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Farmers' Sources and Varieties of Cassava Planting Materials in Coastal Kenya

Patrick Clay Kidasi, Dora Kilalo Chao, Elias Otieno Obudho and Agnes Wakesho Mwang'ombe*

Department of Plant Science and Crop Protection, University of Nairobi, Nairobi, Kenya

Cassava (*Manihot esculenta* Crantz) grows in diverse agro-ecological zones. In Kenya, it is widely cultivated in Western and Coastal regions. It is mainly grown for food and nutrition security and excess roots are sold to generate income for the farm households. Its productivity per unit of the land area is high compared to maize and wheat which are staple crops in the country. However, scarcity of cassava planting materials and pests and diseases limit production in these regions. This study aimed at revealing the sources and varieties of cassava planting materials used by farmers and other farmers' practices in coastal Kenya. Four focus group discussions (FGD) and a survey were conducted in 2018, using a semi-structured questionnaire targeting 250 farmers. The data collected on the sources of planting materials, preferred varieties and the practices employed by the farmers in cassava production, was analyzed using descriptive statistics. Majority of farmers (83%) interviewed indicated that they recycled planting materials from the previous crop while some 67% respondents obtained the planting material from their neighbors. Kenya Agricultural and Livestock Research Organization's (KALRO) and the local markets were reported as sources of planting materials by 11 and 5% farmer respondents, respectively. The only formal seed source reported was KALRO. The rest, own seed, neighbors, and the local markets, were informal seed sources. Piecemeal harvesting practiced by 98% of the farmers favored planting material recycling. Farmers dedicated a small proportion of their land (mean 0.2 ha) to cassava production as reported by 60 and 72.8% of farmers from Taita Taveta and Kilifi, respectively. Slightly above half (56%) of the farmers in Kilifi dedicated slightly more land to cassava, planting between 100 and 4,000 cuttings (2.5% of an acre up to a full acre) compared to 87% farmers from Taita Taveta who planted 100 cuttings or less (which is about 2.5% of an acre or less). A majority (81.1%) of farmers in Taita Taveta planted local cassava varieties compared to Kilifi's 57.8%. Slightly above half of the farmer respondents reported Kibandameno as the preferred variety followed by Tajirika as the second preferred variety as reported by 18% farmers. Kibandameno was preferred for its sweet taste by 75.6% farmers while Tajirika was preferred by 52.4% farmers because of the high yielding capacity. Nearly all farmer respondents, in Taita Taveta County obtained the planting material from informal seed sources, except a negligible number, who reported buying their planting material from KALRO, a formal seed source, far from their locality. Farmers sourcing cuttings from a formal seed source such as those from Kilifi County were

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***Correspondence:**
Patrick Clay Kidasi
patrickclay001@gmail.com;
patrickclay@students.uonbi.ac.ke

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more likely to use a tractor for land preparation compared to those who sourced planting materials informally who more likely had scarce knowledge on cassava production and the value of cassava. Therefore, interventions to establish a sustainable healthy cassava planting materials seed system are needed to address the systemic constraint and help develop a viable cassava value chain.

Keywords: cassava planting materials, varieties, formal seed source, informal seed source, Kilifi, Taita Taveta

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is an important food security crop for more than 800 million people across the tropics (Nassar et al., 2009) in many parts of the global South. It has higher energy yields (1,045 kJ ha^{-1}) compared to maize (836 kJ ha^{-1}) and rice (652 kJ ha^{-1}) (El-Sharkawy, 2003). Despite the energy benefits, there are health risks associated with the consumption of hydrogen cyanide found in cassava (Akinpelu et al., 2011). Cassava as a source of household income and employment, has been promoted as a staple and food security crop in sub-Saharan Africa (Ezedinma, 2017; Githunguri et al., 2017) and for commercialization in many regions because of its high carbohydrates content and gluten-free property (Suárez et al., 2017; Muchira, 2019; Mokhtar, 2020). Cassava is a suitable climate-smart crop for production in arid and semi-arid conditions where the land is fragile and the changing weather patterns often result in erratic rainfall and persistent droughts (Nhamo et al., 2017; Wattel et al., 2019). Nigeria is the largest cassava producer in the world with 53 million MT produced in 2019 (FAOSTAT, 2019). The success of cassava production in Nigeria partly lies in the rapid multiplication technique used, which has the potential of producing 12,000–24,000 stem cuttings per year (Leihner, 2002).

In Kenya, cassava is the second most important root crop after Irish potato grown throughout Kenya but mostly in the western, coastal, and Eastern regions (especially in arid and semi-arid areas) (Muinga et al., 2010; Githunguri et al., 2017). It is a drought-tolerant crop providing a basic diet for most rural households to address food insecurity and mitigate poverty (FAOSTAT, 2018). In 2017, an all-time high of 1,112,000 MT of cassava was produced from 90,400 ha (CUTS, 2019). Thus, cassava production stood at 12.3 MT/ha which is far below the potential 50 MT/ha (FAOSTAT, 2019). Like in other countries where cassava is grown, cassava production in Kenya, faces several limitations one of them being, unavailability of sufficient and appropriate planting material (Mukiibi et al., 2019; Shirima et al., 2019). Cassava has the potential to improve food security and livelihoods of the resource-poor rural farmers, processors, and their families (Suárez et al., 2017; Muchira, 2019; Mokhtar, 2020). Mitigating the challenge of cassava planting materials would contribute to increasing land under cassava and hopefully cassava productivity (Mwango'mbe et al., 2013; Shirima et al., 2019).

In most parts of the world, cassava seed systems are largely informal and operate without public-sector involvement in the production, supply, or quality control of planting materials (Dyer et al., 2011; Legg et al., 2014; McGuire and Sperling, 2016). This is because farmers' demand for planting materials is not met by both informal and formal seed sources. Consequently, the potential to increase cassava acreage and production is limited by insufficient quantities of good quality cassava planting materials (Osei et al., 2009; Mwango'mbe et al., 2013). Mwango'mbe et al. (2013) reported that, among other cassava production constraints, inadequate cassava planting materials could potentially cause a 64.7% decline in the area under cassava within Kilifi County in Kenya. A similar inadequacy of cassava planting materials has been reported in Ghana (Osei et al., 2009), Nigeria (Akinnagbe, 2010), and Tanzania (Nyanda, 2015). Inadequate supply and access of healthy cassava cuttings can also contribute to yield losses (Katono et al., 2015; Ukpe and Mustapha, 2016; Alicai et al., 2019). A limited number of studies have addressed the significant role played by seed sources, either formal or informal, in increasing cassava production and acreage (Alene et al., 2018).

According to Mukiibi et al. (2019) unavailability of cassava planting materials contributes to the recycling of cassava planting materials from the previous crop. Several studies have partly associated the recycling of cuttings, from the farmer's old crop or neighbors' seed, with disease transmission besides the whitefly vectors (Antony et al., 2004; Maruthi et al., 2005). Despite many studies concentrating on the production of healthy cassava planting materials with advanced technologies (Opabode, 2014; Neves et al., 2018; Efferth, 2019), evidence on the sustainability of their seed system and rapid multiplication is scarce (Vidal et al., 2015). In addition, a large number of preferred local and improved cassava varieties experience scarcity of planting materials, causing a real threat of varietal mixture, loss and poor identification (Le et al., 2019). Minisett technology intended for rapid multiplication of planting material (George et al., 2004) widely adopted for yam seed systems [Nath et al., 2007; Issac et al., 2012; Kerala Agricultural University (KAU)., 2016], is not in cassava whose cuttings are perishable and bulky (George et al., 2004; Nahar and Tan, 2012; Yadav et al., 2014).

Breeding for high-yielding and disease-resistant cassava varieties has been emphasized, but with little intervention to sustainably multiply and deliver improved variety planting materials to farmers (FAOSTAT, 2013). Often farmers recycle their crop unaware of the health of the cuttings (Mwango'mbe et al., 2013; Shirima et al., 2019). With the emerging phytosanitary challenges (Legg et al., 2014; McQuaid et al., 2016), there is a clear need for innovative approaches to develop a sustainable "clean seed system" (FAOSTAT, 2010; Shiji et al.,

2014; Castañeda-Méndez et al., 2017) that will provide sufficient quality healthy planting material and avail improved cultivars to the farmers.

The present study aimed to identify constraints related to cassava planting material, such as its sources, varieties and farmer practices in arid and semi-arid coastal areas of Kenya which have part of the population that is chronically food insecure. The knowledge would provide a basis for interventions to deliver quality healthy cassava planting materials with a hope of addressing the weak section of the value chain that limits growth of the cassava industry in Kenya.

MATERIALS AND METHODS

Study Area

The study was undertaken in Kilifi and Taita, two of the 47 counties in Kenya, located in the coastal region (**Appendix 1**). These two counties located in ASAL areas have a population that is chronically food insecure. Following the occurrences of drought and floods in 2019, 2.6 million people in the country were classified in IPC phase 3[1] and/or worse acute food insecurity with urgent actionable need. Moreover, 19% of the IPC population was from the Arid and Semi-arid Lands, which include Kilifi (209,996 people) and Taita Taveta (35,817 people) counties (IPC Global Platform, 2019). The choice of these two counties was motivated by the location in the Arid and Semi-Arid Lands (ASAL) of Kenya and provision of a cheap carbohydrate source for food security.

Kilifi County covers a geographical area of 12,245.9 Km^2 and the agricultural land is estimated to be 689,120 ha accounting for 55% of the total land area. The county has four agro-ecological zones (AEZs) namely: the Coconut-Cassava zone/Coastal Lowland zone (CL3), the Cashew nut-Cassava zone/Coastal Lowland zone (CL4), the Lowland Livestock-Millet zone/Coastal Lowland zone (CL5), and the Lowland Ranching zone/Coastal Lowland zone (CL6) (Jaetzold et al., 2010). Kilifi North and Kaloleni sub-counties where cassava is mainly grown, lie within CL3 and CL4 zones. These sub-counties are characterized by a mean annual temperature of 24°C, precipitation of 900–1,300 mm per annum and an altitude of 1–450 m above sea level. Kilifi county's population is largely rural (78.5%) and slightly over half (52.7%) of the household income in the county comes from agriculture [Government of Kenya (GoK), 2013]. Cassava, as a staple food and source of livelihood, only occupies 0.8% (5,779 ha) of the county's agricultural land [Ministry of Agriculture Livestock and Fisheries (Kenya), 2016].

Taita Taveta County covers a geographical area of 17,084.1 Km^2 with 62% of the land area within Tsavo National Park. The altitude ranges between 500 and 2,228 m above sea level. The terrain is diverse from lowland to highland areas. There are eight Agro-ecological Zones (AEZs) in the county which include lower highland zone (LH2), the upper midland zone 3 (UM3), the upper midland zone 4 (UM4), the low midland zone 4 (LM4), the low midland zone 5 (LM5), the low midland zone 6 (LM6), the lowland zone 5 (L5), and the lowland zone 6 (L6) (Jaetzold et al., 2010). The mean annual rainfall is 650 mm per annum and the average temperature 23°C [Government of Kenya (GoK), 2013]. A majority (95%) of the household income comes from agriculture [Government of Kenya (GoK), 2013]. Maize and beans are the main food crops and cassava is a minor crop for food security, among other crops grown in the county [Ministry of Agriculture Livestock and Fisheries (Kenya), 2016].

Data Collection

Research Design and Sample Size Determination

The study targeted cassava farming households in Kilifi North and Kaloleni sub-counties of Kilifi County and Mwatate, Wundanyi, Voi, and Taveta sub-counties in Taita/Taveta County. The inhabitants practiced agriculture as the main economic activity. A survey tool (questionnaire) was developed to gather information from the farming community in the two counties, on the socio-economic characteristics of the respondents, farm characteristics and farmer practices (**Appendix 2**). The survey was cross-sectional with descriptive and analytical parts.

The study purposely employed a multi-stage sampling procedure. The two counties were purposely selected for the location being in a region where cassava is mainly grown and for the farming patterns. The sub-counties in each county were selected purposely because these were the cassava growing areas within the counties. Systematic random sampling was used to select the households, which participated in the survey. The sample size was calculated using determined formulae and borrowing from other studies earlier conducted (Tirra et al., 2019).

A sample of 250 cassava farmers was selected to which the questionnaire was administered. The sample size used in this study was also based on another related study done by Tirra et al. (2019). The sample size was calculated using the formula described by Anderson et al. (2016) as follows;

$$n = \frac{p\left(1-p\right)Z^2}{E^2}$$

where n is the sample size, p is the proportion of the population having the major interest (in this case cassava cultivation), Z is the confidence interval and E is the margin of error. Since the proportion of the population in the study site was unknown, the values were set as $p = 0.5$, $Z = 1.96$, and $E = 0.062$.

The distribution of the 250 households was such that the households were divided equally among the two counties. Whereas, in Kilifi County, the 125 households were drawn from two sub-counties, the same number was divided between four sub-counties in Taita Taveta County. In Taita Taveta County, the population was sparse and fewer households were growing cassava. The sub-county agricultural officers in each sub-county, assisted by providing a sampling frame for cassava farmers within the targeted areas. Farmers with at least 50 cassava plants physically on the farm met the selection criterion. The second stage entailed a random selection of participants for the

[1]IPC phase 3 is a classification of Acute Food and Livelihood Crisis characterized by households marginally ability to meet minimum food needs particularly associated with irreversible coping strategies.

administration of the questionnaire. Randomizing guarantees population representation and cost-saving (Anderson et al., 2016).

Household Survey

The survey was conducted in July 2018. The survey tool, a semi-structured questionnaire was used in a face-to-face interview to gather information on the demographic characteristics of the farmers, sources of cassava planting materials, quantities planted in a normal season, cassava varieties and their preferred characteristics, cassava acreage and the cassava production practices. The face-to-face interview was conducted with either the head of the household, the cassava farmer, or the available person in the household with relative knowledge of cassava production. During the survey, geographical positioning coordinates of the farms visited were recorded. The semi-structured questionnaire was pre-tested by administering it to a total of 20 farmers randomly selected from the target sub-county during the FGDs. The questionnaire was corrected to accommodate adjustments following the pre-testing during the FGDs. The questionnaires were administered with the help of field assistants who knew the local language. In addition, the cassava farmers were informed of the ongoing exercise and prior appointments were made to reduce the chances of not finding the household heads/cassava farmers.

Focus Group Discussion

Focus group discussions (FGDs) were used to collect farmers' perceptions, farming practices, experiences and challenges related to cassava production in the two counties. It also provided an opportunity to raise awareness about the potential of the cassava crop following the long droughts in both counties, considering cassava is drought-tolerant and low-input crop (section Introduction) (**Appendix 3**). An FGD is a powerful tool used to elicit qualitative information from respondents with similar experiences (Heary and Hennessy, 2002). The intention here, was to bring together cassava farmers from the two counties and identify their perceptions, inconsistencies and variations. The outcomes of the FGDs were eventually used to put into perspective some of the findings reported in the household survey (section Household Survey).

In total, four FGDs were held in Kilifi and Taita Taveta counties, from 21st to 26th May 2018. The two FGDs in Kilifi were conducted in Tezo location (Kilifi North sub-county) and Kayafungo location (Kaloleni sub-county). The two FGDs in Taita Taveta County were conducted in Mwatate location (Mwatate sub-county) and Kitobo location (Taveta sub-county). These particular areas were selected to hold the FGDs because they were within the project area, centrally located and accessible by most farmers. Discussions involved over 30 farmers in each FGD deliberately invited through the group leadership.

Overall, 87 and 79 cassava farmers were purposively selected to participate in Kilifi and Taita Taveta, respectively. All participants were from farmer groups selected purposively on the basis that they had grown or were still growing cassava from lists provided by the farmer groups and sub-county extension officers in their respective sub-counties. The purposive selection of the farmers was carried out to achieve the recommendation as cited by Cameron (2005) and Dawson et al. (1993). While inviting suitable discussion participants, a third gender rule was adopted to ensure that in all groups both genders were represented. Freitas et al. (1998) attributed the improvement to the quality of discussions and their outcomes from a mixed-gender group. In Tezo location within Kilifi County, there were 4 men and 33 women in the FGD. Kayafungo location in Kilifi County had 29 men and 17 women. In Taita Taveta County, Mwatate location had 11 men and 33 women, whereas Kitobo location had 28 males and 7 female participants. Most studies preferred few numbers of participants in FGDs as reported by Smithson (2008) and Krueger and Casey (2000). However, this study had about 40 participants in each FGDs selected from farmer groups sparsely distributed in the sub-counties to maximize the diversity of information on cassava production. Besides having a skilled facilitator in the FGDs, there were clear objectives, suitable settings, appropriate subjects, relevant questions, and honoring of the participants, as described by Krueger (1998) to understand the experiences and reactions of cassava production.

The FGDs were guided by a facilitator using key questions (**Appendix 3**), ensuring even participation, maintaining a neutral attitude and making summaries after every question to reflect the opinion expressed and agreed by all. Agreement was through applause. Initially, the participants interacted with the respective facilitators to share and agree on the views, experiences, and practices. Divergent opinions or variations concerning cassava production were noted down for further prodding for explanations on diversity. These could arise from the difference in gender, locations, and group dynamics. Subsequently, the participants were divided based on gender for further discussion particularly on challenges facing each gender in cassava farming. Discussion in the second session was led by a facilitator of the same gender.

Data Analysis

The qualitative information elicited through the FGDs was subjected to direct content analysis to discover patterns from the responses of participants guided by the lead questions (Robson et al., 2018). In each of the FGDs, there were five assistants taking notes of the session whereby the skilled moderator engaged the participants in the discussion aided by the lead questions (**Appendix 3**). The notes included lists, ranks, identification, concessions, and explanations that arose from the discussions of the lead questions. As part of the analysis, each assistant produced a cleaned report on the participant's responses to each lead question. Thereafter, one report was consolidated for each of the four FGDs.

Multiple response data for farmers' sources of cassava planting materials and cassava varieties were grouped for multiple response analysis on IBM® Statistical Package for Social Sciences (SPSS), Version 21. For instance, the data of farmers' sources of cassava planting materials, land preparation techniques, local and improved cassava varieties grown and the preference of cassava varieties had multiple responses. Data for the two counties were presented as frequencies in the households sampled, percentages and cross-tabulations. A Chi-square test was used to determine

if there was an association between the dependent variables (Formal seed source and informal seed source) and independent variables (County, household gender, hiring a tractor for land preparation, use of hand-hoe for land preparation, use of ox-plow for land preparation, minimum tillage, production of cassava for income generation, received information on cassava production, the challenge of cassava planting materials, marketing challenge, member of a cassava group and access to credit) in the two counties at 5% significance level. Using formal and informal seed sources as dependent variables, the independent variables that showed significant association in the Chi-square test were further subjected to step-wise binary logistic regression to establish the strength of the association based on the odds ratio of the following statistical logistic model;

$$Logit\ (\Pi_i) = \log\left(\frac{\Pi_i}{1-\Pi_i}\right) = \beta_0 + \beta_1 x_i + \ldots + \beta_K x_K$$

where Π_i, β_0, β_1, x_i, β_K, and x_K represented the seed source, constant, coefficient of the kth variable, and the kth variable.

RESULTS

Demographic Characteristics and Farming Practices

Most of the sampled households were male-headed (82%) with an age range of 36–50 years and a mean of 43.6 years (**Table 1**). Households were large in both counties, with an average size of seven members. Females were extensively involved in farm activities. About a third of the respondents from Kilifi County had no formal education, while only 8.8% respondents in Taita Taveta County did not have formal education. Overall, 53.6% of respondents had primary school level education across the two sites, though literacy rates were much higher in Taita Taveta County. According to the FGDs, respondents in both counties plant and maintain cassava for subsistence and income generation. The FGDs consistently ranked cassava as the second most important crop (after maize in Kilifi County), but it was the least crop grown in Taita Taveta County in order of importance.

The household surveys revealed that the mean farm size was 1.4 ± 1.8 ha and that <15% (0.2 ha) was allocated to cassava production (**Table 1**). Approximately 60 and 72.8% of farmers in Kilifi and Taita Taveta County, respectively, allocated <0.2 ha for cassava production (**Figure 1**). More land was allocated for cassava production in Taita Taveta county and yet cassava was ranked the least crop grown among the top 10 crops grown in the county. This clearly indicates a challenge probably of either planting materials or market accessibility or cassava has no value. Approximately 67.2% of the survey respondents in Taita Taveta County had more than 5 years' experience in cassava production compared to 47.2% respondents in Kilifi County (**Table 1**).

On average, the most common means of land preparation were hand-hoe (51.0%), ox-plow (25.1%), tractor (23.6%), and minimum tillage (0.3%). Hand-hoeing was the most popular option for land preparation in both counties, but the order of importance varied for the remaining practices. Whereas, ox-plow and tractor were the most popular secondary options in Kilifi county, this was not the case in Taita Taveta County (**Table 1**). There was similarity in the area under crops and in the land preparation technique in both counties. Almost equal proportions, 51 and 48% of farmers from Kilifi and Taita Taveta,

TABLE 1 | Demographic and socioeconomic characteristics of cassava households' farmers.

Characteristic	Counties ($N = 250$)			*p*-value
	Kilifi (%)	Taita Taveta (%)	Pooled	
Age (years)				0.133^{ns}
<35	24	14.4	19.2	
36–50	39.2	48	43.6	
51–60	11.2	16	13.6	
>60	25.6	21.6	23.6	
Gender				0.41^{ns}
Male	80	84	82	
Female	20	16	18	
Level of education				0.001*
None	32.8	8.8	20.8	
Primary	46.4	60.8	53.6	
Secondary	20	20.8	20.4	
Tertiary	0.8	9.6	5.2	
Years of experience in cassava production (years)				0.003*
<5	52.8	32.8	42.8	
6–10	28	34.4	31.2	
11–15	6.4	20	13.2	
16–20	5.6	7.2	6.4	
>21	7.2	5.6	6.4	
Mean Farm size (Ha)	3.44	3.47	3.46	0.206^{ns}
Mean household size	7.59	6.08	6.84	0.028*
Use of hand-hoe for land preparation				0.001*
Yes	54.4	80.8	67.6	
No	45.6	19.2	32.4	
Use of ox-plow for land preparation				0.591^{ns}
Yes	31.2	35.2	33.2	
No	68.6	64.8	66.8	
Use of tractor for land preparation				0.001*
Yes	46.4	16		
No	53.6	84		
Use of minimum tillage for land preparation				1^{ns}
Yes	0	0.8	0.4	
No	100	99.2	99.6	
Farmers' groups receiving training on cassava production				0.001*
Yes	51.6	4.9	28.5	
No	48.4	95.1	71.5	

*$N = 250$ represented the total number of respondents in Kilifi and Taita Taveta counties; ns, not significant different at ($p < 0.05$); * significant level at 1%, ** significant level at 5%.*

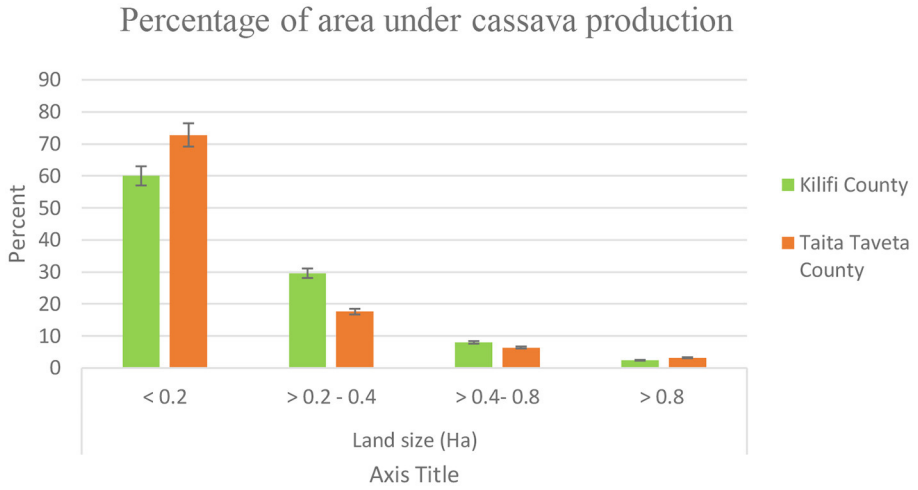

FIGURE 1 | Percentage of the area under cassava production (Ha). Source: Survey Data (2018).

TABLE 2 | Land preparation techniques and their corresponding land sizes.

Land preparation technique	Kilifi						Taita Taveta					
	The area under crops (Ha)						The area under crops (Ha)					
	<0.4		>0.4–0.8		>0.8		<0.4		>0.4–0.8		>0.8	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Hand-hoe	35	51	16	24	17	25	48	48	22	22	31	31
Ox-plow	15	38	11	28	13	33	22	50	9	20	13	30
Tractor	23	40	20	34	15	26	7	35	5	25	8	40
Minimum tillage	0	0	0	0	0	0	0	0	0	0	1	100

respectively, used hand-hoe for land preparation and that their land size was <0.4 ha (**Table 2**).

Approximately every household had at least 2–5 members that could be engaged in this activity in both counties. In addition, the labor costs associated with hand-hoeing were relatively low and affordable to most farmers. The rate for a 10 × 10 m plot was $ 4.94–6.91 per person (Average exchange rate in 2018: $ 1 = 101.2881 KES). Conversely, the cost of hiring a tractor from the county government was $ 49.36 per ha, but it is not reliable due to high demand and requires large areas to justify the investment. Tractor hiring costs from private owners were higher ranging from $ 74.05 to 86.39 per ha. The hilly terrain of Taita Taveta County impedes tractor usage during land preparations.

Cassava Varieties Grown and Their Preferred Traits

The responding farmers grew different local, improved, or combinations of cassava varieties in both counties. Respondents from Kilifi County reportedly grew four types of local cassava varieties, namely Kibandameno (40.5%), Mnusu (0.9%), Mjagu (0.4%), and Mthune (0.4%) in order of occurrence and seven improved cassava varieties namely Tajirika (24.1%), Kaleso (14.2%), Agriculture (6.9%), Shibe (7.3%), Karembo (3%), Nzalauka (1.3%), and Karibuni (0.9%). Farmers in Taita Taveta County grew three local cassava varieties, namely Kibandameno (77.4%), Binti Asmani (2.8%), and Mjagu (0.9%) and three improved cassava varieties namely Agriculture (11.3%), Tajirika (3.8%), and Kaleso (3.8) (**Table 3**).

Kibandameno was particularly preferred as reported by majority (77.4%) respondents followed by Agriculture cassava variety (11.3%) in Taita Taveta County. During the FGDs, farmers in both counties confirmed that Agriculture cassava variety was earlier distributed by agricultural extension officers, therefore partly explains its second position in preference. Overall, slightly over half (52%) of the respondents, variety (52%) was mostly preferred Kibandameno followed second by Tajirika variety as reported by about a fifth (18%) of the respondents. This was the opposite during the FGDs (**Table 3**). Distinct differences existed in the choice of either local or improved cassava varieties in the two counties. For example, a majority (81.1%) of the farmers had local cassava varieties but only 18.9% account for improved cassava varieties in Taita Taveta County. There were 42.2 and 57.8% of the farmers with local

TABLE 3 | Cassava varieties preferred by farmers.

Cassava variety	Kilifi		Taita Taveta		Total	
	Percent	Count	Percent	Count	Percent	Count
Kibandameno*	40.5	94	77.4	82	52	176
Tajirika	24.1	56	3.8	4	18	60
Kaleso	14.2	33	3.8	4	11	37
Agriculture	6.9	16	11.3	12	8.3	28
Shibe	7.3	17	0	0	5	17
Karembo	3	7	0	0	2.1	7
Binti Asmani*	0	0	2.8	3	0.9	3
Nzalauka	1.3	3	0	0	0.9	3
Karibuni	0.9	2	0	0	0.6	2
Mnusu*	0.9	2	0	0	0.6	2
Mjagu*	0.4	1	0.9	1	0.6	2
Mthune*	0.4	1	0	0	0.3	1
Total	**100**	**232**	**100**	**106**	**100**	**338**

The varieties with an asterisk (*)are local varieties; the rest are improved varieties.

TABLE 4 | Local and improved cassava varieties grown in Kilifi and Taita Taveta counties.

Cassava variety	Kilifi		Taita Taveta		Total	
	Percentage	Count	Percentage	Count	Percentage	Count
Local varieties	42.2	98	81.1	86	54.4	184
Improved varieties	57.8	134	18.9	20	45.6	154
Total	**100**	**232**	**100**	**106**	**100**	**338**

TABLE 5 | Distances by road of KALROs the study area sub-counties.

Kenya Agricultural Research Institute (Arid and Range Land Research Institute), Kiboko, Makueni County				**Kenya Agricultural Research Institute (Arid and Range Land Research Institute), Mtwapa, Kilifi County**	
Taveta sub-county	Wundanyi sub-county	Mwatate sub-county	Voi sub-county	Kilifi North sub-county	Kaloleni sub-county
214 Km	213 Km	199 Km	174 Km	40.2 Km	28.8 Km

Distances determined from the Google Maps (https://www.google.co.ke/maps).

and improved cassava varieties, respectively, in Kilifi County (**Table 4**). These results can be attributed to the respective distances to KALRO stations that have a collection of cassava varieties. For instance, KALRO (Industrial Crops Research Institute) Mtwapa is within Kilifi County whereas KALRO (Arid and Range Land Research Institute) Kiboko is in Makueni County (**Table 5**).

The preference of cassava varieties is determined by acceptance by farmers following continuous observations over many years. Therefore, over three-quarters of the farmers failed to recall when most of the cassava varieties were introduced but only 21% revealed that Tajirika was introduced about 10 years back. Furthermore, 16% of respondents reported that Kibandameno had existed for over 10 years. During the FGDs farmers showed preference to Tajirika owing to its pests and disease tolerance and high yielding properties. Conversely, Kibandameno was preferred because of its sweet taste. The relationship between years and the sweet taste of Kibandameno demonstrates its value to most farmers. In addition, the survey data revealed that 75.6% of farmers attributed sweet taste, 61% drought tolerance and 56.4% good cooking quality as their most preferred traits in Kibandameno. About a third (30.5%) of the farmers reported Kibandameno as being convenient for subsistence utilization owing to its early maturity within 6–8 months after planting, despite being a low yielding variety. On the other hand, 52.3% of the farmers attributed high yielding, 17.1% drought tolerance and 28.6% tolerance to pests and diseases as preferred traits in Tajirika variety. Consequently, Tajirika traits were perceived by farmers as ideal for commercial purposes. Local cassava varieties such as Binti Asmani, Mnusu, Mjagu, and Mthune were scarce and sparsely distributed. Therefore, traits like the sweet taste, good cooking quality, and drought tolerance were not familiar except to the few farmers who had the local varieties (**Table 6**).

Quantity of Cassava Cuttings

In Taita Taveta, most of the respondents (87.2%) plant <100 cuttings, whereas in Kilifi County 56% of farmers plant between 100 and 4,000 cuttings (**Table 7**). This reflects well the rather different land allocation for cassava production in the two counties (**Table 1**, **Figure 1**). The FGDs in Taita Taveta County revealed that majority of farmers planted cassava cuttings in lines that are spaced 10 meters or more, as a border crop or randomly sparse in the fields purposely to intensify intercropping with maize and bananas. Planting of fewer cuttings (<100) in Taita Taveta County could be attributed to the spacing of cassava at planting to facilitate intercropping of other prioritized crops. In addition, farmers in Taita Taveta County consistently reported invasions by mammals and rodents such as elephants and moles, in cassava farms from the neighboring Tsavo National Parks (section Study Area). This could also lead to planting fewer cuttings of cassavas. Conversely, most farmers in Kilifi County agreed on planting cassava evenly at a spacing of 1 m. With this one-meter spacing, effective intercropping was possible for about 3–5 months after planting before cassava developed a large canopy to inhibit the growth of other crops underneath.

Sources of Cassava Planting Material and Knowledge

The household survey revealed that in both counties households have multiple sources to access the cassava planting material. In Kilifi County, 76% of the farmers used own planting material, 81% received seeds from their neighbors, 11% bought seeds from the local market, and 20% from KALRO. In Taita Taveta County most of the farmers used own cuttings (89%), 54% received seeds from neighbors, and 2%, bought from KALRO. Most respondents indicated that few local markets had cassava cuttings for planting.

TABLE 6 | Farmers' preferred traits in cassava varieties.

Cassava variety	High yielding		Drought tolerance		Pests and diseases tolerance		Sweet taste		Good cooking quality	
	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*
Kibandameno	30.5	46	61	25	28.6	4	75.6	93	56.4	9
Tajirika	52.3	79	17.1	7	42.9	6	8.9	11	0	0
Kaleso	7.9	12	12.3	5	14.3	2	8.2	10	25	4
Agriculture	4.6	7	2.4	1	7.1	1	5.7	7	6.2	1
Shibe	2.6	4	2.4	1	7.1	1	0	0	0	0
Karembo	0.7	1	2.4	1	0	0	0.8	1	0	0
Binti Asmani	0	0	0	0	0	0	0.8	1	6.2	1
Nzalauka	0	0	0	0	0	0	0	0	0	0
Karibuni	0.7	1	0	0	0	0	0	0	0	0
Mnusu	0.7	1	2.4	1	0	0	0	0	0	0
Mjagu	0	0	0	0	0	0	0	0	6.2	1
Mthune	0	0	0	0	0	0	0	0	0	0
Total	**100**	**151**	**100**	**41**	**100**	**14**	**100**	**123**	**100**	**16**

TABLE 7 | Amount of cuttings sourced for planting.

Number of planted cuttings	Kilifi		Taita Taveta		Total	
	Percent	Count	Percent	Count	Percent	Count
<100	41.6	52	87.2	109	64.4	161
>100–500	18.4	23	8	10	13.2	33
>500–1,000	12.8	16	4.8	6	8.8	22
>1,000–4,000	24.8	31	0	0	12.4	31
>4,000	2.4	3	0	0	1.2	3
Total	**100**	**125**	**100**	**125**	**100**	**250**

TABLE 8 | Cassava seed sources in Kilifi and Taita Taveta counties.

Cassava seed sources	Kilifi		Taita Taveta		Total	
	Percent	Count	Percent	Count	Percent	Count
Farmers' seed	76	94	89	109	83	203
Neighbors' seed	81	100	54	66	67	166
Local market	11	13	0	0	5	13
KALRO	20	25	2	2	11	27
Total		**123**		**123**		**246**

Of the four sources of cassava planting materials, KALRO was the only formal seed source while the rest were informal (**Table 8**). In the context of cassava sources, the formal seed entails seed production activities operated by either public or commercial sectors whereas informal are the total of farmers' production, selection, and exchange of seed activities (Almekinders, 2000). Relatively few farmers had utilized the formal seed source to have their first crop, the "seeds" of which are recycled for the subsequent planting seasons.

Focus group discussions participants corroborated that intensive recycling of cassava planting material from own plots, neighbors, and local markets' seed was practiced by farmers. The respondents indicated that the piecemeal harvesting technique[2] was widely adopted for the subsistence and commercial utilization of cassava roots. This technique is very prevalent as it assures the availability of cuttings for the next planting season. Indeed, the survey revealed that 98% of the cassava farmer respondents practice piecemeal harvesting. Unfortunately, this piecemeal harvesting is disadvantageous because it has the potential to influence the concentration of cyanide (bitterness) and rotting of the remaining roots on the ground as perceived by most farmers in both counties.

Knowledge transmission of cassava production by the sub-county agricultural officers to farmers differed in these two counties. Training on practical skills of cassava growing and other crops was delivered through organized farmer groups. During the survey, slightly over half of the cassava farmer respondents in Kilifi County had received information on cassava crop husbandry, unlike in Taita Taveta County, where <5% of respondents had received training (**Table 1**). These trainings were conducted at least twice per month to impart skills such as cassava husbandry, storage of cuttings, pest, and disease management. Part of the information dissemination mentioned during FGDs involved farmers teaching one another on the best practices of cassava crop husbandry shared by the sub-county agricultural officers. Furthermore, most farmers in Taita Taveta, who did not have frequent training, mentioned that they relied on indigenous techniques passed down through generations. These skills included slanting cuttings while planting, hand weeding around the cassava root ground region and observation of ground cracking as a sign of maturity of roots in the soil.

Characteristics of Farmers Sourcing From Formal and Informal Seed Sources

Only two farmers in Taita Taveta County obtained cassava from a formal seed source. Therefore, only data of Kilifi farmers

[2]Piecemeal harvesting technique involved the harvesting of a portion of roots in the soil and leaving the rest attached to the cassava crop for the future.

TABLE 9 | Traits of farmers sourcing from formal and informal seed sources in Kilifi County.

Independent variable		Formal seed source %	Informal seed source %	Chi-square	*p*-value	Phi	Adjusted residual
Household head gender	Female	8.8 (11)	11.2 (14)	11.250	0.001*	−0.3	−3.4
	Male	11.2 (14)	68.8 (86)				3.4
Hiring a tractor	Yes	17.6 (22)	28.8 (36)	21.745	0.001*	0.417	−4.7
	No	2.4 (3)	51.2 (64)				4.7
Use of an ox-plow	Yes	3.2 (4)	28 (35)	3.364	0.067^{ns}	−0.164	−1.8
	No	16.8 (21)	52 (65)				1.8
Use of Hand-hoe	Yes	8.8 (11)	45.6 (57)	1.363	0.243^{ns}	−0.104	−1.2
	No	11.2 (14)	34.4 (43)				1.2
Production of cassava for food	Yes	20 (25)	79.2 (99)	0.252	0.616^{ns}	0.045	−0.5
	No	0 (0)	0.8 (1)				0.5
Production of cassava for income generation	Yes	17.6 (22)	61.6 (77)	1.469	0.226^{ns}	0.108	−1.2
	No	2.4 (3)	18.4 (23)				1.2
Produce cassava for soil conservation	Yes	1.6 (2)	0.8 (1)	4.184	0.041**	0.183	−2
	No	18.4 (23)	79.2 (99)				2
Received training on cassava production	Yes	14.5 (18)	37.1 (46)	5.211	0.022**	−0.205	−2.3
	No	5.6 (7)	42.7 (53)				2.3
Challenge of cassava planting materials	Yes	9.6 (12)	53.667	3.104	0.078^{ns}	−0.158	−1.8
	No	10.4 (13)	26.433				1.8
Marketing challenges	Yes	11.2 (14)	12.8 (16)	17.544	0.001*	0.375	−4.2
	No	8.8 (11)	67.2 (84)				4.2
Member of cassava group	Yes	16.8 (21)	24.8 (31)	23.125	0.001*	−0.43	−4.8
	No	3.2 (4)	55.2 (69)				4.8
Access to credit	Yes	13.7 (17)	15.3 (19)	25.239	0.001*	−0.451	−5
	No	5.6 (7)	65.3 (81)				5

*Values in brackets under the formal and informal seed sources represented their respective frequencies of participants in Kilifi County. The percentages are from the total frequencies (counts) of formal and informal seed sources of each independent variable. *Significance level at 1%, **significance level at 5%, and ^{ns}not significantly different.*

was analyzed to establish their characteristic relationship with sourcing either formal or informal seeds sources. The Chi^2 test revealed sourcing from either formal or informal seed had no association with the use of ox-plow, hand-hoe, production of cassava for food, income generation and the challenge of cassava planting materials in Kilifi County. Of the 125 farmers interviewed in Kilifi, 68.8% male-household heads sourced informal seeds whereas 8.8% female-household heads sourced formal seeds. About a fifth (17.6%) respondents reported the possibility of hiring a tractor for land preparation and sourcing of formal seed. Only 14.5% farmers who received training on cassava production and 16.8% farmers belonging to a farmers' group sourced formal seeds. Majority, 67.2% participants sourced planting materials informally and had no market challenges. This can be attributed to their subsistence utilization rather than commercialization. During the FGDs in Kilifi, majority of farmers agreed that the lack of market limits commercialization and production of cassava. Few farmers sourcing from either formal (13.7%) or informal (15.3%) seed sources reported investing in cassava production as evidenced by their access to credit (**Table 9**).

The significantly different independent variables (**Table 9**) determined from the Chi^2 test were further subjected to a step-wise binary logistic regression (Tranmer and Elliot, 2008) and established the following equation:

$$Logit\ (\Pi_i) = -0.346 - 1.705x_{i_1} + 2.044x_{i_2} + 2.702x_{i_3} + 1.117x_{i_4} + 1.473x_{i_5} - 1.819x_{i_6} - 0.589x_{i_7}$$

Where Π_i = formal seed source in Kilifi County, x_{i_1} = male household head, x_{i_2} = use of a tractor for land preparation, x_{i_3} = production of cassava for soil conservation, x_{i_4} = receiving training on cassava production, x_{i_5} = experiencing marketing challenges, x_{i_6} = member of a cassava group and x_{i_7} = access to credit for cassava production.

Among the variables assessed in the binary logistic regression, the male-headed households, use of a tractor for land preparation and experiencing marketing challenges were significantly different ($p < 0.05$). Farmers in Kilifi County using a tractor for land preparation and experiencing marketing challenges had a positive association with sourcing formal seed. From this data, it can be elucidated that there are farmers with the potential to invest in cassava production but marketing challenges impedes their effort. This further revealed that cassava production should not only be addressed on the unavailability of planting materials but all challenges across its value chain. The use of ox-plow and hand-hoe depicts scarce resources for the cassava farmer but there was a willingness to inject the meager resources into

cassava production for its perceived value. It also indicates that cassava growing requires minimal resources and could be attended to using relatively cheap land preparation methods. Male-headed household was negatively associated with sourcing formal seeds (**Table 10**).

In brief, with the male household head, production of cassava for soil conservation, received training on cassava production, experiencing marketing challenges, member of a cassava group and access to credit to finance cassava production adjusted, a farmer using a tractor for land preparation is about 8 times [Exp(B) = 7.723] more likely to source from a formal seed source (95% CI: 1.284, 46.451; $p = 0.026$). On the other hand, by adjusting the male household head, use of a tractor for land preparation, production of cassava for soil conservation, received training on cassava production, member of a cassava group and access to credit to finance cassava production, a farmer experiencing cassava marketing challenges is 4 times [Exp(B) = 4.36] more likely to source from a formal seed source (95% CI: 1.43, 16.628; $p = 0.031$) (**Table 10**).

DISCUSSION

Demographic and Farmer Characteristics

The study has found extensive adoption of informal seeds particularly from farmers' own and the neighbors' seeds, that contribute to recycling. Similar findings were reported by Buthelezi and Ngobeni (2015) in South Africa, with farmers' seed leading with 91%, ahead of neighbors and relatives at 71 and 8%, respectively. Elsewhere, Chikoti et al. (2016) also reported the sourcing of cassava cuttings from farmers' fields (34.7%), neighbors' (39%), and the Ministry of Agriculture and Cooperatives (33.3%) in Samfya district of Zambia. Recycling of cassava planting materials plays a role in degenerating the quality of the cuttings through pests and diseases and poor post-harvest handling. In this study, it was found that recycling of cuttings is intensified by piecemeal harvesting techniques, largely practiced by farmers in the region as a method of preserving the mature roots and by the distances from seed sources and storage challenges. Hence, the farmers opted to use the easiest route which is the crop in their field or from the neighbor, unaware of the crop and human health risks. According to Mwango'mbe et al. (2013), recycling of cassava cuttings is due to the scarcity experienced, because of the ravages of climate (long droughts) and for lack of innovative multiplication techniques. Considerable distances from most formal seed sources and storage challenges have been reported by Mdenye et al. (2018) and El-Sharkawy (2003). Moreover, the characteristic of low multiplication in cassava (Otoo, 1994) associated with their relatively high cost per cutting and perishability (Mdenye et al., 2018) promotes recycling.

Also, this study found three means of land preparation but most cassava farmers use marginal resources, such as the hand-hoe with family-based manpower with few hiring a tractor and an ox-plow for use. A few farmers (**Table 3**) had financial potential and were able to source formal seed and hire a tractor for land preparation in Kilifi County. According to some authors, despite the constraint of fertility and low inputs interventions, reasonable yield can be realized at harvesting (Nweke et al., 2002; Mutegi-Murori, 2010). Several studies have shown that majority of farmers depend on family labor for cassava production (Dixon et al., 2003; Wiggins, 2009; FAO, 2015). More cassava production was evident in Kilifi County following the allocation of more land for cassava relative to Taita Taveta County. Apart from its sparse distribution, cassava is planted as an intercrop with others in the field in Taita Taveta County. This demonstrates the low preference and value cassava holds as a crop in Taita Taveta County. Few stems are grown sparsely to provide enough space for intercropping with other crops throughout the production period. This study further provides the quantities of cuttings sourced by farmers that were partly contributed by the value endorsed on cassava and the relative knowledge about it. The risk-averseness of market-oriented cassava farmers was not only based on the availability of a market (Nassar and Ortiz, 2010), but also the increased cost of production particularly incurred on the planting materials (Onyemauwa, 2020).

According to Ndunguru et al. (2015), cassava seed scarcity has resulted in the loss of some varieties, particularly the local varieties. As observed in this study, majority of the farmers had a challenge in recalling the introduction of some improved varieties and a few local varieties that were partially acknowledged in terms of the traits. Despite the presence of various local and improved cassava varieties, there is a major challenge for scarcity of planting materials which may lead to variety mixture, loss, poor identification and naming (Le et al., 2019) apart from preventing the development of the cassava industry. Few local varieties exist following their preferred traits by most farmers and are maintained by intercropping with other crops in the field. Similar findings have been reported by Nakabonge et al. (2018). Owing to the commercialization of cassava due to its gluten-free property (Ziska et al., 2009) and for subsequent value additions (Lekule and Sarwatt, 1992; Kuiper et al., 2007; Enidiok et al., 2008), there is a desire for traits, like high yielding potential and tolerance to pests and disease, as is with the case for Tajirika variety [Kenya Agricultural Research Institute (KARI), 2008; Mwango'mbe et al., 2013; Saggafu et al., 2019]. Therefore, breeding for cassava varieties should be considered to address preferred traits by farmers (Kamau et al., 2016; Badewa et al., 2020) and other cassava value chain actors, such as millers, but incorporate a component of multiplication to avail the same to small scale farmers. This study has captured most local cassava varieties with farmers, unlike many studies that dwell on improved varieties (Abdoulaye and Sanders, 2002; Opabode, 2014).

Policy and Practical Implications and Recommendations

The transition of cassava status from subsistence to a commercial crop is delayed by inadequate policies that are not effective to match with cassava industry dynamics. The cassava value chain is largely appreciated based on value addition on

TABLE 10 | Variables in the Equation of farmers sourcing from a formal seed source in Kilifi County.

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
Step 1[a]	Gender of the household head (Male)	−1.705	0.716	5.675	1	0.017**	0.182	0.045	0.739
	Use of a tractor for land preparation (Yes)	2.044	0.915	4.987	1	0.026**	7.723	1.284	46.451
	Production of cassava for soil conservation (Yes)	2.702	2.193	1.518	1	0.218[na]	14.905	0.203	1095.574
	Training on cassava production (Yes)	1.117	0.901	1.535	1	0.215[na]	3.055	0.522	17.877
	Marketing challenge	1.473	0.683	4.649	1	0.031**	4.360	1.143	16.628
	Member of a cassava group	−1.819	1.060	2.943	1	0.086[na]	0.162	0.020	1.296
	Access to credit	−0.589	0.801	0.540	1	0.463[na]	0.555	0.115	2.670
	Constant	−0.346	1.554	0.050	1	0.824	0.707		

[a]*Variable(s) entered in step 1: gender of the household head, use of a tractor for land preparation, production of cassava for soil conservation, received training on cassava production, marketing challenge, member of a cassava group, access to credit.* *Significance level at 1%, **significance level at 5%, and [na]no association.

the yields rather than its production facets especially the planting materials. In Kenya, the Seeds and Plant Varieties Act (Cap 326) governs the cassava seed industry, however, cassava being vegetatively propagated is largely dominated by informal seed sources as attributed to the endemic diseases and the associated cost in securing the formal seed certification. Lack of policies on cassava-based products has also contributed to low production and motivation of investing in cassava. For instance, Nigeria is a leading producer of cassava, which is partly because of the associated policies that enhance production and utilization, contrary to Kenya.

This study has revealed that farmers who received training on cassava production are inclined to frequent utilization of cassava cuttings, even if from informal sources, like their own seed. Given that own seed, as an informal source, was the major practice by most farmers, it is necessary to estimate the demand for cuttings for planting. This will provide evidence for the need to mitigate against inadequate quality cassava planting material as a limitation to production. Moreover, the National Cassava Policy and the Seed and Plant Varieties Act (Cap 326) of Kenya have a challenge in coordination and formal linkages. Therefore, the realization of policies, such as the adoption of a minimum of 10 and 20% substitution of wheat with cassava flour for bread and in other baked products and confectionaries, respectively, cannot be implemented. It is important to ensure enabling environments particularly, access to healthy cassava planting materials and researched-based extension packages and technologies and extensive awareness on cassava.

It is paramount that a sustainable healthy cassava planting material seed system be developed to prevent recycling that largely plays a role in degenerating the quality of planting material. The degeneration may be because of the presence of pests and diseases and post-harvest handling, among other factors. The seed system will deliver improved varieties to cassava farmers. Addressing this systemic constraint along the cassava value chain will help grow the cassava industry. There is a need for more extensive training of cassava farmers in Taita Taveta County to realize the potential for cassava as a crop and improve lives through employment, income generation, and increased household food security.

CONCLUSION

Herein, there is evidence that there are two main sources of cassava cuttings that is the informal and formal seed sources. Cassava farmers from Kilifi and Taita Taveta Counties mainly use the informal seed sources by recycling their own or neighbors' cassava cuttings. All this is occasioned by the scarcity of cassava planting materials, a main constraint in the cassava value chain in the region. There are many cassava varieties, both improved and local and the farmers prefer Kibandameno (a local cultivar) for food and Tajirika (an improved cultivar) for income generation. Cassava production is more valued in Kilifi, inclining toward improved varieties than in Taita Taveta, that plant more of the local varieties, but both counties mainly grow cassava for food security.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

PK was actively collected the survey data, analyzed, and draft the manuscript. DC and AM was instrumental in developing of the survey and focused group discussions lead questions, commenting, and guiding through the entire manuscript. EO was key help on developing of the semi-structured questionnaire and data analysis. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2021.611089/full#supplementary-material

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