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Potential of Mobile Phone-Based Decision Support Systems on Selecting of Sorghum Varietal Seeds in Homa Bay County, Kenya

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Decision Support System (DSS) is critical in interactive and quick decision making as it reduces uncertainty due to its compatibility or interactivity, expandability, accessibility and functionality. Several mobile-based DSS have been developed over the years, but little evidence on whether sorghum farmers are consulted in the development of mobile apps that aid in selecting sorghum variety seeds. A baseline survey was conducted in Homa Bay County to establish the user requirements for mobile-based DSS to reduce uncertainty for sorghum varietal seeds formulating a total of 150 sorghum farmers. SPSS computer-based software was used to analyse the data. Results revealed that 73.3% possessed basic phones while 26.7% owned smartphones. Majority of the farmers (60%) made phone calls while 28.7% used SMS, to access agricultural information. About 82% farmers did not use mobile-based apps (SMS, calls) but 80.9% would consider using a sorghum varietal seed selection app. Majority of the farmers (42.7%) planted seredo variety while 34.7% preferred indigenous varieties (*Ochuti, Obama, Andiwo*). There was a positive relationship between occupation and three mobile apps (WhatsApp, Facebook and Calls) implying, there was increased use of three apps as occupation level got higher. The correlation findings showed that as education level increased there was also increased use of WhatsApp and Facebook, however, calls, internet and SMS usage had negative relationship with education of respondents. End-user involvement and requirements consideration during system development is paramount for DSS adoption. Hence, DSS should be interactive with real time sorghum information, sensitize farmers on different platforms and farmers to consider smartphones technology due to different features applications.

Keywords: Decision Support System; Mobile-based Platform; Sorghum production

Introduction

A decision support system is critical in decision making process which requires users in its coordination. The DSS should facilitate, generate, analyse and compare different alternative decisions. Decision making in agriculture means selecting options that improves crop productivity

and making higher profits. The users have to deal with different data and information which are enormous resulting to translation problems. Agricultural information on sorghum seed varieties have been researched and documented for farmers to access in different forms. Information's role is ever increasing in regard to weather, soil, diseases, seed, fertilizer, markets and insects for economic and sustainable development. Therefore, information on sorghum seed variety selection ought to be accurate, flexible, interactive, reliable and timely for quick decision-making. Information is mostly available from various sources such as agricultural research institutions, public and private universities disseminated in different pathways such as Information and Communication Technologies (ICTs), fellow farmers, agricultural extension officers; print media like Journals, factsheets, briefs, newspapers; electronic media such as CDs/DVDs/tapes, radio, TVs among others ([1]; [2]).

The rapid expansion and uptake of mobile phone technologies in developing countries has not only enhanced service delivery across businesses, but also farmer's households and agricultural organizations. Despite the many research and availability of information, access to timely information on the sorghum seed variety selection is constrained by lack of resources, connectivity, infrastructure networks, and lack of capacity building on DSS. [3] noted that farmers depended on traditional knowledge, experience and guesswork inorder to make decisions for day-to-day activities which are not very effective in improving livelihood. Further, ([3]) pointed out that DSS provides farmers with timely extension services and advises on daily or in emergency cases on matters pertaining agricultural production, marketing, technology, food security and nutrition. Different ICT tools have been established to assist in decision making but of late more mobile-based applications are being used to forge closer links between farmers and the experts though not on sorghum seed varieties selection for different agro ecological zones.

Decision Support System (DSS) refers to an information system that interacts and aids users in judgment and making choices ([4]). For sorghum variety selection, a number of options needs to be factored in, which can be strenuous and highly demanding, therefore a DSS tool will help farmers

to decide on the appropriate sorghum variety. In their works, [5] pointed out that the system ought to give accurate results from the multiple choices on the specific crop variety. [6] reported that crop productivity in agriculture can be enhanced by DSS. Therefore, a DSS tool needs to be developed inorder to aid with timely information for sorghum seed variety selection. An improper decision on selection of sorghum grain can negatively affect productivity.

Sorghum (*Sorghum bicolor L. Moench*) is ranked third most important staple food, drought resistant hardy crop in Kenya yet farmers still experience failure periodically threatening food and income security. Sorghum production is linked to the contributions of food security, income growth and poverty alleviation mainly for low-income households. The farmers in the growing areas still experience periodic low yield ([7], [8] and this is a threat to food and income security. They noted that the low productivity of sorghum had been attributed to factors such as poor technology transfer, diseases, insect pest damage and rainfall variability, dwindling research on sorghum and minimal input production systems among others.

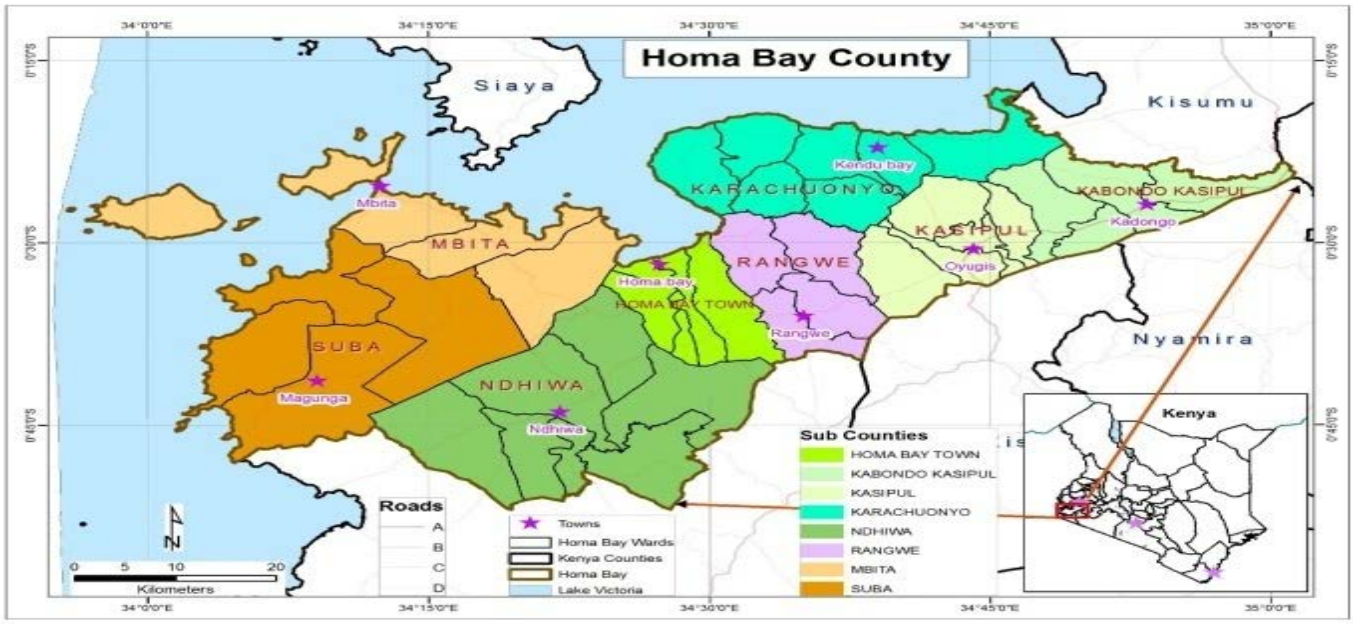
Sorghum farmers practice the traditional methods or use analogous experiences for seed selection prompting them to make wrong choices on sorghum seeds. They obtain seed through both formal and informal channels with the latter being the largest source for smallholder farmers. There is need therefore to have interventions to increase sorghum productivity through a decision support system platform for the right sorghum seed variety selection. Sorghum farmers in Homa Bay County get the seeds from relatives, purchase from Agrovets, and thereafter they rely on own stock. Farmers rarely use Improved Varieties (IVs) such as *Gadam, Seredo, Serena* and *Sila* but rely on Farmer's Varieties (FVs) like *Ochuti, Obama, Andiwo, Maro gwom* hence making the demand on IVs very low. [9] found out that 58.1% farmers used local varieties of sorghum while farmers (41.9%) used the improved variety of sorghum. The improved varieties is almost negligible mainly due to poor participation in the selection process, poor intervention of improved agricultural technologies (absence of improved varieties), birds damage to early maturity varieties, diseases (grain mold, head smut, anthrocnose) and insect pests (shoot fly and stalk borer) [10].

The focus of this paper therefore, is to help developers identify the sorghum or user requirements before coming up with a mobile application for sorghum seed varietal selection system in Homa Bay County, Kenya inorder to increase sorghum yield.

Materials and Methods

Study Area

The study was conducted in Homa Bay County which lies in the western part of Kenya with the latitude 0°32′6.15″S, 34.453097 and longitudes 34°27′ 11.15″E, 0.535043. Homa Bay covers an approximate area of 3,342.2km^2 with a population of about 963,794 people, with average annual temperature is 22.5°C with average annual rainfall as 1226 mm ([9]). Homa Bay County is characterized by different soil types and rock. Temperature of the area plays a vital role in evapotranspiration, hence experiencing spatial and seasonal variability in different months of the year. The area experiences two rainy seasons: the long rains are between March – April – May while the short rains starts in September to November. Farming and Fishing are the major occupation of Homa Bay County (Figure 1).



Source: Google Map (2020)

Figure 1: Homa Bay County

Sampling Techniques

Homa Bay County is made up of eight sub-counties: Ndhiwa, Rangwe, Homa Bay, Suba, Kasipul, Kabondo Kasipul, Mbita, Karachuonyo. The sampling frame for this study consists of the sorghum farmers. Purposive sampling technique was employed to select the areas with high concentration of sorghum production in Homa Bay County. From the list of sorghum farmers in the high sorghum producing areas, 150 sorghum farmers were selected. The sample size was determined using [11] formula. This formula assumed 95% confidence level and 0.5 (±5) level of precision.

$$n = \frac{N}{1 + N(e)^2}$$

Where n = the sample size,

N = the population size, and e is the level of precision.

Data Collection

A survey was conducted in the month of January-February, 2019 using guided questionnaires on an ODK mobile-based toolkit. The questionnaire covered the socio-economic characteristics, mobile types, apps used, sorghum varieties planted and the need for new DSS. 150 sorghum farmers selected for the study were interviewed by the trained enumerators.

Data Analysis

The collected data was then transferred to Census and Survey Processing System (CS Pro). After which it was converted to EXCEL then to SPPS. Quantitative data was analysed using descriptive statistics using SPPS version 20. Logistic regression was used as a modelling test to predict nominal dependent variables (mobile application tools, sorghum varieties) against independent variables (occupation, education, age categories) while the K-means clustering method was used to categorize the respondents with regard to the mobile apps, sorghum varieties and agro-ecological zones. The chi-square means was used to show the association/relationship between the variables.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of the Respondents

Different variables such as farm size, education background, age, farmers' attitudes, perception and technological adoption were useful in determining the farmer's needs for the development of a DSS. This was to establish how the characteristics of sorghum farmers influences ones decision on using the mobile-based phone services available to access information for informed decision making.

In Table 1, 47.3% respondents were between 21–40 years old with 50 respondents owning basic phones while 21 with smartphones. 34.7% respondents were aged between 41–60 years, 40 respondents with basic phones while 21 with smartphones; 15.3% represented the 61–80, 2% were 20 years and below while 0.7% respondents was 80 years and above who did not own smartphones. The age category with highest possession of phones (smart or basic) suggests that the group was in its prime stage, responsible, energetic and resource providers. Farmers owning mobile phones for a long time are believed to possess better skills in making phone calls, SMSing which helps in the adoption of technology and agricultural usage [12].

Education level on mobile applications usage revealed that 59.3% of the respondents had attained basic education and owned basic phones (76) with 33.3% with secondary education had the highest possession of smartphones (23). Majority of farmers with basic education made phone calls to fellow farmers, extension agents and agrovets. These results show that literacy level among farmers was very low. Otherwise, the high number of farmers with low level of education is attributed to lack of resources to pay for school fees. In addition, low rate of technological adoption is due to the low level of education hence not accessing agricultural information through the DSS. These findings are similar to [13] studies where the main reasons for non-adoption of technology are weak perceptions of technology and low education of farmers. Farmers with high education level used their smartphones to accessing agricultural information. Improved technologies and new

innovations are adopted when farmers' are able to comprehend their benefits through reading. Farmer's education is very critical when interpreting the accessed and acquired information.

The male gender (65.3%) had 31 smartphone possession compared to the female 34.7% with 9 owning smartphones but majority of male 67 possessed basic phones while 43 female owned basic phones. In terms of the application used, 90 farmers' made phone calls with the male farmers' making more calls, with short message services being the secondly used application. In some instances, the female were not aware of the mobile applications used. This is attributed to the fact that the male are the providers and endowed with resources.

Of the 77.3% married respondents, 29 owned smartphones while 87 had basic phones, 11.3% singles with 8 owning smartphones while 9 had basic phones, 10.7% widowed with 2 owning smartphones while 14 owned basic phones and 0.7% separated with 1 owning smartphone and zero with no basic phones. The married couples dominated the other marital status by choosing to make phone calls and SMS respectively through their basic phones. The married also owned smartphones compared to the other status since there was support from their spouses in acquiring the phones.

Farming was the main source of livelihood with 64%, followed by businessmen (22%), business and farmers (13) while public servants and retirees had 4 each. Majority made phone calls (90) and SMS (43). Farmers involved in farming used phone calls and SMS at 60 and 26 respectively. This implies that income obtained from off farm activities assisted in acquiring improved seeds, latest or modern mobile phones, pesticides, attend seminars and telecommunication gadgets. The sorghum farmers depended mainly on farming, followed by self-employment, business and farming and then public servant. Farming activity is the main source of livelihood and this is for subsistence. The findings are similar to ([13], [14]). A lot of research have shown that use of mobile phones enhances income for smallholder farmers' ([12]; [15]; [16]). The findings corroborates ([1]) study where the main activities was farming, followed by business.

Majority of sorghum farmers 74.6% owned between less than 1.5 acres and 3 acres of land, 10% owned between 4.6 and 6 acres, 7.3% owned between 3.1 and 4.5 acres, while 8% owned

between 6.1 and more than 10.6 acres of land. The farm size is an important variable in determining the uptake of technologies ([17]). [18]); [19] noted that farmers with small farms were less interested on new and advanced technologies compared to commercialized farms. Farmers with large farm size are more likely to obtain information from numerous of sources such as face-to-face interactions and modern ICT ([20]). Experimentation on new crop varieties and also crop diversification is possible on a larger farm size.

Table 1: Demographic Characteristics on the Mobile-based Apps and ownership(n=150)

Variables	%age	SP	BP	None	SMS	IN	YT	WA	FB	Calls
Age category										
<20	2.0	2	1	0	1	1	0	0	0	1
21-40	47.3	21	50	0	19	2	1	1	1	47
41-60	34.7	12	40	5	17	1	0	2	0	27
61-80	15.3	5	18	1	6	2	0	0	0	14
>81	0.7	0	1	0	0	0	0	0	0	1
Education Level										
None	0.7	0	1	0	0	0	0	0	0	1
Primary	59.3	13	76	2	26	4	1	1	0	55
Secondary	33.3	23	27	3	15	2	0	1	1	28
Tertiary	6.7	4	6	1	2	0	0	1	0	6
Gender										
Female	34.7	9	43	0	19	2	1	0	0	30
Male	65.3	31	67	6	24	4	0	3	1	60
Marital Status										
Married	77.3	29	87	6	33	3	1	3	1	69
Single	11.3	8	9	0	2	2	0	0	0	13
Widow/er	10.7	2	14	0	7	1	0	0	0	8
Separated	0.7	1	0	0	1	0	0	0	0	0
Occupation										
Public Servant	2.0	1	3	1	2	0	0	0	0	0
Farmer	64.0	18	78	4	26	5	0	1	0	60
Retired	2.7	1	3	0	2	1	0	0	0	1
Business	22.0	15	18	1	9	0	1	0	0	22
Busi.&Farm	8.7	5	7	0	4	0	0	2	1	6
Others	0.6	0	1	0	0	0	0	0	0	1
Farm size										
<1.5	37.3	14	42	2	1	2	1	35	2	13
1.6-3.0	37.3	14	42	3	0	0	0	34	0	19

3.1-4.5	7.3	1	10	0	0	1	0	7	0	3
4.6-6.0	10.3	4	11	1	0	0	0	6	2	6
6.1-7.5	1.3	1	1	0	0	0	0	1	0	1
7.6-9.0	0.7	1	0	0	0	0	0	1	0	0
9.1-10.5	3.3	3	2	0	0	0	0	4	1	0
>10.6	2.7	2	2	0	0	0	0	2	1	1

Notations: SP – Smartphone, BP – Basic phone, IN – Internet, YT – YouTube, WA – Whatsapp, FB - Facebook

In general, majority of the sorghum farmers (110) owned basic phones while (40) owned the smartphones. Farmers commonly made phone calls (90), with 64 and 26 farmers possessing basic phones and smartphones respectively. Short messaging services (43) was the second commonly used application with 35 basic phone owners while 8 farmers possessing smartphones. From the results shown above, the most commonly owned phone was basic phone with minority using the smart phones as well as using them for accessing information. This is contrary to ([21]) findings of applications of smartphone-based as the common phone for its farming applications like pest and disease detection, farm management applications. Though smartphones are useful tools that are equipped with various sensors for diverse farming tasks, Homa bay sorghum farmers have stuck to basic phones due to lack of awareness on the sophisticated applications, expensive handsets and high cost charged, interactivity problems, insufficient information, language complexity and poor network connection. Majority of farmers with basic phones preferred them due to affordability and no literacy skills needed to operate them.

Table 2: Relationship between Socio-economic Factors and Mobile-based Applications

	Gender	Age	Marital	Education	Occup	Land	None	SMS	Inter	Whats	FB	Calls
Gender	1											
Age	0.046	1										
Marital	-0.278**	0.153*	1									
Education	0.396*	0.117	-0.151*	1								
Occup	0.068	-0.01	-0.057	0.07	1							
Land	0.148*	0.282**	-0.055	0.14*	-0.106	1						
None	-0.134	-0.005	0.106	-0.021	-0.052	-0.016	1					
SMS	-0.134	-0.005	0.106	-0.021	-0.052*	-0.016	*1.000	1				
Internet	0.004**	0.002**	0.077	-0.042	-0.032*	-0.056	-0.130	-0.130	1			
WhatsApp	0.103	0.002**	-0.067	0.122	0.014*	-0.058	-0.091	-0.091	-0.029	1		
Facebook	0.059*	-0.069	-0.039*	0.070	0.020*	-0.075	-0.052	-0.052	-0.017	-0.012	1	
Calls	0.023*	-0.038*	-0.065	-0.058	0.067	-0.027	-0.787	-0.787	-0.253	-0.177	-0.102	1

Source: Own Analysis (2019): ***Sig. 1%, **sig.5% and *sig.10%

Notation: Occup – Occupations; Inter – Internet; What – Whatsapp; FB – Facebook

Pearson's Moment Correlation determined the significant difference and degree of association among variables (Table 2). There was a positive relationship between occupation and three mobile apps (WhatsApp, Facebook and Calls). This could mean that, there was increased use of these three apps as occupation level got higher. However there was a negative relationship between occupation and SMS plus Internet options. The correlation findings also shows that as education level increased there was also increased use of WhatsApp and Facebook, however, calls, internet and SMS uses had negative relationship with education of respondents.

It was also evident that there was a significant negative relationship of land owned with marital status which could imply more married sorghum farmers had more land.

Gender had a significant effect on the land ownership which may imply that the males inherited land compared to female who do not inherit land in African society. Age category posted a positive relationship with use of internet and WhatsApp, in contrast, there was low use of the Facebook, calls and SMS with higher age category. There was a significant positive relationship between gender and education level. The size of land did not result to higher use of all mobile apps.

Information Sources/Pathways

Ninety four of the farmers sourced information from person-to-person (farmer, extension officer and agro-vets), while 35 farmers listened to radio, 7 farmers' used SMS and phone calls, with just 1 farmer reading brochures to access information as shown in Figure 2.

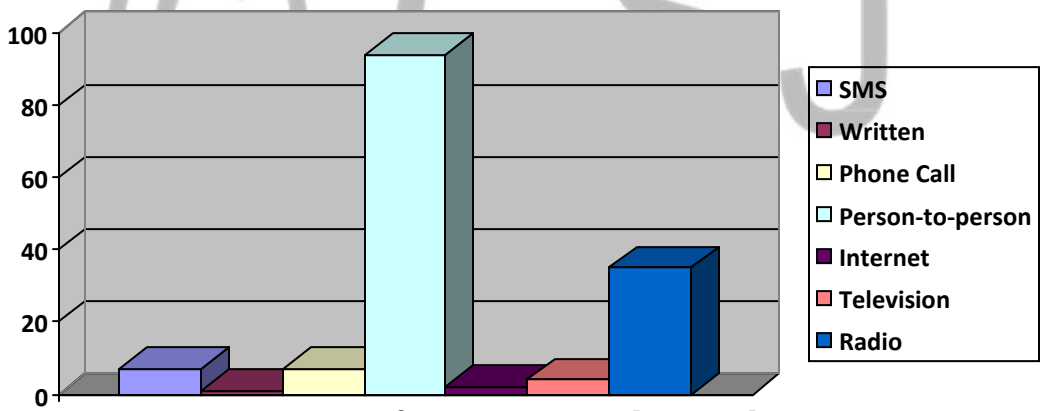


Figure 2: Information received/Sourced

Information sources significantly affected how the information was received/sourced for by the sorghum farmers through the channels. Majority of the farmers made phone calls and used SMS (Short Messaging Services) applications for accessing information on the basic phone because of affordability and interactivity. Farmers share farm knowledge mostly with their agricultural extensionists, fellow farmers, families, and friends. This is similar to a study by [22] and [23] where farmers used phones to share agriculture-related use from agricultural agents. Different organisations

such as Ministry of Agriculture, Livestock and Fisheries introduced use of short messaging service codes like “12316” at all levels of the agricultural sector and DigiFarm.

Sorghum Information

Type of Sorghum Varieties Grown (Most preferred)

Farmers in the county are heterogeneous group so they do not select sorghum seeds in the same way. Sorghum farming in Homa Bay County is second to maize farming. From the study, Seredo was the most preferred (42.7%), others (Ochuti, Andiwo, Marogwom) was 34.7%, Sila was 14%, Serena with 5.3% and Gadam 3.3% (Figure 3).

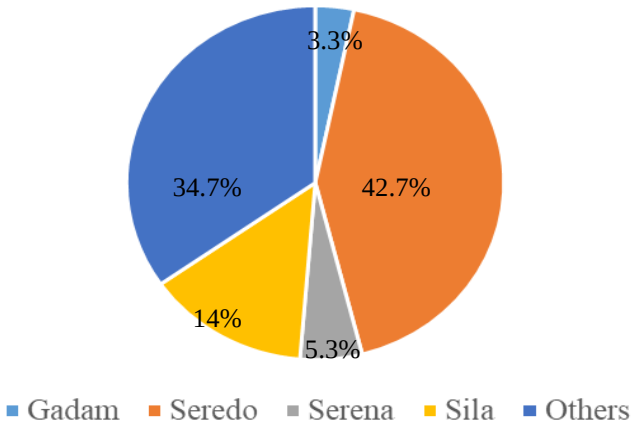


Figure 3: Type of Sorghum varieties grown

Majority of farmers planted local sorghum varieties without knowing the scientific names, no clear definition or information on the preferred sorghum varieties that perform well. They planted the landraces due to the diverse qualities shown over the hybrid varieties which few farmers only grow due to the requests by contracting companies. From the results, Seredo is the most preferred variety. It is brown in color, takes 3.5 month to mature, According to Kenya Seed, the most popular variety is Gadam in terms of marketing ([24]). The brown Seredo variety is preferred because they are resistant to birds and weevils. [7] reported that the preferred variety was because of the yield, marketability, ease of cooking, drought resistance, mature early, pest resistance and price. [7] In

their study conducted in Mbeere South County, Kenya, reported that Gadam and Serena had been adopted by farmers while Seredo and KARI Mtama 1 are adopted by very few farmers. Gadam is reported to perform well in the drier lowlands of Machakos, Kitui, Mwingi, Makueni, Tharaka, Mbeere, Kilifi, Tanariver, Marsabit, Moyale, Homa-bay and Kajiado.

Farmers using Decision Support Systems

This section sought to find out if the sorghum farmers used any mobile applications for decision making before, during and after for their sorghum production. Farmers interviewed, majority, (80%) did not use DSS while (20%) used different DSS to access sorghum information as shown in Figure 4. The number of sorghum farmers using mobile apps was observed to be very low as shown below.

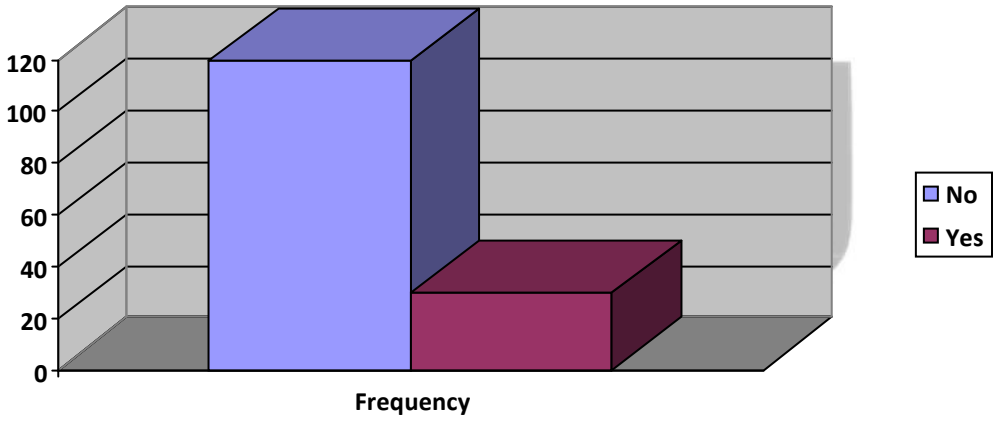


Figure 4: Farmers using DSS for sorghum information

The farmers using the DSS are few probably because when developing the system, the developers do not have the user's needs in mind and therefore there is high chance of farmers being unable to interact with the system. The findings are in line with [25] research on DSS where he noted the underutilization and ineffectiveness of DSS. In addition, the AgriDSS are poorly adapted to farmers' needs and practices hence lack of use to their fullest potential ([26]; [27]; [28]). In recent times, the DSS have been re-developed by involving stakeholders. For example, DSS by [29] for improved communication; [30] with minimal data requirement.

An Improved Decision Support System

Respondents were asked whether they would like a new decision support system to be developed. 80.9% farmers would like the development of an improved decision support system while 19.1% were not for the idea (Table 4).

Table 4: Development of an Improved or New Decision Support System

	Frequency	Percent
No	28	19.1
Yes	122	80.9

Majority of the farmers would consider using a new DSS for entire sorghum value chain with information being disseminated in a simpler or vernacular language. For instance, the sorghum names to be standardized by using images and local names. This finding tallied with [31] research where test users would like a new application of a crop cycle with a language that farmers are more comfortable with. [32] Recommends that an AgriDSS must therefore be in line with the farmers' practice as well as farmers' needs, knowledge or experience for it to function properly.

Reasons for not using Mobile Applications

Application usage depended on the affordability, availability of network, interactivity, usability and awareness. Results in Table 5 that majority of farmers did not have any idea was 52% (78), expensive handset was 20% (30), interactivity was 9.3% (14), insufficient information was 7.3% (11), poor network connection was % (3), language complexity and expensive had 4.7% (7) each.

Table 5: Reasons for not using Mobile Applications

Reasons for not using Apps	Frequency	Percentage
Interactivity	14	9.3
Poor network connection	3	2.0
Expensive handsets	30	20.0
Insufficient Information	11	7.3
Language complexity	7	4.7
No idea	78	52.0
Expensive	7	4.7

Farmers have depended mostly on accessing agronomic information and other services through making calls and SMS. The SMS application bridges the information gap between sources (fellow farmers, researchers, and agrovets) and the targets. Through SMS, information on particular sorghum variety, from land preparation to production, harvesting, to harvest handling, value addition, markets and prices can be accessed. The SMS and calling were found to be 'easily accessible' for the mobile phone enabled services unlike other applications like Internet, Youtube, Whatsap and Facebook. Through SMSes, farmers are able to get instant alerts for commodities and markets and also for real time alerts.

Conclusions and Recommendations

From the survey, the low adoption of technology by sorghum farmers has contributed to the poor crop productivity and food insecurity in the Homa Bay County. This has been attributed by lack of awareness and training on the latest technologies that could help in proper and appropriate decision making process on sorghum production. The education level attained by the few sorghum farmers was significant in influencing the use of mobile-based applications like SMS and calls. Therefore, the information being relayed to farmers should be interactive and simple. Despite the numerous information sources, farmers are not informed of latest and available mobile apps that

could be used to access timely information hence the low sorghum productivity. More awareness and sensitization on the use of apps should be done through campaigns by the relevant authorities. Female farmers were noted to lag behind in the mobile-based usage yet they are the food providers. It is therefore, paramount that they are involved in the DSS development from farmers' needs assessment to the last stage of development.

On a new or improved DSS, sorghum information mainly on sorghum seed varieties selection, market pricing and available market, crop disease prevention and controls, need to be incorporated. The seed variety DSS tool will need to provide suggestions about seed varieties based on their agro-ecological zones. The DSS tool should have both Audio visual tool so that farmers who are physically challenged are also able to access information.

The young people must be encouraged to form Startups and AgTechagribusinesses. These mobile apps could be developed to provide farm-to-market advisory services, training, sharing topical information and keeping them informed of upcoming products, services and events.

The study recommends that any policy intervention on sorghum production, the national and county governments should provide the appropriate sorghum seeds acceptable to the farmers and suitable for agro-ecological zones.

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Conflict of Interest

This research paper has no conflict of interest.

Author Contributions

Conceptualization – Susan Mbanda; methodology – Susan Mbanda; formal analysis – Susan Mbanda; writing and draft preparation – Susan Mbanda; review and editing – Hillary Nyanganga, Evans Chimoita and Phoebe Ong'alo. All co-authors mentioned have contributed substantially to this work.

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