)

NB: most crops were grown in intercropping

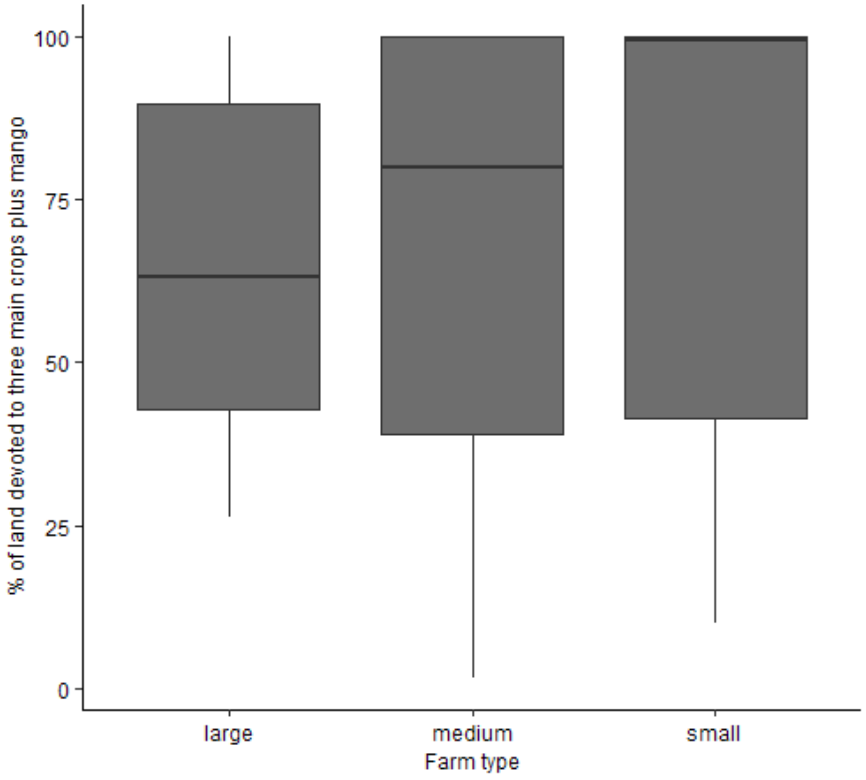


Figure 9: Percentage of total land owned devoted to the three main crops cultivated plus mango

NB: Farmers reporting land areas of > 100% of their total land owned were corrected to 100% (33% of cases)

3.15 Household sources of revenue

INCOME FROM DIFFERENT SOURCES IN USD STILL TO BE ADDED

In Kitui Central, only 36% of the farmers reported having off-farm sources of income, in contrast to 72% of the farmers in Mwingi West. Main sources of off-farm income were work for the government or public institutions, having an own business, and income from remittances (Table 17).

Table 17: Percentage of farmers indicating to earn income from off-farm activities in Kitui Central (n=50) and Mwingi West (n=51)

	Kitui Central	Mwingi West
Work for government or public institution	12%	20%
Casual labour off-farm	4%	8%
Have an own business	8%	28%
Remittances	8%	12%
Rent out land to others	4%	2%
Work in local business	0%	2%
Other	0%	4%

3.16 Food security

All farmers indicated that there are times in the year when less food is available compared with other times. Over the last year, the months with food shortages started in June in Kitui Central, and in August in Mwingi West (Figure 10). The peak of food shortage was from September to November.

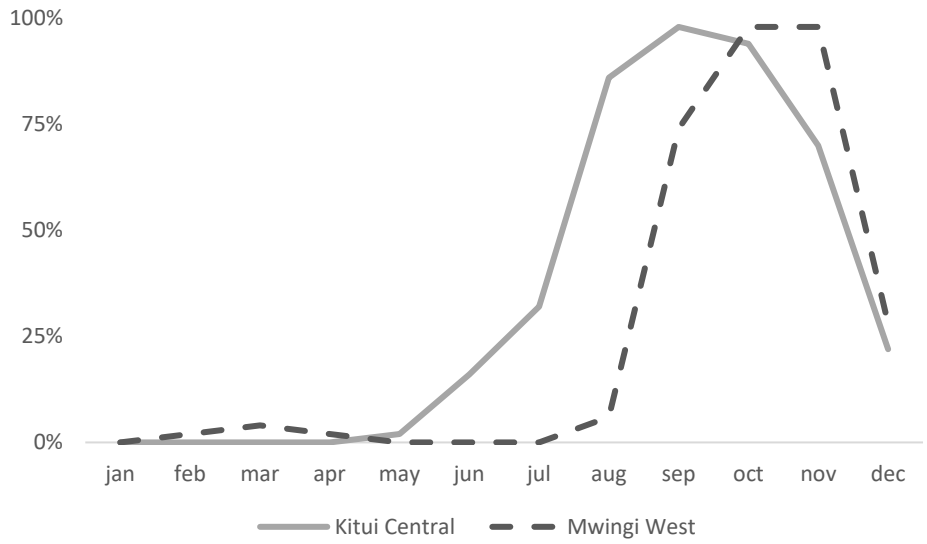


Figure 10: Percentage of farmers indicating months with food shortages in the last year

The majority of farmers in Kitui Central mentioned September and October as worst months in terms of food availability, and November in Mwingi West. Februari was considered the best month for food availability in both locations.

4. Conclusions

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