



Characteristics of Smallholder Cereal Farmers and Influence on Drought Adaptations in Makueni County, Kenya

Jackob Haywood Ondiko*, Amon Mwangi Karanja, Humphreys Were Obulinji and Kennedy Nyabuti Ondimu

Department of Geography, Egerton University P.O. Box 536-20115
Nakuru, Kenya

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*Correspondence

Jackob Haywood Ondiko
ondikojackob2018@gmail.com

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Abstract: Characteristics of smallholder cereal farmers are key factors influencing adoption of community based drought adaptations and indigenous knowledge in drought-prone arid and semi-Arid Lands globally. Increasing frequency and severity of drought experienced in drylands is a major challenge to rain-fed cereal production in Africa. Kenya experiences frequent droughts which influence levels of vulnerability of the smallholder cereal farmers in arid and semi-Arid Lands that cover 80% of the surface area in the country. Frequent droughts and adverse pedo-climatic conditions in Makueni County in Kenya, influence cereal production, consequently, food security. This study evaluated the influence of characteristics of smallholder cereal farmers on adoption of drought adaptation techniques in Makueni County, Kenya. The study adopted explanatory sequential mixed methods research design. The study analysed the household data from a sample of 225 participants. More females than males adapted to droughts through use of indigenous knowledge including drought monitoring and prediction (61%), bio-control of weeds (57%), seed preservation (55%), use of farm manure (54%), supplementary irrigation (51%) and early planting of seeds (51%). Frequent droughts in Makueni County resulted in adoption of small farm sizes where 60%, 43% and 42% of the cereal farmers produced between 1 to 10 bags of maize, sorghum and finger millet, respectively. Information and data generated by this study is expected to result in improvement in drought adaptation policy formulation and drought adaptation capacity development among the smallholder cereal farmers. These efforts will result in improvement in food production and security in Arid and Semi-Arid Lands in Kenya. This study recommends studies on sustainable drought management practices in Arid and Semi-Arid Lands in Kenya.

Key words: Community based adaptations, indigenous knowledge, drought, drought prediction, drought monitoring.

Characteristics of smallholder cereal farmers are crucial factors in drought adaptation and production of cereals, particularly in Arid and Semi-Arid Lands (ASALs),

where agriculture is highly susceptible to environmental challenges. According to Zhang *et al.* (2016), the rate of aridity and desertification is escalating globally at a rate of 1.74% every decade. This alarming trend underscores the urgent need for effective support for smallholder cereal farmers in vulnerable regions, aiming to enhance their resilience, agricultural productivity, and long-term sustainability. The escalating aridity and desertification in ASALs have led to a notable increase in the severity and impact of droughts (Han *et al.*, 2022; Kew *et al.*, 2019; Leeper *et al.*, 2022; Wahl *et al.*, 2022; Xue and Ullrich, 2022). Severe drought conditions significantly hinder cereal production, resulting in fluctuating yields in affected regions globally. These fluctuations are particularly pronounced in global drought hot-spots, including the Midwestern United States, a large area of South America, the Eurasian belt extending from Eastern Europe to Eastern Asia, and equatorial Africa. In these areas, the impact of drought on agricultural output not only threatens food security but also poses economic challenges to farmers and communities reliant on staple cereal supplies (Reho *et al.*, 2024). Droughts significantly affect agronomic activities and cereal production in the regions. However, Ripoll *et al.* (2017) established that young people were adapting to adverse agricultural conditions through adoption of modern agro-systems, drought adaptation techniques and smart agricultural practices in rural areas in Africa. These efforts were noted to be positively influencing cereal yields.

Cereals including sorghum (*Sorghum bicolor* (L.) Moench) (Muui *et al.*, 2013), finger millet (*Eleusine coracana* (L.) Gaertn) (Belete, 2020; Crutchfield, 2017; Tigchelaar *et al.*, 2018) and maize (*Zea mays* (L.) (Mbinda *et al.*, 2021; Nhamo, 2019) are resilient to droughts and they are adaptable to adverse Agro-ecological zones (AEZs) in ASALs in Africa. Africa experienced increasing drought recurrence in the last one century: 1910s, 1940s, 1960s, 1970s, 1980s, 1990s, 2000s and 2010s (Funk *et al.*, 2023; Gbegbelegbe *et al.*, 2024; Han *et al.*, 2022; Kew *et al.*, 2019; Ruwanza *et al.*, 2022). Approximately 45% of land in Africa is degraded and comprise ASALs (Africa Group of Negotiators Experts Support [AGNES], 2020). However, increase in population in ASALs and the consequent

increase in demand for food is a major concern for governments and farmers in the regions. These challenges require drought adaptations whose adoption is influenced by characteristics of smallholder farmers in ASALs. Besides, Asravor *et al.* (2023) found that young people who adapted to adverse pedo-climatic conditions and adopted data-driven and fast decision making in agro-production in Ghana, recorded improvement in cereal yields.

Several drought episodes were experienced in North Eastern Africa in 1980s, 2000s and 2010s while central parts of East Africa experienced severe drought in 2003 (Haile *et al.*, 2020). The droughts significantly affected smallholder cereal production despite the rapid annual increase in demand thereby making ASALs in East African region food insecure. Inadequate adaptation and resilience to drought conditions in the region were still a challenge to cereal production. However, Ayele *et al.* (2021) pointed out that age determined adoption of commercialization and agribusiness which resulted in improvement in cereal production in Ethiopia. Haile *et al.* (2020) noted that over ten severe droughts have been recorded in East Africa since 1970s whereas Kenya recorded the events in 2010, 2011 and 2012.

Increasing frequency and severity of droughts were established in ASALs in Kenya (Han *et al.*, 2022; Nyangena, 2020; Ondiko and Karanja, 2021). Therefore, drought is a major constraint to cereal production hence regarded as a key factor influencing levels of vulnerability of smallholder cereal farmers. These events necessitate improvement in response techniques and levels of adaptation which form the basis for characterization of smallholder farmers in affected regions.

Drought-tolerant cereals are used as both drought adaptation options as well as potential food grains for managing food insecurity during drought in ASALs in Kenya. In spite of adoption of these drought-resilient cereals in ASALs in Kenya, increased drought severity and frequency which was experienced from 1990 to 2020, significantly affected yields (Nyangena, 2020). Ondiko and Karanja (2021) reported that Kenya experienced a reduced drought return period from five to three years. Furthermore, Han *et al.* (2022); Kew *et al.* (2019); Lam *et al.* (2023); Ondiko and Karanja

(2021); Venton (2018) established that droughts occurred in Kenya in all the decades since 1900 whereby severe droughts were experienced in 1930s, 1940s, 1950s 1980s, 1990s and 2000s. The periodic droughts ranged from mild to severe; mostly affecting North-eastern, Coast, Nyanza, and parts of North Rift Valley (Kagwiria *et al.*, 2019; Mutua *et al.*, 2016; Nyangena, 2020). In addition, Karanja (2018) revealed that droughts significantly affect smallholder livelihoods in ASALs in Kenya. Ondiko and Recha (2022) also found that drought is a major constraint to cereal production in ASALs in Kenya. Therefore, adaptation to frequent droughts in Makueni County are influenced by the characteristics of the smallholder farmers which in turn influence cereal production.

Even though frequent droughts significantly affect cereal yields; Community Based Adaptations (CBAs) and Indigenous Knowledge (IK) influence production of drought-resilient cereals (Mundia *et al.*, 2019). In addition, Njagi *et al.* (2019) pointed out that majority of the smallholder farmers in Kenya prepared their farms using human labour pointing to low adoption of technology. However, adoption of CBA and IK is influenced by characteristics of smallholder cereal farmers in ASALs such as Makueni County in Kenya.

Aoko (2023), Kagwiria *et al.* (2019) and Radeny *et al.* (2019) have demonstrated that the adoption of CBAs and IK in drought management enhances cereal production in ASALs. In this context, this study aimed at establishing the characteristics of smallholder cereal farmers, focusing on key variables such as age, gender, education, occupation and farm ownership. It was hypothesized that these characteristics significantly influence the adoption of CBAs and IK drought adaptation strategies, ultimately affecting cereal production and yields in ASALs in Kenya.

Materials and Methods

Study area

This study was conducted in Makueni County, located 200 kilometres Southeast of Nairobi city, Kenya. The county is located between latitudes 1°35' and 3°00'S and between longitudes 37°10' and 38°30'E. The county is bordered by Machakos County to the North, Kitui County to the Northeast and East, Kajiado

County to the West and Southwest, and Taita Taveta County to the South. Makueni County has a surface area of 8,177 square kilometres (km²) (Kenya National Bureau of Statistics [KNBS], 2019). Makueni County is classified as Agro-Ecological Zone V (AEZ 5) which is an ASAL in Eastern Kenya (Kitinya *et al.*, 2012). The county has six sub-Counties namely: Mbooni, Kilome, Kaiti, Makueni, Kibwezi West, and Kibwezi East (Amukono, 2016). The sample study sites included the following sub-Counties: Kibwezi West, Kibwezi East, Makueni and Kilome. Rainfall received in the Northern highlands in the study area ranges from 800 millimetres (mm) to 1200 mm per annum and 300 to 400 mm per annum in the Southern lowlands of the county (Kitinya *et al.*, 2012). The county experiences high temperatures with a mean ranging from 23.0° to 27.0°C (Amukono, 2016). Further, the lowlands experience higher temperatures up-to 35.8°C (GoK, 2013). The altitude of the study area ranges from 600 metres (m) to 1900 m above sea level with a generally low-lying terrain (County Government of Makueni [CGoM], 2017). The total population of Makueni County was 987,653 people (KNBS, 2019).

Data collection

Household survey was conducted on the smallholder cereal farming households in Kibwezi East, Kibwezi West, Kilome and Makueni sub-Counties in Makueni County. Systematic random sampling was used for the selection of the units of analysis who were smallholder cereal farmers. Listing, assigning numbers to the population and calculation of the sampling fraction was done followed by the selection of the first unit. Thereafter every K^{th} number in the population was selected to form the study sample that was administered with semi-structured questionnaires for collection of data on drought adaptation techniques and to establish the characteristics of the smallholder cereal farmers.

Results and Discussion

Gender of the Smallholder Cereal Farmers

Results in Figure 1 show that 53% of the household heads were males while 47% were females. The study found that smallholder cereal farming in Makueni County was dominated by males. The large number of males

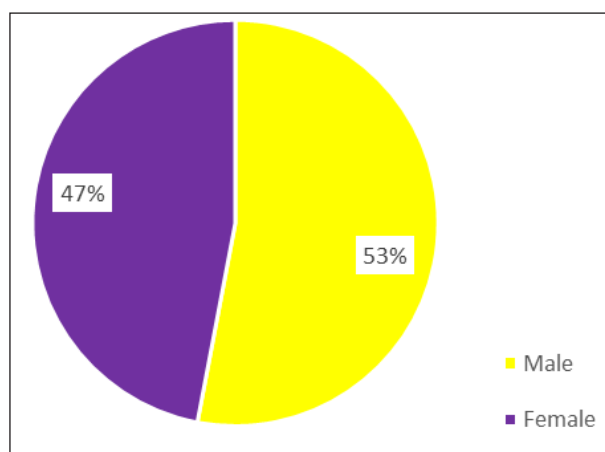


Fig. 1: Gender of Smallholder Farmers in Makueni County.

in smallholder farming was attributed to the land tenure systems, economic conditions and traditional practices such as land ownership that favour males in the study area.

The results of this study align well with previous research conducted among smallholder crop farmers in Cape and Limpopo Provinces of South Africa by Koshe (2022). The study found that majority of the smallholder farmers in the two regions were males. Fiwa *et al.* (2015) also reported that smallholder crop farming in Mpumalanga in South Africa was dominated by males. These results are also consistent with results of studies conducted among smallholder crop farmers in Southern and Eastern Africa by Fitawek (2022) which found that majority of the farmers who invested in large-scale agriculture were males.

Age of the smallholder cereal farmers

Results in Figure 2 show that 28% of the household heads were between 18 to 35 years old, 40% of the household heads were between 36 and 53 years old, 24% were between 54 and 71 years old while only 8% were above 71 years old. This implies that cereal farming is more popular among cereal farmers in the middle-ages and advanced ages compared to the youthful members of the society.

These results are consistent with results of a study on crop production in Mpumalanga in South Africa (Fiwa *et al.*, 2015) which established that majority of the smallholder farmers were in the age group 30 to 55 years. Fitawek (2022) also found that majority of the farmers in Southern and Eastern Africa, who invested in large-scale agriculture were aged between 30 and 49 years. However, the results of the study contrast those of studies conducted in Cape and Limpopo Provinces of South Africa by Koshe (2022) which revealed that majority of the farmers were above 65 years old.

Level of education of the smallholder cereal farmers: Results in Figure 3 show that very few cereal farmers had no formal education (7.0%) and degree level education (1.8%). Majority of the smallholder cereal farmers had primary education (37.3%), followed by secondary education (34.9%), higher-A education (8.9%) and diploma education (8.0%). Only 1.8% of the farmers did not respond to this question.

These results are consistent with those of a study conducted by Mhambi (2022), in

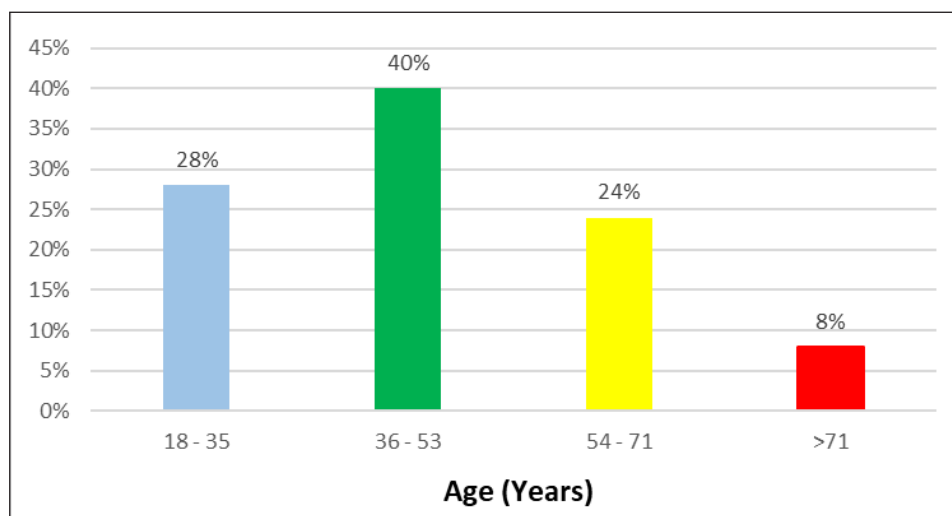


Fig. 2. Age of the Smallholder Farmers in Makueni County.

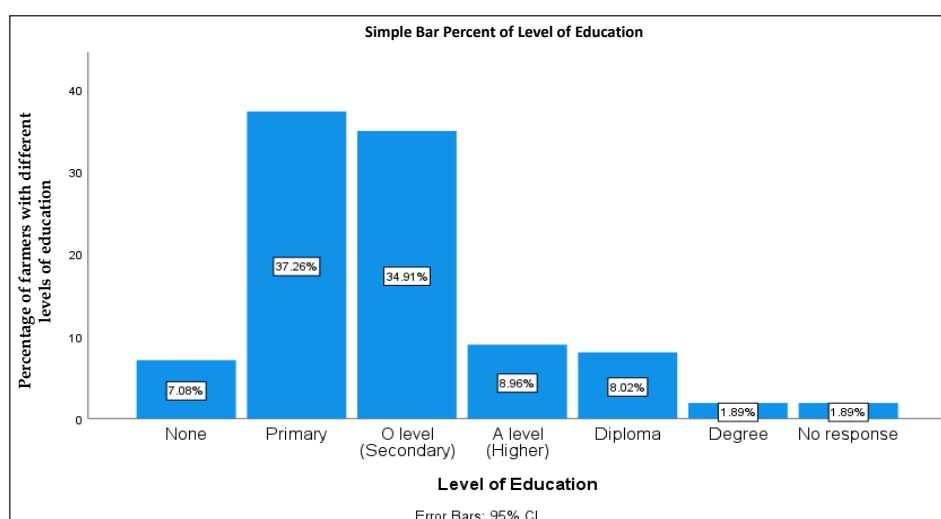


Fig. 3. Level of Education of the Smallholder Farmers in Makueni County.

Mqanduli, Eastern Cape Province and Limpopo Provinces of South Africa, on crop production which found that majority of the stallholder farmers had primary education. Fiwa *et al.* (2015) also reported that majority of the crop farmers in Mpumalanga in South Africa had primary education. Fitawek (2022) also revealed that majority of the farmers in Eastern Africa who invested in large-scale agriculture had primary education.

Occupation of the smallholder cereal farmers:

Results in Figure 4 indicate that 66% of the respondents were occupationally smallholder cereal farmers, 15% were employed, 11% were traders and 8% were agro-pastoralists. This implies that smallholder cereal production is a very popular economic activity in the study area.

These results are consistent with results of a study on crop production in Mpumalanga region and Limpopo Province in South Africa (Hlatshwayo *et al.*, 2023), which established that majority of the farmers were crop producers.

Influence of characteristics of smallholder farmers on CBA and IK drought adaptations:

Results in Table 1 show that more females than males in Makueni County adapted to droughts through IK drought prediction and monitoring (61%), late planting of cereal seeds (57%), bio-control of weeds (57%), IK-based seed preservation (55%) and use of farm manure (54%). In addition, more females adapted to droughts through supplementary irrigation (51%) and early planting of seeds (51%). On the other hand, the results show that more males than females in Makueni County adapted to droughts through planting early maturing seeds (58%), planting drought resistant cereal

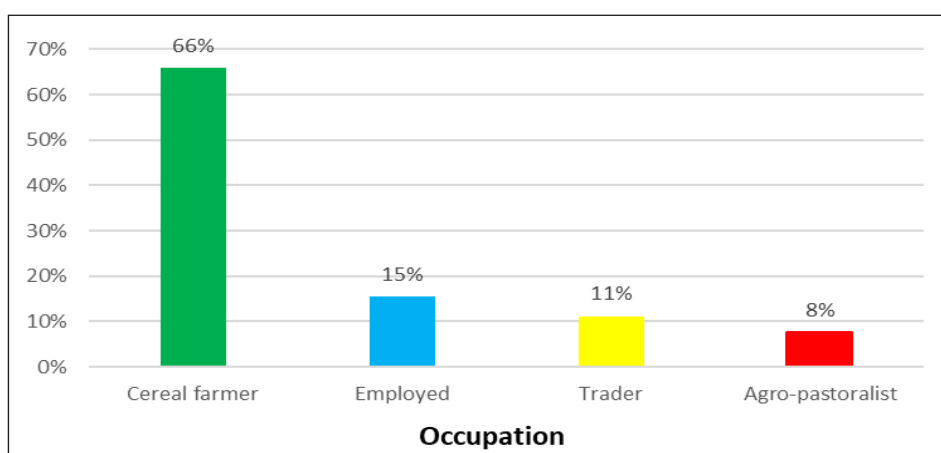


Fig. 4. Occupation of the Smallholder Cereal Farmers in Makueni County.

Table 1. Cross-tabulation of gender and drought adaptations (N=212)

Drought adaptations	Gender %	
	Female	Male
IK drought prediction and monitoring	61	39
Supplementary irrigation	51	49
Early planting of cereal seeds	52	48
Late planting of cereal seeds	57	43
Use of farm manure	54	46
Increasing farm size	55	45
Decreasing farm size	51	49
IK bio-control of weeds and pests	57	43
Use of improved seeds	47	53
Adoption of farm mechanization	53	47
IK based seed preservation	55	45
IK based seed storage	55	45
Planting early maturing seeds	42	58
Planting drought resistant seeds	46	54

seeds (54%) and use of improved cereal seeds (53%).

Results of this study are consistent with those of studies conducted in Vhembe District in South Africa and rural areas of Eswatini by Phoobane and Masinde (2024) and Tfwala, *et al.* (2023), respectively. The studies in Southern Africa established that use of IK was very popular whereby majority of the farmers adopted IK techniques and early warning systems in drought prediction. In addition, Habakubaho *et al.* (2023) found that adoption of IK-based weather forecasting and drought

prediction techniques such as observing the colour of the sky and clouds, day-time variation in temperatures, occurrence of lightning and thunderstorm, and monitoring the patterns, strength and direction of winds in drought-prone area of Nyagatare and Gatsibo Districts of Rwanda were also practiced. Further, IK-based drought prediction and monitoring influenced the time of land preparation and planting in Limpopo Province, South Africa (Rankoana, 2022).

Results in Table 2 show that 35% to 55% of the smallholder cereal farmers who adapted to droughts were between 36 and 53 years old. The most popular drought adaptation strategies among farmers in the age bracket included increasing farm size (55%) and use of farm manure (50%). This study found that IK-based bio-control of weeds, use of improved seeds and planting early maturing cereal seeds were practiced by 49%, 48% and 46% of the smallholder cereal farmers in the 36 to 53 years age bracket. It is not clear why majority of the farmers in the 36 to 53 years old age bracket practiced more drought adaptation strategies compared to the other age brackets.

Results of this study are consistent with the results of a study conducted in Africa by Ripoll *et al.* (2017) which revealed that young people have adopted improved methods of crop production and that they have adopted modern techniques in rural development where cereal production, agribusiness and agricultural

Table 2. Cross-Tabulation of Age and Drought Adaptations (N=212)

Drought adaptations	Age %			
	18-35 Years	36-53 Years	54-71 Years	>72 Years
IK drought prediction and Monitoring	29	44	20	7
Supplementary irrigation	30	44	17	9
Early planting of Seeds	24	41	27	8
Late planting of seeds	30	35	19	16
Use of farm manure	18	50	22	10
Increasing farm size	20	55	20	5
Decreasing farm size	26	40	23	11
IK bio-control of weeds and pests	27	49	17	7
Use of improved seeds	27	48	21	4
Adoption of farm mechanization	27	41	20	12
IK based seed preservation	16	44	32	8
IK based seed storage	15	45	30	10
Planting early maturing seeds	18	46	31	5
Planting drought resistant seeds	22	39	32	7

Table 3. Cross-Tabulation of Education Level and Drought Adaptations (N=212)

Drought Adaptations	Level of education %					
	Informal education	Primary	Secondary	A-Level	Diploma	Degree
IK drought prediction and Monitoring	4	50	26	10	9	1
Supplementary irrigation	8	44	30	7	8	3
Early planting of seeds	9	33	36	10	9	3
Late planting of seeds	0	58	24	12	6	0
Use of farm manure	7	38	31	12	10	2
Increasing farm size	8	28	24	22	12	6
Decreasing farm size	11	31	40	9	9	0
IK bio-control of weeds and pests	5	43	26	12	11	3
Use of improved seeds	5	35	29	15	12	4
Adoption of farm mechanization	0	37	23	23	11	6
IK based seed preservation	10	32	33	11	10	4
IK-based seed storage	7	31	33	11	13	5
Planting early maturing seeds	10	30	32	14	11	3
Planting drought resistant seeds	8	36	33	11	10	2

research play a key role despite the financial and systems-based challenges. Further, Asravor *et al.* (2023) established that youth farm operators were more efficient in agricultural production and decision making compared to middle-aged and aged farmers in Ghana. The results of the study are also consistent with the results of a study conducted by Ayele *et al.* (2021) in Guji Zone in Ethiopia which established that cereal commercialization was influenced by the age of the smallholder farmers.

Results in Table 3 show that majority (58%) of the cereal farmers who practiced drought adaptations in Makueni County had primary education. The results also revealed that late planting of seeds and IK-based drought prediction and monitoring were practiced by majority of the cereal farmers with primary

education at 58% and 50%, respectively. The results also show that decreasing farm size (40%), early planting of seeds (36%), IK-based seed preservation (33%) and IK-based seed storage (33%) were the most popular drought adaptation strategies among cereal farming households with secondary education.

The results of this study are consistent with those of a study conducted by Murugani (2016) in Limpopo Province in South Africa, which found that crop production was popular among smallholder farmers with primary education. These results are also consistent with results of a study on crop production in South Africa (Fiwa, 2015), which reported that majority of the small holder farmers had lower and upper primary education. Fitawek (2022) also found that majority of the farmers who invested in

Table 4. Cross-tabulation of occupation and drought adaptations (N=212)

Drought Adaptations	Occupation %				
	Cereal Farmer	Agro-pastoralist	Teacher	Civil servant	Trader
Supplementary irrigation	66	13	1	1	19
Early planting of seeds	69	6	4	4	17
Late planting of seeds	66	14	0	3	17
Use of farm manure	63	8	3	5	21
Increasing farm size	72	4	6	4	14
Decreasing farm size	61	7	2	4	26
IK bio-control of weeds and pests	69	6	6	1	18
Use of improved seeds	71	6	6	1	16
IK based seed storage	70	7	1	4	18
Planting drought resistant seeds	67	6	7	4	16

Table 5. Cross-Tabulation of Gender and Agronomic Adaptations (N=212)

Agronomic adaptations	Gender %	
	Females	Males
Improving land tillage	54	46
Improving seed spacing	54	46
Timely weeding	56	44
Timely application of organic manure	55	45
Mono-cropping	60	40
Inter-cropping with legumes	50	50
Inter-cropping with cereals	56	44
Practicing agro-forestry	54	46

large-scale agriculture in Eastern Africa had primary education.

Results in Table 4 indicate that majority of the cereal farming households were primarily farmers with 60% to 72% of the cereal farmers practicing different strategies of drought adaptation. The results indicate that increasing farm size (72%), use of improved cereal seeds (71%) and IK-based cereal seed storage (70%) were the most popular drought adaptation strategies among cereal farmers. The study also revealed that late planting of cereal seeds (14%) and supplementary irrigation (13%) were popular drought strategies among agro-pastoralists.

These results are consistent with those of a study that was conducted in Mpumalanga region and Limpopo Province in South Africa by Hlatshwayo *et al.* (2023), which established that majority of the farmers were crop producers.

Results in Table 5 indicate that more females than males practice agronomic adaptations in the study area. The results show that the following agronomic adaptations were the most popular among female cereal farmers: mono-cropping (60%), timely weeding (56%) and

inter-cropping with cereals (56%). The results also show that inter-cropping with legumes (50%), improvement in land tillage (46%), improving seed spacing (46%) and practicing agro-forestry (46%) were the most popular agronomic adaptations among male cereal farmers in the study area.

These results are consistent with results of a study on crop production in Malawi by National Statistics Office (NSO) (2012) which established that more females inter-cropped compared to males; however, the study established that more males practiced mono-cropping compared to females in Malawi. Fitawek (2022) also found that majority of the farmers who invested in large-scale agriculture in Madagascar, Mozambique and Kenya were males. This indicates that agro-practices of the family were influenced, to a large extent, by the male household heads. The large number of male-headed households is an indication that traditional practices that favour male dominance in land ownership still influence crop production in Madagascar, Mozambique and Kenya.

Farm size in hectares: Table 6 indicates that 32.9%, 30.2% and 24.4% of the smallholder sorghum, finger millet and maize farmers, respectively, cultivated the cereals on small farm sizes ranging from 0.1 to 0.5 hectares (ha). The study revealed that only 12%, 1.8% and 0.9% of the maize, sorghum and finger millet farmers, respectively, cultivated the cereals on farm sizes above 3.1 ha.

These results are consistent with those of a study on crop production in Malawi by Fiwa (2015) which argued that the most common size of smallholder farms was 1.88 ha, signifying a high popularity of smallholder farming in the country. The study also corroborates the results

Table 6. Farm Size in Hectares in Makueni County

	Sorghum		Finger millet		Maize	
	No. of farmers	Per cent	No. of farmers	Per cent	No. of farmers	Per cent
No response	103	48.4	115	54.2	15	7.1
0.0-0.5	70	32.9	64	30.2	52	24.4
0.6-1.0	14	6.7	12	5.8	33	15.6
1.1-2.0	14	6.7	13	6.2	49	23.1
2.1-3.0	7	3.5	6	2.7	38	17.8
>3.1	4	1.8	2	0.9	25	12.0
Total	212	100.0	212	100.0	212	100.0

of a study conducted in Malawi by NSO (2012), which established that smallholder farming was very popular in the country whereby the average farm size was 1.9 ha. Fitawek (2022) also found that majority of the farmers in Southern and Eastern Africa who invested in large-scale agriculture had less than 1.0 ha of farmland while a smaller number had between 1 and 3 ha of farmland.

Conclusions

Majority of the smallholder cereal farming household heads were males. Majority of the cereal farmers were in the age bracket between 36 and 53 years old. Majority of the smallholder cereal farmers had primary education. Smallholder cereal farming was the most popular occupation in the study area. More females than males adapted to droughts through CBA and IK drought adaptations including drought prediction and monitoring, seed preservation, use of farm manure, supplementary irrigation, early planting of seeds and bio-control of weeds. More males than females in Makueni County adapted to droughts through use of improved seeds and planting early maturing cereal varieties. The middle-aged farmers who were in the age bracket between 36 and 53 years old preferred IK-based bio-control of weeds, use of improved seeds and planting early maturing cereal seeds. Majority of the smallholder farmers produced cereals on small farm sizes below 0.5 ha thereby making farm size a key factor in drought adaptation and cereal production in Makueni County. Information and data generated by this study can be used to improve drought adaptation policy formulation and drought adaptation capacity building among smallholder cereal farmers to improve food production and security in other ASALs in Kenya. This study recommends up-scaling the most popular drought adaptation practices that have been adopted by majority of the cereal farmers in Makueni County, to other regions with similar AEZs. This study also recommends studies on sustainable drought management practices in ASALs in Kenya.

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