

# The Influence of Pandemic Viral Diseases and Drought On Cassava Production in Southeastern Tanzania

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## Abstract:

Cassava (*Manihot esculenta* Crantz) is a key staple food and sanctuary crop, predominantly grown by women-headed households in the coastal belt and lake zones of Tanzania. However, its production and productivity is mostly affected by abiotic factors such as drought and biotic like Cassava Mosaic Disease (CMD) and Cassava Brown Streak Disease (CBSD). The current study evaluated how pandemic viral infections and drought affected cassava productivity and production in Mtwara and Lindi. The study used a cross-sectional research design to collect primary data from 120 smallholder cassava producers. Descriptive statistics were used to analysis qualitative data while disease severity, incidence, whitefly population abundance and CBSD necrotic; information methods were used to assess the influence of diseases on cassava production and productivity. Results showed that the majority of cassava growers suffered insufficient rainfall (84%), late onset rainfall (65%), high temperature and pro-longed dry spells due to drought incidences (58%). Moreover, cassava growers reported that poor root quality (76%) and reduced cassava yield (88.5%) were two of the significant effects of CBSD and CMD on cassava output in the studied area. To enhance cassava production and reduce yield losses, the present study recommends the increased awareness campaigns on availability, accessibility and use of improved cassava varieties which are resistant and/or tolerant to drought, diseases and insect-pests in the study area. This must be accompanied by viable agronomic packages for prospective cassava cultivation in Tanzania at large.

**Keywords:** Cassava, drought, Yield loss, Cassava brown and mosaic disease, Mtwara and Lindi

## 1. Introduction

Cassava (*Manihot esculenta* Crantz) is a vegetatively propagated root crop that sustains over a billion people globally [1]. It serves as a staple food for approximately 800 million individuals worldwide [2] and ranks as the tenth most-produced food crop globally, the foremost in Africa, and the third most significant in Tanzania [3]. Cassava is cultivated on approximately 27.52 million hectares worldwide,

with Africa accounting for 78.6% of this area (192.1 million hectares) and Tanzania contributing nearly one million hectares, representing 3.6% of the global cassava cultivation [3]. Global cassava root production is estimated at 303.57 million tons, of which Africa produces 63.3% (192.1 million tons), while Tanzania contributes 2.7% (8.18 million tons) [3].

In Tanzania, cassava is a critical staple crop and a pillar of food security, particularly in the coastal and lake zones, second only to maize. Predominantly cultivated by smallholder farmers many of whom are female-headed households residing in semi-arid regions the crop plays a crucial role in subsistence agriculture [3]. Cassava offers multiple agronomic advantages, including high drought tolerance and the ability to thrive in nutrient-deficient soils with minimal rainfall and agricultural inputs, making it one of Africa's most resilient food crops [4,5]. Beyond its role in food security, cassava increasingly serves as an economic asset, with its fresh roots and processed derivatives such as high-quality cassava flour (HQCF), starch, ethanol, and pharmaceutical ingredients contributing to income generation [6].

Despite its potential, cassava production in Tanzania remains suboptimal. The estimated average fresh root yield stands at 5.7 t/ha [6,3], significantly below its genetic yield potential of 75–90 t/ha [7]. Productivity is severely hindered by both biotic and abiotic stressors, particularly two devastating viral diseases Cassava Mosaic Disease (CMD) and Cassava Brown Streak Disease (CBSD) [13] and insect pests such as Cassava Green Mites (CGM) and Cassava Mealybugs (CMB). The aggressive strain of CMD was initially reported in Uganda in the mid-1990s before spreading to neighboring regions, including Tanzania (reference). These viral diseases drastically impair locally cultivated cassava varieties, with yield losses reaching up to 100% [9].

In addition to disease threats, the increasing frequency and severity of droughts have exacerbated cassava production challenges, jeopardizing food security in affected regions [8]. While cassava is inherently drought-tolerant, its resilience is increasingly compromised in regions experiencing intensified drought conditions. The cumulative impact of drought stress on both yield quantity and nutritional quality poses a growing threat to future food security [10].

In response to these challenges, the Tanzania Agricultural Research Institute (TARI) and its development partners have undertaken various initiatives to combat viral pandemics and drought-related threats. These efforts include the development, multiplication, and dissemination of disease-resistant and drought-tolerant cassava varieties, particularly Kiroba, along with a limited distribution of Pwani, Mkumba, Mkuranga<sup>1</sup>, and Kizimbani. Additionally, TARI has promoted improved agronomic practices and technological interventions to enhance cassava productivity. Nevertheless, the adoption rate of improved cassava varieties remains low in the southern coastal belt [11]. Consequently, the majority of smallholder farmers continue to rely on traditional landraces that exhibit lower yield potential, heightened susceptibility to disease and pests, and reduced drought tolerance [12].

Extensive research on cassava viral pandemics, specifically CBSD and CMD, has been conducted across East African nations, including Tanzania [14,15,20,16]. These studies have primarily focused on understanding the etiology, symptoms, genetic diversity, and transmission mechanisms of viral pathogens, as well as their epidemiological patterns and control strategies [17,18]. Additional research has examined the origin, evolution, distribution, and spread of cassava viral pandemics within East

Africa [19,21]. However, relatively little scholarly attention has been devoted to assessing the direct impact of these viral diseases on cassava production and productivity in Tanzania, particularly within the Mtwara and Lindi regions. Likewise, the role of drought as a compounding factor in cassava yield decline has remained largely unexplored.

Thus, diverging from previous studies that have predominantly centered on disease pathology and epidemiology, the present study aims to bridge this knowledge gap by investigating the dual impact of pandemic viral diseases and drought on cassava production and productivity in Southeastern Tanzania.

## 2. Materials and Methods

### 2.1 Study area

The study was conducted between late December 2019 and mid-January 2020 in the Mtwara (10°16'0"S, 40°11'0"E) and Lindi (9°59'15.36"S, 39°41'53.52"E) regions of Southeastern Tanzania. These locations were selected for their significance as leading cassava-producing areas in the country. According to NBS (2021), Mtwara and Lindi accounted for approximately 26.4% of the total harvested cassava area and contributed 32.9% of the national cassava production.

In Mtwara, the study covered Nanyamba Town Council and Mtwara District Council, with the region leading in cassava cultivation, comprising 21.1% of the total harvested area and producing 25% of Tanzania's cassava yield in 2019. Similarly, in Lindi, the study focused on Mtama District Council and Lindi Municipality. Lindi ranked as Tanzania's fifth-largest cassava-producing region in 2019, contributing 5.4% of the total harvested area and 7.9% of national cassava production (NBS, 2021).

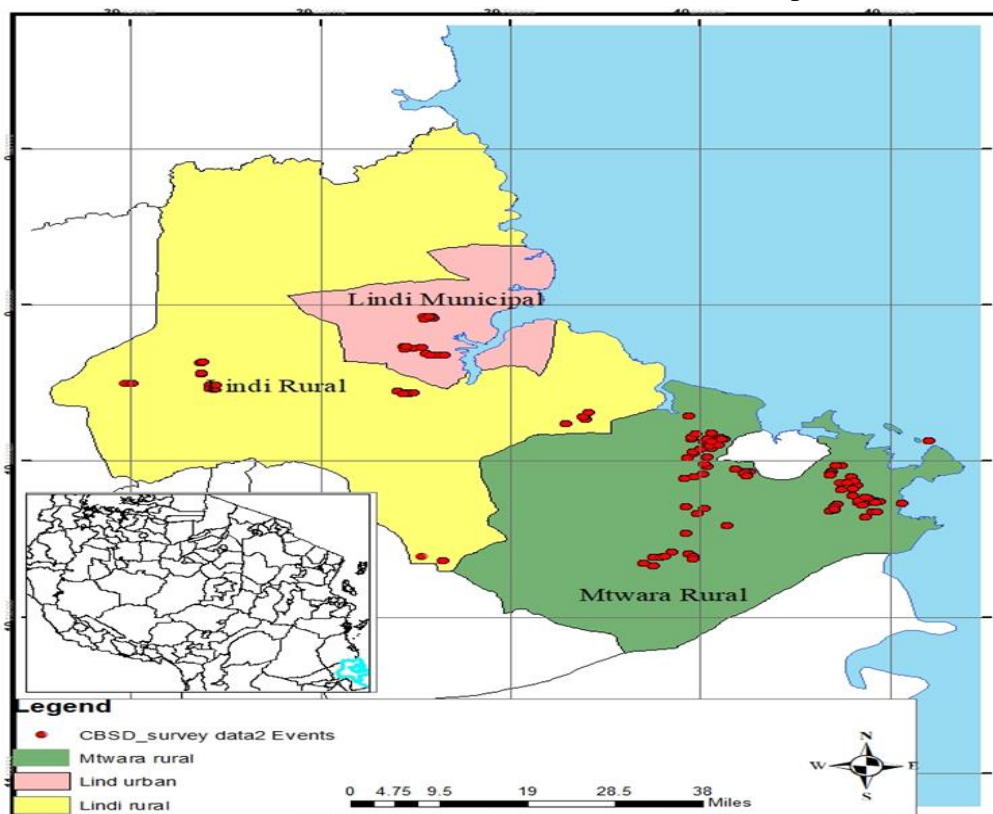


Figure 1: Location of study area of CBSD and CMD cassava yield loss in Lindi and Mtwara regions of Tanzania

### 2.2. Weather pattern of Mtwara and Lindi regions

Between 2015 and 2020, the Mtwara and Lindi regions in Southeastern Tanzania exhibited distinct climatic patterns characterized by variations in temperature, precipitation, and relative humidity that significantly influenced cassava production. In 2015 and 2016, moderate to above-average rainfall, coupled with warm temperatures around 28°C, and supported healthy cassava growth, although high humidity during the wet season sometimes increased the risk of waterlogging and root rot. However, 2018 brought below-average rainfall and drought conditions, with prolonged dry spells reducing yields and causing stress to the crop, despite cassava's drought tolerance. The warmer temperatures, combined with low humidity, exacerbated the challenge in 2018. In contrast, 2019 and 2020 saw consistent rainfall, high humidity, and optimal temperatures, which led to bountiful harvests. While abundant precipitation in these years enhanced growth, the increased humidity also raised concerns about pests and disease. Overall, cassava production was most successful when rainfall was consistent, temperatures remained stable, and humidity levels balanced moisture needs without leading to excess water or disease. Drought years, such as 2018, underscored the crop's vulnerability to prolonged dry conditions, despite its resilience.

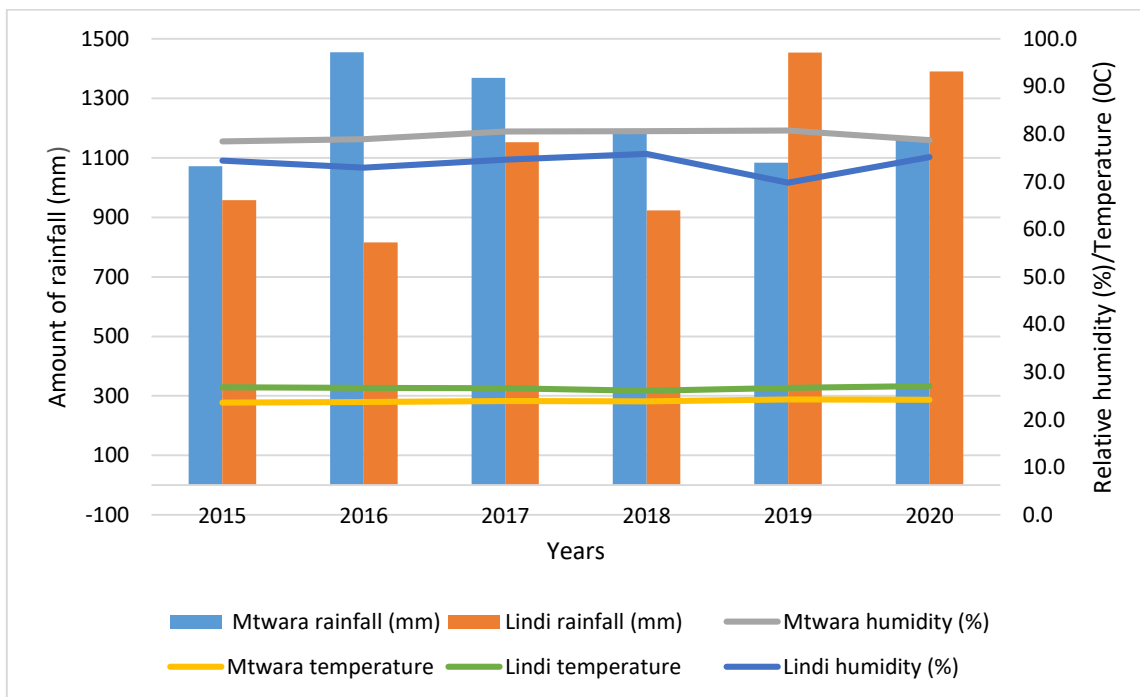


Figure 2: Weather pattern in Mtwara and Lindi regions from 2015 to 2020

### 2.3. Research design, sample size and sampling methods

This study employed a cross-sectional research design whereby data was collected at a single point in time. A purposive sampling technique was used to select districts with high potential of cassava production while random sampling techniques were used to select villages and respondents. A total of 120 respondents were drawn from a sample frame of all cassava growers in the study area. The sample size comprised of 95 and 35 cassava growers in Mtwara and Lindi regions respectively. Both primary and secondary data were collected. Primary data were collected using semi-structured questionnaire which was administered to household head growing cassava in the study area. In addition, a practical

assessment using destructive sampling technique as described by [23] was done in farmers' fields for all 120 respondents to assess CBSD root incidences and severity for only 5 plants per farm selected randomly. The assessment of foliar CBSD and CMD incidence was determined by taking the proportional of infected cassava plants over the total cassava plants assessed in the field. Disease severity was determined as per [9], where the extent of expression of the disease symptoms based on 1–5 scale was determined, scale 1 indicates healthy plants with no symptoms and 5 represents a very severe symptom [24,25].

Whitefly population was recorded for cassava by counting adult whitefly on the undersides of the young full opened topmost five leaves of the thirty cassava plants selected in a similar “X” diagonal manner. A total of 15 plants from each field were assessed and data was recorded on a structured datasheet. Whitefly population abundance was calculated by taking the total number of whitefly in all sampling to the total number of sampling units of occurrence. For CBSD root assessment, a destructive sampling method was done on 5 plants selected randomly from each farmer's field, a total of 600 plants samples were assessed from all 120 fields surveyed. During the assessment, plants were uprooted; each root was separated from the mother plant and cut longitudinally. The assessment was done using a scale of 1 to 5 where 1 indicated no symptoms and 5 showed very severe symptoms [25]. A total of 74 varieties were assessed for CBSD root necrotic symptoms.

## 2.4. Data analysis

The data collected were summarized and analyzed using descriptive statistics where Statistical Package for Socio Science (SPSS) software version 16 was used. The report was summarized in the form of frequency distribution, mean, and cross-tabulation.

## 3. Results

### 3.1. Socio-economic profile of respondent

Table 1 presents key findings about cassava producers in Mtwara and Lindi. The results indicate that cassava farming is predominantly male-led (nearly 90%), with most producers being married (95.8%), having a primary education level (78.2%), and relying on crop farming (98.3%) as their primary source of household income. Most cassava producers (48.7%) had less than 10 years of experience in cassava production, with an average of 16.9 years. Experience ranged from a minimum of 2 years to a maximum of 60 years.

Additionally, most cassava producers (96.7%) owned land and allocated an average of 6 to 10 acres for cassava cultivation. However, the land allocated for cassava production varied significantly across districts ( $p < 0.1$ ;  $\chi^2 = 32.7$ ), suggesting differences in crop prioritization.

Moreover, the household size among cassava producers varied significantly across district councils ( $p < 0.05$ ;  $\chi^2 = 13.7$ ), with an average of 6 people per household. Mtwara (37.5%) and Mtama (7.5%) district councils had the highest number of people per household compared to other councils.

In terms of income, Majority (nearly 46.7%) of cassava producers earned less than 100,000 TZS per month. The average monthly income was TZS 231,315 (approximately 100 USD), with a minimum of

TZS 17,500 (7.5 USD) and a maximum of TZS 5,750,000 (2486 USD). Households with multiple income sources and larger cultivated areas earned significantly higher incomes than those with a single income source or smaller areas under cultivation.

Table 1. Socio-economic profile of respondents at the surveyed areas

Variable	Category	% Farmers per district (N=120)				% Total	Df	$\chi^2$	P-value
		Nanyamba TC	Mtwara DC	Lindi MC	Mtama DC				
Gender	Male	8.3	55.0	12.5	14.2	90	3	2.9	0.32
	Female	0.0	7.5	0.0	2.5	10			
Household size (#)	<3	0.8	5.8	5.0	3.3	15	6	13.7	0.03
	3 to 5	1.7	19.2	5.0	5.8	31.7			
	>5	5.8	37.5	2.5	7.5	53.3			
Marital status	Married	8.3	60.0	11.7	15.8	95.8	3	0.71	0.87
	Not married	0.0	2.5	0.8	0.8	4.2			
Main sources of income	Employment	0.0	2.5	0.8	0.8	4.2	8	16.3	0.06
	Crop farming	8.3	59.2	12.5	16.7	98.3			
	Livestock keeping	2.5	27.5	1.7	7.5	39.2			
	Business	4.2	12.5	7.5	2.5	27.5			
	Fishing	1.7	2.5	3.3	4.2	11.7			
Education level	Informal	0.8	7.5	1.7	0.8	10.8	9	9.4	0.86
	Primary	7.5	49.2	9.2	12.5	78.3			
	Secondary	0.0	5.0	1.7	2.5	9.2			
	College/University	0.0	0.8	0.0	0.8	1.7			
Land ownership	Yes	8.3	61.7	10.0	16.7	96.7	3.0	14.8	0.002
	No	0.0	0.8	2.5	0.0	3.3			
Farm size (acres)	< 2	0.0	6.8	0.8	1.7	9.3	9.0	32.7	0.092
	2 to 5	3.4	19.5	5.1	4.2	32.2			
	6 to 10	4.2	24.6	3.4	6.8	39.0			
	> 10	0.8	11.9	2.5	4.2	19.5			
Experience in cassava production (Years)	<10	5.0	28.6	8.4	6.7	48.7	6	6.59	0.36
	11 to 20	0.0	14.3	1.7	4.2	20.2			
	>20	3.4	20.2	1.7	5.9	31.1			
Household Monthly income	<100,000	5.0	30.0	5.0	6.7	46.7	9	4.17	0.9
	100,000 to 300,000	1.7	21.7	5.0	6.7	35.0			
	300,001 to 500,000	0.8	8.3	1.7	3.3	14.2			
	500,000 to >500,000	0.8	2.5	0.8	0.0	4.2			
	>500,000	0.8	2.5	0.8	0.0	4.2			

Df= Degree of freedom,  $\chi^2$  = chi square, TC= Town Council, DC= District council

### 3.2. Food and cash crops cultivated in the study area

The findings indicated that the primary cash crops cultivated by smallholder cassava farmers in the studied locations included cashew nuts, sesame, cassava, groundnuts, and maize (Figure 3). These crops were primarily grown due to their high market demand and profitability, providing farmers with a reliable source of income.

Additionally, cassava was the main staple crop, followed by maize, cowpeas, sorghum, and rice (Figure 4). These staple crops were grown primarily for household consumption, ensuring food security in the region. The choice of crops was influenced by local climatic conditions, soil types, and the availability of labor.

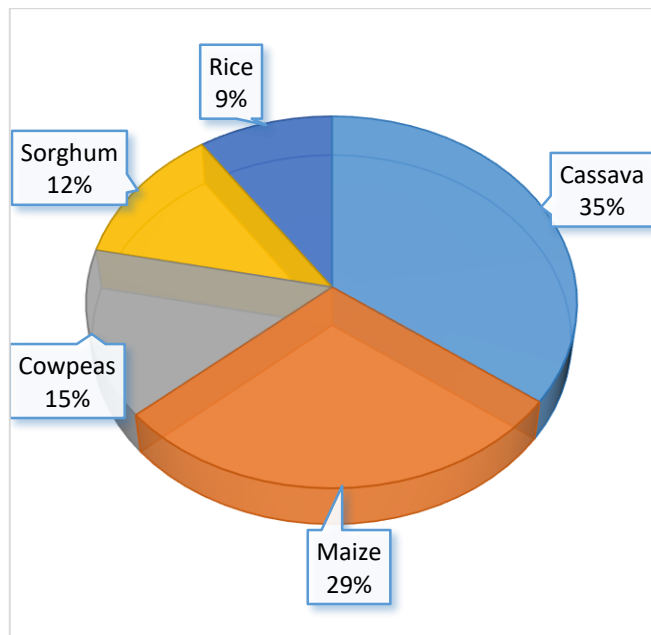
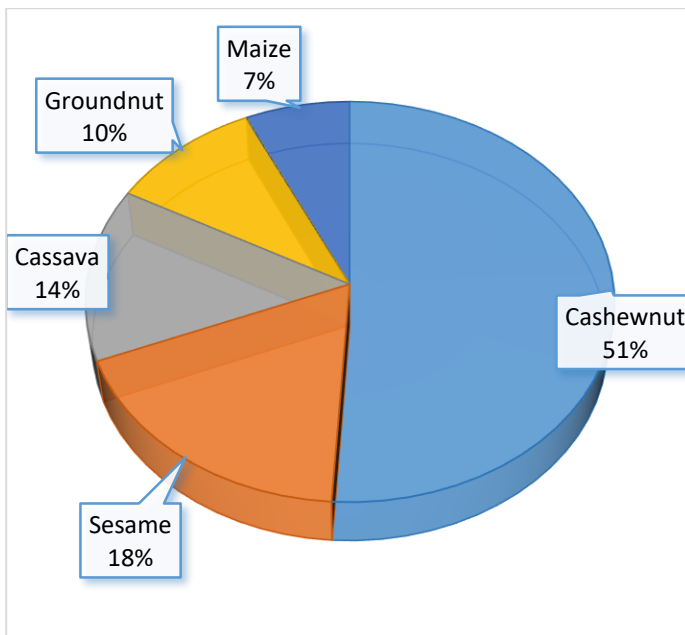


Figure 3. Most produced cash crops in the study area

Figure 4. Most produced food crops in the study area

### 3.3 Cassava production

#### 3.3.1. Cassava cropping system, reasons for cassava production and sources of planting materials

The results in Table 2 indicate that the majority of cassava producers (81.7%) practice a mixed cropping system. The most common crops grown alongside cassava include cashew nuts, cowpeas, pineapples, and maize. The major reasons reported for mixed cropping was to mitigate the financial impact of crop failure due to pests, diseases, or unfavorable weather conditions, while also enhancing food security and providing additional sources of income.

In addition, results exhibited a significant difference ( $p < 0.05$ ;  $\chi^2 = 8.63$ ) among cassava producers regarding their primary reasons for cultivating cassava in the study locations. It was found that the majority of smallholder farmers (42.1%) grew cassava primarily as a source of food, while 34% cultivated it for its drought resilient properties.

Likewise, a statistical significant difference ( $p < 0.1$ ;  $\chi^2 = 7.05$ ) was also observed on the major sources of cassava planting materials in the studied sites. The most reported source of cassava planting material (about 50.2%) came from own recycled cultivars followed by and fellow farmers (43.3). These findings suggest that the majority of smallholder cassava producers (93.5%) rely on informal sources for planting

materials, while only 6.5% obtain their materials from formal sources such as research institutes, seed producers, or NGOs. This poses a significant risk to the cassava producers in the study area, as using planting materials from informal sources could lead to the spread of diseases and result in increased vulnerability to pest attacks, given that many of these cultivars are susceptible to such threats (Table 2).

Table 2. Cassava farming system, reasons for growing cassava and source of planting materials

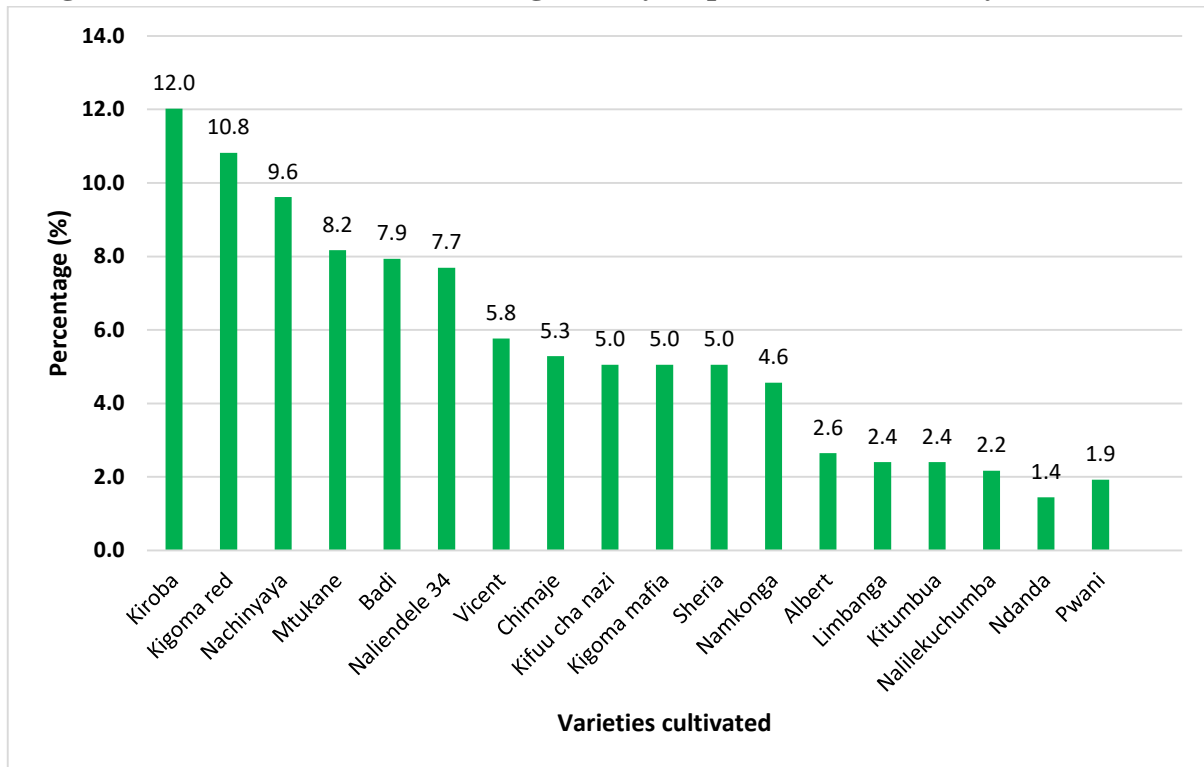
Variable	Category	% Farmers per district (N=120)					%	Df	Chi2	P-value
		Nanyamba TC	Mtwara DC	Lindi MC	Mtama DC	Total				
Cassava farming system	Mixed cropping	6.9	49.2	10.0	15.4	81.5				
	Sole cropping	0.8	14.6	2.3	0.8	18.5	3	4.77	0.189	
Reasons for growing cassava	Source of food	4.6	24.9	5.6	7.0	42.1				
	Drought resilience	3.5	18.9	4.9	6.7	34.0				
	Source of income	0.4	11.9	3.2	3.5	18.9				
	Low management cost	1.4	0.7	1.8	1.1	4.9	3.0	8.63	0.035	
Source of planting materials	Own recycled cultivars	4.0	32.6	5.3	8.4	50.2				
	Other farmers	4.4	26.9	5.7	6.2	43.2				
	Research institute	0.0	0.0	0.4	0.0	0.4				
	Seed producers	0.0	2.6	0.0	0.9	3.5				
	NGO's	0.0	2.2	0.4	0.0	2.6	3	7.05	0.072	

### 3.3.2 Types of cassava cultivars produced in the study area

The verdicts showed several cassava cultivars grown by respondents in the study area including 15 local cultivars and 3 improved varieties. The most commonly used local cultivars were Kigoma Red (10.8%), Nachinyaya (9.6%), Mtukane (8.2%), Badi (7.9%), Vicent (5.8%), Chimaje (5.3%), Kifuu cha Nazi (5.0%), Kigoma Mafia (5.0%), Sheria (5.0%), and Namkongga (4.6%). Whereas the most grown improved cultivars were Kiroba (12%), Naliendele 34 (7.7%), and Pwani (1.9%) as shown in Figure 4.

The findings illustrated that Kigoma Red was the most widely produced local cassava cultivar across the studied sites, with higher production in Mtwara (19.2%) and Mtama (6.7%) district councils compared to other locations. While the most commonly produced improved variety was Kiroba, which was predominantly grown in Mtwara (20%) and Mtama (10%) district councils, while it was least produced in Nanyamba Town Council (4.2%). These results suggest the need for enhanced dissemination of improved cassava varieties in the studied locations.

Figure 5. Name of Cassava varieties grown by respondents in the study area (N=120)



### 3.4. Farmer’s knowledge on climatic variation, knowledge sources and evidence of climate change

The results revealed that majority of cassava producers (98.3%) were knowledgeable about climate change. This high percentage can be attributed to the accessibility of various information sources that effectively raised awareness among farmers. However, a significance difference ( $p < 0.1$ ;  $\chi^2 = 7.12$ ) was revealed on the knowledge of climate change across the district councils studied.

Likewise, the findings illustrated a significant difference ( $p < 0.1$ ;  $\chi^2 = 6.29$ ) on the major sources on climate change information across the district councils studied. Moreover, it was depicted that the primary sources of climate change information were radio (42.3%), television (19.0%), and traditional and religious leaders (15.1%), which are widely relied upon in rural areas for disseminating critical updates.

Moreover, the major indicators of climate variations experienced by cassava producers included inadequate rainfall (22.8%), late onset of rains (17.8%), high temperature (15.8%), intermittent rains (13.5%) and prolonged dry spells (12.8%), and, as shown in Table 3. Furthermore, results indicated a significant difference ( $p < 0.05$ ;  $\chi^2 = 11.22$ ) on the reported evidence of climate change across the studied locations. These indicators significantly affect agricultural activities, highlighting the importance of increased awareness and adaptation strategies among farmers to address the challenges posed by climate change.

Table 3. Farmers’ awareness, information sources and indicators of climate change

Variable	Category	% Farmers per district (N=120)					P-value
		Nanyamb a TC	Mtwar a DC	Lind i MC	Mtam a DC	% Tota l D f	

Ever heard about climate change	Yes	7.5	62.5	12.5	15.8	98.3			
	No	0.8	0.0	0.0			0.8	1.7	3 7.12 0.07
Source of information about climate change	Radio	2.8	25.8	6.0	7.7	42.3			
	Television	0.8	11.3	3.6	3.2	19.0			
	Tradition and religious leaders	2.8	7.7	1.8	2.8	15.1			
	Friends	0.4	7.3	1.2	1.2	10.1			
	Extension workers	2.6	4.8	0.4	1.2	9.1	2		
	Books & meetings	0.0	2.8	0.4	1.2	4.4	4	6.29	0.09
Reported evidence of climate change	Inadequate rainfall	1.8	13.8	3.2	4.1	22.8			
	Late onset of rains	1.6	9.9	2.7	3.6	17.8			
	High temperatures	1.8	8.8	2.0	3.2	15.8			
	Intermittent rains	2.3	5.6	2.9	2.7	13.5			
	Prolonged dry spell	1.4	8.1	1.4	2.0	12.9			
	Early rains outset	0.7	3.4	2.0	2.9	9.0	1	11.2	
	Drying of rivers	0.5	4.3	1.4	2.0	8.1	9	2	0.04

### 3.5. Impact of drought on crop production and water qualities

The study revealed that drought is a significant challenge impacting crop production in the studied area. It was found that cassava producers have faced drought conditions since the 1950s, with the most severe episodes occurring consecutively from 2015 to 2018, attributed to climate change. The study found that the majority of cassava producers (91.7%) reported negative impacts of drought on their crop production. However, the severe impact was evidenced in Mtwara DC (60%) and Mtama DC (12.5%) with little impact evidenced on Nanyamba TC (7.5%) (Table 6).

The primary effects identified were a reduction in drinking water quality (84.2%) and a decrease in water availability for crop production (89.2%), as shown in Table 6. Furthermore, the results indicated significant differences in the impact of drought on drinking water quality ( $p < 0.01$ ;  $\chi^2 = 41.16$ ) and water availability for crop production ( $p < 0.01$ ;  $\chi^2 = 34.87$ ), respectively.

Table 6. Drought impact on the households' water quality and availability

Variable	Category	% Farmers per district (N=120)				Total	D	χ <sup>2</sup>	P-value
		Nanyamba TC	Mtwara DC	Lindi MC	Mtama DC				
Affected by drought	Yes	7.5	60.0	11.7	12.5	91.7			
	No	0.8	2.5	1.7	3.3	8.3	3	1.22	0.78
Drinking water quality	Quality decrease	7.5	59.2	6.7	10.8	84.2		41.1	
	Quality	1.7	0.8	3.3	0.8	6.7	9	6	0.00

		increase								
		No difference	0.8	2.5	3.3	3.3	10.0			
Water availability for agricultural purposes		Decrease	9.2	60.0	7.5	12.5	89.2			
		Increase	0.8	0.0	2.5	0.0	3.3			
		Remain the same	0.0	1.7	3.3	2.5	7.5	9	7	0.01
										34.8

Results indicated a significant difference ( $p < 0.01$ ;  $\chi^2 = 34.87$ ) on the drought implication of cassava growers in the studied districts. It was revealed that cassava producers experienced negative effect of drought occurrence on their households. The major drought implication reported by majority of the cassava producers were insufficient household food (43.4%) and reduction of household income (39.6%). In addition, drought implication was highly observed in Mtwara DC (27.5%) and less observed in Nanyamba TC (3.8%) (Table 7).

On the same lens, it was discovered that smallholder cassava farmers (54.2%) incurred extra cost for purchasing more seeds and employ additional labour to supplement crops destroyed by dry spell in the study area. Furthermore, the findings showed a significant difference ( $p < 0.01$ ;  $\chi^2 = 17.04$ ) in the inputs purchased to supplement affected crops by dry spells across the studied district councils.

Despite of the drought implications majority of cassava producers (83.3%) used various strategies to mitigate effect of drought in their localities. The major steps taken by majority of cassava producers were growing drought tolerant crops and/or varieties (57.2 %), crop rotation (23.5%) and early planting (12.0%). Furthermore, results indicated that there is a significant difference ( $p < 0.1$ ;  $\chi^2 = 10.61$ ) in various steps taken by cassava producers to mitigate drought impact across the study sites.

Table 7. Drought implications and steps taken by the households to mitigate its impacts

Variable	Category	% Farmers per district (N=120)				%	D	f	$\chi^2$	P-value
		Nanyamba TC	Mtwara DC	Lin Di M C	Mtama DC					
Implications of drought to cassava producers	Family food scarcity	3.8	27.5	5.3	6.8	43.4				
	Decreased income	3.0	24.9	5.3	6.4	39.6				
	Failed school enrollment	0.8	5.7	0.0	0.4	6.8				
	Piecework engagement	0.8	7.5	0.0	0.8	9.1				
	Death of livestock	0.0	0.4	0.0	0.0	0.4		7.0	0.0	
	No water	0.4	0.4	0.0	0.0	0.8		9	8	69
Input purchased to supplement affected crops by dry spell	Yes	2.5	42.5	3.3	5.8	54.2				
	No	6.7	19.2	9.2	10.8	45.3		3	04	09

						8			
Did you take any steps to mitigate impact of drought to household	Yes	5.0	54.2	9.2	15.0	3	7.5	0.2	
	No	3.3	8.3	3.3	1.7	7	4	6	72
Steps taken to mitigate drought impact	Growing drought-tolerant cultivars	4.8	36.1	7.2	9.0	2			
	Crop rotation	1.8	12.0	3.6	6.0	5			
	Early planting	2.4	3.0	3.0	3.6	0			
	Off farm activities	0.6	2.4	0.6	0.6	4.2			
	Irrigating crops	0.6	1.2	0.0	0.0	1.8	10.	0.0	
	Production halt	0.0	1.2	0.0	0.0	1.2	8	61	89

### 3.6. Farmer’s knowledge on CMD and CBSD diseases

Farmers’ knowledge of economically significant diseases in cassava production is crucial for reducing the spread of these diseases from one field to another. Farmers with a solid understanding of biotic constraints can adopt effective coping strategies, such as using planting materials from asymptomatic plants, growing tolerant varieties, and practicing rouging to manage diseases. The results showed approximately 82.5% of the cassava producers in the studied location could identify cassava mosaic disease (CMD) foliar symptoms. However, the findings showed that the knowledge of CMD folia symptoms identification was statistically significant ( $p < 0.01$ ;  $\chi^2 = 17.97$ ) across the studied districts. Likewise, results indicated a statistical significant differences ( $p < 0.01$ ;  $\chi^2 = 14.76$ ) on the ability to recognize cassava brown streak disease (CBSD) symptoms on roots, and leaves ( $p < 0.01$ ;  $\chi^2 = 15.15$ ), respectively. Moreover, it was revealed that about 75.8% of cassava producers had knowledge on how to identify the CBSD stem foliar symptoms while 90.8% had the ability to identify the CBSD root symptoms and 68.3% managed to identify CBSD stem symptoms, respectively.

Despite this awareness of disease symptoms, most farmers lacked knowledge about how these diseases are spread, with only 29.2% of respondents being aware of transmission methods. Among these, 32.5% identified the use of infected planting materials as a transmission route, and 22.3% attributed the spread by whiteflies. The other causes mentioned included mdengela plants (14.6%), strong winds (10.8%), and rainfall (7%) (Table 10). Furthermore, results indicated a significant difference ( $p < 0.01$ ;  $\chi^2 = 15.15$ ) on the various disease transmission methods in the study areas. Some farmers mistakenly believed that parasitic dodder weeds (*Cuscuta cephalanthi*) were responsible for disease spread. These findings underscore the urgent need to raise farmers' awareness about the actual causes of cassava diseases, their modes of transmission, and effective control measures to minimize their impact on crop production.

Table 10. Respondent awareness on CMD and CBSD diseases and their spread (N=120)

Variable	Category	% Farmers per district (N=120)	%		P-value
			Tot al	D f	

		Nanyamba TC	Mtwarara DC	Lin di MC	Mtama DC					
						82.				
Ability to identify CMD foliar symptoms	Yes	7.5	56.7	5.8	12.5	5				
	No	0.8	5.8	6.7	4.2	5	3	7	4	17.9 0.00
						75.				
Ability to identify to identify CBSD foliar symptoms	Yes	5.8	53.3	5.0	11.7	8				
	No	2.5	9.2	7.5	5.0	2	3	6	2	24. 14.7 0.00
						90.				
Ability to identify the CBSD root symptoms	Yes	7.5	60.8	8.3	14.2	8				15.1 0.00
	No	0.8	1.7	4.2	2.5	9.2	3	5	1	
						68.				
Ability to identify the CBSD stem symptoms	Yes	6.7	45.0	5.8	10.8	3				
	No	1.7	17.5	6.7	5.8	7	3	4.45	7	31. 0.21
						29.				
Knowledge how the diseases are spread	Yes	2.5	20.8	2.5	3.3	2				
	No	5.8	41.7	0	13.3	8	3	2.06	1	10. 70. 0.56
						32.				
Ways diseases spread	Infected seedlings use	4.5	16.6	5.1	6.4	5				
	Whitefly	3.2	8.3	5.1	5.7	3				22.
	Mdengela plant	3.2	5.1	2.5	3.8	6				14.
	Strong wind	1.9	3.8	1.9	3.2	8				10.
	Rainfall	1.3	2.5	1.3	2.5	7.0				
	Drought	1.3	2.5	0.6	1.3	5.7				
	Soil characteristics	0.6	1.9	1.3	0.6	4.5				
	Infected instrument use	0.6	1.3	0.0	0.6	2.5	4	5.99	1	1 0.01

Most of the respondents reported that the occurrence of both CBSD and CMD threatened their crops production leading to the reduced crop productivity and household income. The most reported effect of CBSD in cassava production were poor quality of roots (28.8%) and reduced cassava yield (26.9%) while, CMD disease was reported to affect the cassava yield (31.9%) and quality of leaves that were used as vegetables (20.1%). Likewise, it was reported that the persistence drought has a great contribution on the occurrence of cassava diseases. This was evidenced by the study findings which showed the increased CBSD and CMD diseases severity by 40.7% and 42% respectively (Table 11).

Table 11. Effect of drought on CMD and CBSD diseases on cassava production (N=120)

Variable	Category	% Farmers per district (N=120)				%	D	χ <sup>2</sup>	P-value
		Nanya mba TC	Mtw ara DC	Lin di M C	Mta ma DC				
CBSDnegative effect	Yield	2.2	16.6	3.3	4.9	26.9			
	Root quality	2.2	19.6	3.0	4.1	28.8			
	Leave vegetables	0.5	7.1	0.8	1.9	10.3			
	Yield and tuber quality	1.4	8.4	2.2	3.0	14.9			
	Yield and leave as vegetables	1.1	6.5	0.8	1.6	10.1			
	Tuber quality and leaves	1.1	5.2	0.8	1.9	9.0	1.3	52	0.682
	CMDnegative effect	Yield	2.5	20.1	3.4	5.7	31.7		
Root quality		1.1	8.8	1.4	2.8	14.2			
Leaves vegetables		1.7	12.7	1.4	3.4	19.3			
Yield and tuber quality		0.6	5.1	0.8	1.1	7.6			
Yield and leave as vegetables		1.7	13.3	1.4	3.7	20.1			
Tuber quality and leaves		0.6	4.5	0.8	1.1	7.1	0.3	31	0.96
Drought occurrence has effect on CMD and CBSD		Yes	4.2	41.5	5.9	9.3	61.0		
	No	4.2	21.2	5.9	7.6	39.0	5.6	19	0.519
Effect of drought occurrence on CMD and CBSD	CMD increases severity	2.7	26.7	4.0	7.3	40.7			
	CBSD increases severity	3.3	26.7	4.7	7.3	42.0			
	CMD decreases severity	0.7	8.0	1.3	2.0	12.0	6.0	33	0.097
	CBSD decreases severity	0.7	8.0	0.0	0.0	8.7	3.0	33	0.097

decreases

### 3.7. CMD and CBSD foliar incidences and severity and whitefly vector

The assessment results indicated that there was a significant difference ( $P \leq 0.05$ ) between plants for both CMD and CBSD foliar diseases incidence and severity across the districts. Lindi municipal district had the highest level of CBSD incidence and severity of 44.1% and 2.5 respectively and the incidences and severity were observed at Mtanda, Mayanga and Ng'apa wards. While the lowest CBSD incidences and severity were recorded at Mnara and Pangatena wards. In the case of CMD, the highest incidence and severity were recorded at Mtwara rural (Mayanga and Madimba wards) and the lowest CMD incidences and severity were observed at Mnara, Pangatena and Kiwalala wards of Lindi rural district. For different cultivars assessed, about 70.8% and 48.6% had CBSD and CMD foliar symptoms respectively. The highest score of CBSD foliar symptoms was observed on Likaladau followed by Kamulya and Mandangwa cultivars while Kizimbani variety, Namikonga, Salanga and Mnondola cultivars did not show any foliar disease symptoms. Furthermore, CMD foliar symptoms scored highest for Likonde, Namtitima, Binti Salum, Kigomaasili, Nangaimo, Kiyevu and Mandangwa cultivars. It was also recorded that varieties, Kizimbani and Pwani and cultivars Namajongonda, Salanga and Nanjenjeha had no CMD foliar symptoms (Table 12).

Table 12. CBSD and CMD incidence and severity in Mtwara and Lindi districts of Tanzania

District	Wards	CBSD		CMD	
		Severity	Incidence	Severity	Incidence
Mtwara DC	Madimba	1.7	22.4	1.7	21.28
	Mayanga	2.4	42.3	1.92	27.85
	Mkunwa	1.8	26.3	1.66	19.73
	Ziwani	1.9	28	1.6	18.67
	Mtiniko	1.7	21.3	1.46	14.13
	Nanguruwe	1.7	21.1	1.61	19.2
	Tangazo	2	30.7	1.61	18.13
	<b>Mean</b>	<b>1.8</b>	<b>25.9</b>	<b>1.6</b>	<b>18.7</b>
Mtama DC	Pangatena	1.2	6.1	1.11	3.2
	Kiwalala	1.9	27.2	1.11	3.2
	Jamhuri	1.7	22.4	1.12	4
	Mnara	1.2	5.7	1.07	2.27
	<b>Mean</b>	<b>1.5</b>	<b>14.1</b>	<b>1.1</b>	<b>3.1</b>
Lindi Municipal	Ng'apa	2.3	38.9	1.37	12
	Mtanda	2.6	49.3	1.25	7.2
	<b>Mean</b>	<b>2.5</b>	<b>44.1</b>	<b>1.3</b>	<b>9.6</b>
<b>Grand mean</b>		1.8	24.8	1.58	17.77
<b>SE</b>		0.84	13.48	0.862	12.25
<b>CV %</b>		44.62	49.19	55.51	72.63
<b>F-prob.</b>		<.001	<.001	<.001	<.001

LSD 1.37 29.16 1.38 26.43

SE= standard error, CV= coefficient of variation, LSD=least significance different

### 3.8. Whitefly population in the study area.

The number of whiteflies was significantly changing from one field to another, Mtwara rural district had many number of whiteflies with an average of 12.9 and 12.4 population for each plant scored for CBSD and CMD foliar symptoms respectively. The maximum count of adult whitefly was recorded at Nanguruwe (20.1 whiteflies). Also, the number of nymphs showed a significant difference ( $P \leq 0.05$ ) over the surveyed districts where Mtwara rural had 8.7 and 7.3 for the plant assessed for CBSD and CMD foliar symptoms respectively (Table 13).

Table 13. Whitefly population observed in the study area

Districts	Wards	Whitefly count on CBSD plants		Whitefly count on CMD plants	
		Adult	Nymph	Adult	Nymph
Mtwara rural	Madimba	4.8	4.4	4.78	3.97
	Mayanga	4.6	8	4.62	6.55
	Mkunwa	6	6.1	6.08	5.39
	Ziwani	4.3	7.5	5.27	6.45
	Mtiniko	3.5	3.3	3.97	3.32
	Nanguruwe	20	8.9	20.16	8.57
	Tangazo	5.8	7.5	4.63	6
	<b>Mean</b>	<b>12.9</b>	<b>8.2</b>	<b>12.4</b>	<b>7.3</b>
Lindi rural	Pangatena	3.3	8.7	3.51	6.8
	Kiwalala	4.3	6.6	4.68	6.49
	Jamhuri	3.3	8.4	4.49	9.87
	Mnara	0.9	2.5	1.63	2.69
	<b>Mean</b>	<b>2.1</b>	<b>5.5</b>	<b>3.1</b>	<b>6.3</b>
Lindi Municipal	Ngapa	5	4.7	6.21	5.01
	Mtanda	4.5	6.5	5.45	5.96
	<b>Mean</b>	<b>4.7</b>	<b>5.6</b>	<b>5.8</b>	<b>5.5</b>
<b>Grand mean</b>		6.5	6.8	6.63	5.88
<b>SE</b>		9.243	9.311	8.632	7.863
<b>CV (%)</b>		187.65	153.78	166.09	143.99
<b>F-prob.</b>		<.001	<.001	<.001	<.001
<b>LSD</b>		15.06	15.17	13.81	12.58

\*SE= standard error, CV= coefficient of variation, LSD=least significance different

### 3.9 Whitefly count on different cultivars/varieties

The results showed that there was a minor variation of whitefly population with the sampling age of the crop and cultivar. Young plants were having more whiteflies than old plants and this could be due to tenderness of the leave. It was also noted that some cultivars for example Biana observed to have a large count of whiteflies than others (Table 14)

Table 14. Average Whitefly count on different cultivars/varieties

Variety	Ad ult	Nymph	Variety	Ad ult	Nymph	Variety	Ad ult	Nymph	Variety	Ad ult	Nymph
	107								Kizimba		
Biana	.0	71.1	Badi	5.0	5.1	Nalembi	3.3	2.0	ni	1.5	2.0
Namanjon	24.		Linyamw						Mandang		
gonda	3	17.5	e	5.0	1.8	Limbanga	3.3	3.7	wa	1.5	1.3
	22.		Kifuu cha			Kigoma					
Bint Salum	9	11.7	Nazi	4.8	5.8	mafia	3.3	4.2	Nanyime	1.5	1.1
Mwendow	18.										
aloya	3	10.7	Kiroba	4.5	4.9	Kaniki	3.3	2.3	Mkumba	1.5	0.0
	14.								Mnondol		
Malaya	0	6.3	Nangundu	4.2	1.0	Likonde	3.0	3.0	a	1.5	3.8
Kasarawen											
de	9.0	4.5	Vicent	4.1	4.8	Likambioti	3.0	1.5	Kiyeyu	1.3	0.5
Namikong									Mgologo		
a	8.4	8.1	Kibaha	4.0	5.3	Namtitima	3.0	1.5	ro	0.7	1.5
						Kigomaasil			Nanjenje		
Mbilimbi	7.9	5.4	Chawaka	4.0	6.1	i	2.9	12.0	ha	0.5	6.1
Pwani	7.5	22.0	Kidubwa	4.0	6.3	Katiwanya	2.8	2.2	Lipujuka	0.5	3.0
									Ismail		
Chiyeyu	7.0	3.5	Dankani	4.0	2.0	Chimaje	2.8	3.5	Hassan	0.0	0.0
									JumaNgo		
Yuda	6.8	3.0	Ndanda	4.0	5.3	Luaha	2.8	7.1	zi	0.0	0.0
						Namayakat			Likalada		
Kitumbua	6.3	7.0	Kamulya	3.8	6.8	a	2.8	2.0	u	0.0	0.0
Nanga						Nalilekuch			Makutop		
nguyi	5.8	4.0	Nangaimo	3.8	2.3	umba	2.7	4.0	ora	0.0	0.0
Lihumbuk											
wa	5.6	5.8	Mreteta	3.6	2.1	Kisukari	2.5	4.3	Mbwani	0.0	0.0
Naliendele			Linyamw			Manjongon					
34	5.6	5.7	e	3.5	3.5	da	2.5	0.0	Mnonda	0.0	0.0
Nkandimb											
a	5.5	6.9	Musa said	3.5	3.3	Mmasasi	2.3	4.9	Salanga	0.0	0.0
						Kigoma					
Mtukane	5.3	5.9	Sheria	3.5	4.3	red	2.2	1.0			
			Nakuchim								
Supa	5.2	5.5	a	3.4	4.3	Albert	2.2	3.3			
Nachinyay			Bint								
a	5.1	5.9	Ismail	3.3	1.5	Kisinzya	1.8	1.0			

### 3.10. Effects of CBSD on cultivars

The results showed that local cultivars genotypes recorded higher (66.7%) CBSD root necrosis compared to improved cultivars. The highest average CBSD root score was observed on cultivars; Nalilekuchumba (4.75), Kigoma red (4.65), Musa said (4.5), Mreteta (4), and Juma Ngozi (4). On the contrary, the lowest score was observed on Nalembi, Namtitima and Nangundu cultivars. This implies that there is an opportunity of obtaining new CBSD sources of resistance from the existing local cultivars. Furthermore, among other improved varieties that are tolerant to the disease, they scored an average of 3 and 3.5 for Kiroba and Naliendele34 respectively. Naliendele34 was released in 2003 and has broken its resistance though it is still preferred by farmers due to other traits like mealiness and food cookerbility. (Figure 6).

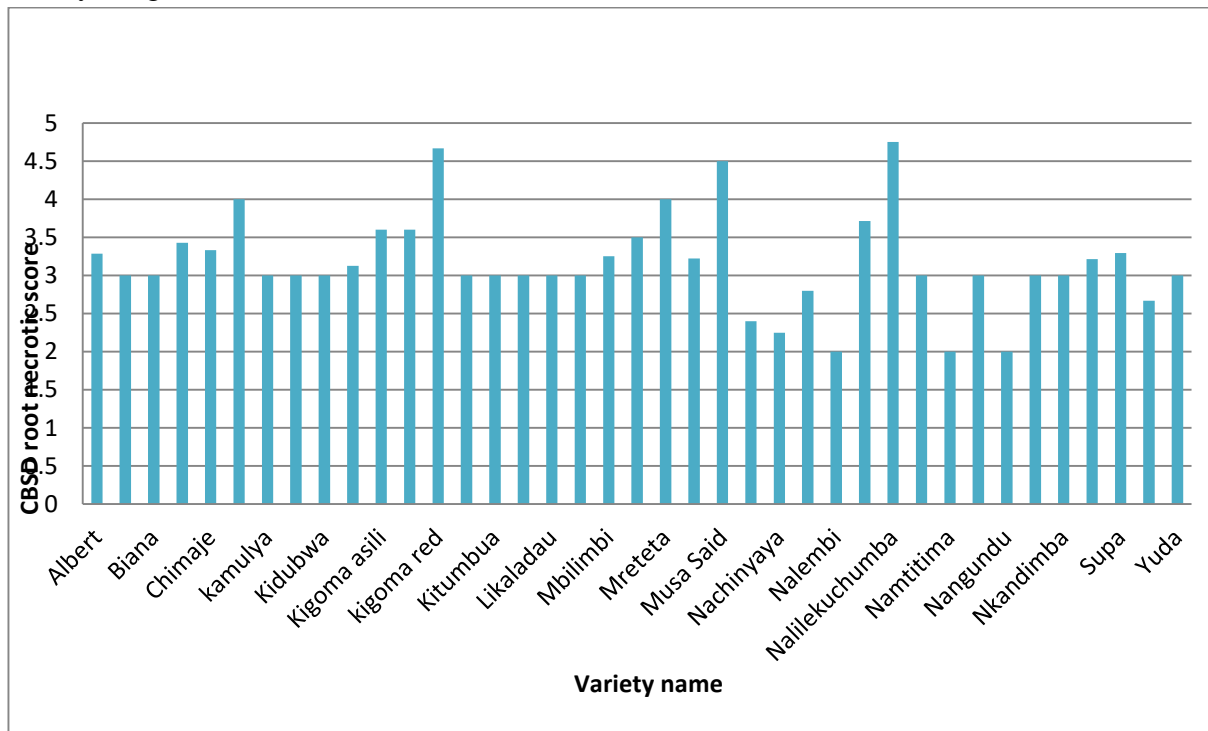


Figure 6. Average score of different varieties with CBSD root necrosis

Additionally, assessment of CBSD necrotic symptoms across the districts showed that most wards within the surveyed districts were severely affected with the disease with an average CBSD root score of not less than 3, only three wards namely Mnara, Tangazo and Mkunwa out of 13 wards had an average score of less than 3 CBSD root necrosis (Figure 7).

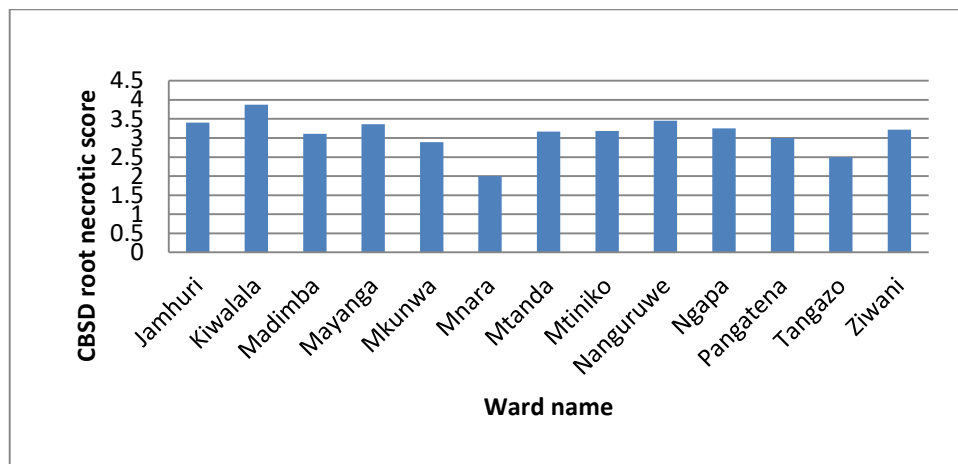


Figure 7. Average CBSD necrotic score in 13 Wards of Lindi and Mtwara regions

About 18.2% of the uprooted roots across the wards had CBSD root necrotic symptoms and, the average yield loss measured ranged from 8.4% to 23.6% of the total root yield. However, the proportion of root necrotic parts to the roots affected ranged from 4.3% to 24.6%. A large average amount of yield loss was observed in Lindi municipal (19.0%) while the lowest yield loss was observed at Lindi rural (13.1%). On the other hand, a very low (0.5%) of roots with necrotic symptoms and yield loss were measured at Mnara ward with an average diseases score of 2 (1-5%) by CBSD root necrosis which is regarded as no yield loss (Figure 5, Table16).

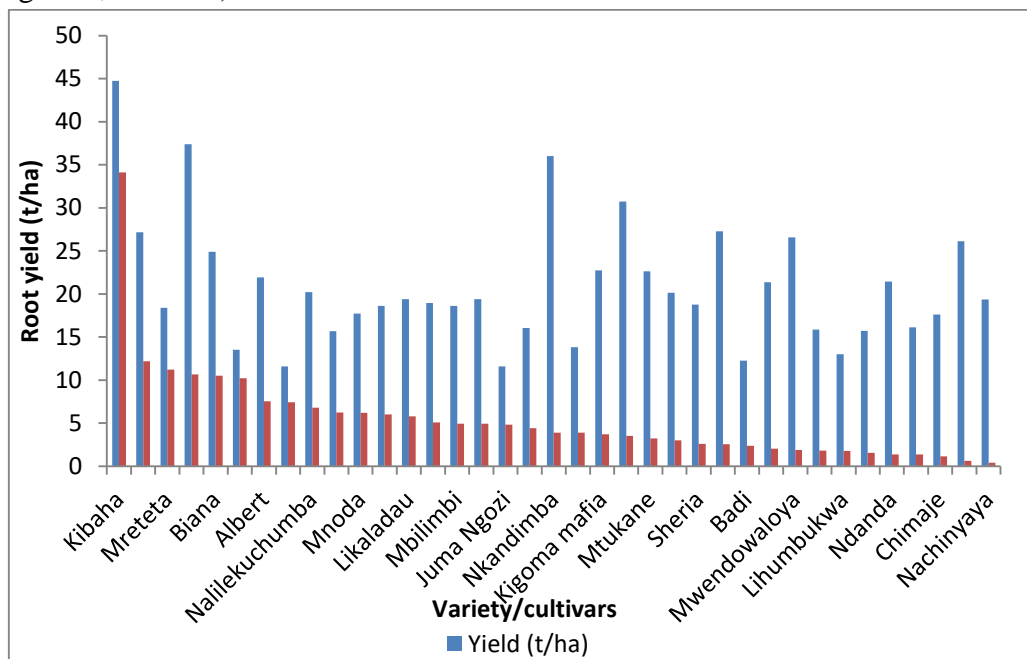


Figure 8. Root yield and yield loss due to CBSD in different cultivars grown in selected villages of Lindi and Mtwara regions

Table16. Percentage roots with CBSD in relation to yield loss across surveyed Wards

District	Ward	Average number of roots	Average severity	Yield (t/ha)	% roots affected	% Yield loss	% Portion
Mtwara DC	Madimba	6.7	3.1	19.4	16	13.1	11
	Mayanga	8.6	3.4	22.8	25.7	22.1	15.7
	Mkunwa	7.5	2.9	18.3	10.9	8.4	5.7

	Tangazo	6	2.5	20.5	13.7	9.9	4.3
	Ziwani	4.5	3.2	9.9	19.5	20.2	12.3
	Mtiniko	6.5	3.2	18.4	29.9	20.8	17.6
	Nanguru we	9.7	3.5	26.2	27.9	23.6	24.6
	<b>Mean</b>	<b>7.1</b>	<b>3.1</b>	<b>19.4</b>	<b>20.5</b>	<b>16.9</b>	<b>13</b>
	Pangatena	5.8	3	17	13.2	14.1	8.5
Mtama	Jamhuri	7.4	3.4	24.9	18.9	17.4	13.2
DC	Mnara	5.6	2	22.6	0.5	0	0
	Kiwalala	8	3.9	18	19.9	21.1	18.7
	<b>Mean</b>	<b>6.7</b>	<b>3.1</b>	<b>20.6</b>	<b>13.1</b>	<b>13.1</b>	<b>10.1</b>
Lindi MC	Ngapa	6.5	3.3	16.9	21.6	17.6	17.5
	Mtanda	6.8	3.2	19.4	19.1	20.4	16.7
	<b>Mean</b>	<b>6.6</b>	<b>3.2</b>	<b>18.1</b>	<b>20.3</b>	<b>19</b>	<b>17.1</b>
	<b>Grand mean</b>	<b>6.9</b>	<b>3.1</b>	<b>19.6</b>	<b>18.2</b>	<b>16.1</b>	<b>12.7</b>
	<b>SE</b>	3.3	1.0	13.8	30.5	30.4	25.8
	<b>CV (%)</b>	46.1	30.8	68.7	163.7	191.8	208.6
	<b>F-prob</b>	< 0.001	0.382	0.001	< 0.001	0.001	0.002
	<b>LSD</b>	5.77	2.014	24.29	53.51	53.44	45.23

Sample	Size	Minimum	Maximum	Mean	Variance	SD	SE	P-value
Average severity of CBSD score	193	2	5	3.223	1.028	1.014	0.0729	< 0.001
% root with CBSD	600	0	100	18.61	1042	32.27	1.318	< 0.001
Number of roots	600	1	21	7.12	12.38	3.519	0.1437	< 0.001
Portion with necrosis	600	0	100	12.34	728.6	26.99	1.102	< 0.001
Yield loss (%)	600	0	100	15.86	1029	32.08	1.31	< 0.001
Yield (t/ha)	600	1.4	97.4	20.14	205	14.32	0.5845	< 0.001

#### 4.0 Discussion

The findings of this study underscore the profound impact of pandemic viral diseases, particularly Cassava Brown Streak Disease (CBSD) and Cassava Mosaic Disease (CMD), along with prolonged

drought conditions, on cassava production in Southeastern Tanzania. The empirical data demonstrate substantial reductions in cassava yield and root quality, affirming prior research on the deleterious effects of biotic and abiotic stressors on cassava productivity and food security. These challenges necessitate a shift towards integrated management approaches combining climate adaptation, improved cultivar adoption, and enhanced disease surveillance.

#### **4.1 Impact of Drought on Cassava Production**

The study found that 84% of cassava growers experienced insufficient rainfall, with 65% reporting delayed onset and 58% facing prolonged dry spells, critically hindering plant growth and yield. These findings align with the National Cassava Development Strategy (NCDS) 2020–2030, which emphasizes that climate variability, including drought, poses a substantial threat to cassava production in Tanzania. Furthermore, [10] emphasized the interplay between temperature extremes and moisture deficits, demonstrating how these climatic fluctuations exacerbate physiological stress, ultimately diminishing both productivity and root nutritional composition. In addition, [28] further corroborate that intensified drought conditions are likely to reduce cassava resilience, requiring more robust drought-tolerant varieties.

Weather variations threatened crops and caused yield and quality loss, leading to food shortages in Lindi and Mtwara in other crops rather than cassava. This results in a lack of food and decreased family income. This phenomenon of food insecurity due to drought has also been reported by [33]. Growing drought-tolerant crops like cassava is a major coping strategy that farmers use to ensure food security and income gain for the household. Most respondents (94.2%) in the study area depend on cassava as their main source of food on a daily basis. The drought resilience trait of the crop, as reported by 64.2% of farmers, makes cassava the primary staple in the study area. In addition, the crop acts as a source of income; this was reported by 61 farmers who ranked cassava as the second most important cash crop after cashew nuts for household income generation. However, cassava is constrained by several factors that lead to low production and productivity compared to its yield potential.

#### **4.2 Effect of Viral Diseases on Cassava Yield and Quality**

The data indicate that CMD and CBSD are primary constraints to cassava productivity, with 88.5% of farmers reporting yield declines and 76% noting poor root quality. CBSD was particularly devastating, as it caused significant necrotic deterioration of root tissues, rendering them unsuitable for consumption and commercial processing. Tomlinson et al. (2018) established that CBSD-induced root necrosis is a major impediment to cassava value chains in sub-Saharan Africa. Similarly, [1] emphasized the compounded impact of CBSD on smallholder farmers, advocating for more aggressive phytosanitary measures to curtail its spread. Similarly, [7] documented severe yield losses attributable to CMD, particularly in susceptible cultivars, where total crop failure was frequently observed in the absence of disease-resistant genotypes.

The two economically significant pandemic viral diseases in Tanzania have been major biotic constraints for cassava farmers, limiting the mass production of quality cassava roots. CBSD and CMD have been recognized worldwide as threats to food security in SSA [28]. The increasing incidence and severity of these diseases have been caused by the high population of the vector *B. tabaci* in the study area, a trend also observed by other scholars like [29-31]. It was noticed that although farmers have good

knowledge of insect pests and diseases, they continue to use cultivars highly susceptible to these diseases, which negatively impacts cassava productivity in Lindi and Mtwara. Furthermore, organoleptic or other desirable properties of local landraces are often cited by farmers as reasons for their preference over improved disease-resistant cultivars, even where landraces yield less [32]. Although the most resistant cultivars yielded significantly more than the most susceptible ones, some susceptible cultivars produced high yields in low-disease-pressure areas like Ntene and Mnara wards. These results highlight the importance of applying a balanced strategy to CBSD management that enhances tolerance while also making use of yield and quality traits present in local landraces. Phytosanitary control measures, including the use of disease-free planting material, must be emphasized to minimize disease spread.

#### **4.3 Vector Prevalence and Disease Transmission Dynamics**

The study recorded high populations of whiteflies (*Bemisia tabaci*), with the Mtwara District Council exhibiting an alarming mean of 12.9 whiteflies per plant, corroborating the hypothesis that vector density correlates directly with disease incidence. This observation aligns with [18], who demonstrated that the prevalence of *B. tabaci* significantly contributes to the epidemiological spread of CMD and CBSD across East Africa. More recently, [33] outlined how increased vector populations under changing climate conditions are accelerating disease transmission, stressing the need for region-specific vector control strategies. Additionally, integrated pest management (IPM) approaches, including biological control methods, have been recommended as a viable alternative to synthetic insecticides in whitefly regulation.

#### **4.4 Farmer Awareness and Disease Management Practices**

Despite 82.5% of farmers being able to identify CMD symptoms and 75.8% recognizing CBSD symptoms, only 29.2% understood the transmission mechanisms. This knowledge gap hampers effective disease control and underscores the need for targeted agricultural extension programs. The NCDS 2020–2030 highlighted the prominence of farmer education in disease mitigation, advocating for comprehensive training to enhance understanding of disease epidemiology and control measures. Additionally, [34] accentuated that farmer education plays a pivotal role in disease mitigation, advocating for comprehensive training initiatives to enhance awareness of disease epidemiology, transmission pathways, and phytosanitary control measures. Likewise, [35] underlined that despite growing awareness, the slow adoption of improved seed systems remains a critical barrier, necessitating policy-driven incentives for farmers to transition towards certified planting materials.

#### **4.5 Strategies for Enhancing Cassava Productivity**

The study advocates for the adoption of improved, disease-resistant cassava varieties as a cornerstone of sustainable cassava production. This recommendation is supported by [36] who demonstrated that the use of certified, disease-free planting materials substantially mitigates CMD and CBSD prevalence. Additionally, the Tanzania Agricultural Research Institute (TARI) has developed robust disease-resistant cassava genotypes, such as Kiroba, yet adoption rates remain disappointingly low. The [28] FAO (2021) report highlights that improved seed accessibility through public-private partnerships can significantly enhance smallholder adoption.

**Conclusion**

The study underscores the severe impact of Cassava Brown Streak Disease (CBSD) and Cassava Mosaic Disease (CMD), compounded by climate variations to cassava production in Southeastern Tanzania, particularly in Lindi and Mtwara regions. The empirical evidence highlights that, farmers continue to favour local cassava cultivars, which are highly susceptible to these diseases, leading to significant yield losses. Thus the study emphasizes the urgent necessity for an integrated approach that amalgamates climate-resilient agricultural practices, deployment of disease-resistant cultivars, and comprehensive farmer education initiatives. Furthermore, Mnara ward in Lindi is identified as an optimal location for cassava seed production due to its lower disease pressure compared to other wards. The study strongly supports proactive policy interventions and research-driven solutions to bolster cassava resilience against environmental and pathological stressors. Ensuring sustained cassava production will necessitate a multi-faceted strategy encompassing genetic improvement, agronomic optimization, and participatory farmer engagement to fortify food security and economic stability in the regions. Future efforts should prioritize scaling up adoption pathways for improved cassava varieties while reinforcing disease surveillance networks to mitigate emerging threats effectively.

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**Data Availability Statement:**

Raw data can be provided to scientists on request by contacting with the authors

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