DISSEMINATION APPROACHES THAT ENHANCE ADOPTION OF CLIMATE RESILIENT TIMPS FOR PIGEON PEA, SORGHUM AND GREEN GRAMS VALUE CHAINS IN MACHAKOS COUNTY, KENYA

ABSTRACT

Dissemination approaches play a key role in facilitating the adoption of climate smart technologies, innovations and management practices among farmers. Various approaches used in Kenya include the top down approaches and bottom up approaches. This study was conducted to determine and validate dissemination approaches that enhance sustainable adoption of climate resilient TIMPs for Sorghum, Green grams and pigeon peas value chains among farmers in Machakos county. The objectives included: to Identify dissemination approaches for TIMPS in sorghum, green grams and pigeon peas in Machakos county, to assess the frequency of use of dissemination approaches for TIMPS by stakeholders and to determine the stakeholders' perception on the effectiveness of the dissemination approaches for TIMPS. The study used a survey research design where champion farmers and extension service providers were purposively selected for data collection. The descriptive analysis was conducted using the SPSS version 16. A weighted index was computed to aid comparison for various values chains and categories. The results showed that farmer-to-farmer and T&V dissemination approaches were the frequently used dissemination approaches whereas education institution was the least used dissemination approach in the three value chains in the county. Enhanced utilization of farmer-to-farmer, T&V and demand driven dissemination approaches for enhance adoption of green grams, pigeon peas and sorghum for improved productivity and household income.

Keywords: Climate smart TIMPS, dissemination approaches, Utilization, Adoption

1. INTRODUCTION

Agricultural dissemination approaches in developing countries play a key role in facilitating the adoption of climate smart technologies, innovations and management practices among farmers. Over the years, agricultural organisations in the public and private sector have developed different extension approaches for disseminating information to farmers. Various approaches used in Kenya include the top down approaches such as training and visit approach and farm visits and bottom up approaches such as commodity based approach (Chimoita et al 2017). These approaches are used in both public and private extension services provision including those run by non-governmental organizations in the developing countries.

Public extension service providers in Kenya include the Ministry of agriculture, livestock and fisheries (MoALF), Universities and Kenya Agricultural and Livestock Research Organisation (KALRO) while private service providers include non-commercial extension service providers such as non-governmental organisations, faith-based initiatives and community-based organisations (CBOs) and commercial providers such as private practitioners and input suppliers. Non-commercial service providers provide agricultural extension services with an aim of empowering rural farmers with knowledge and skills as a sustainable way of curbing chronic poverty prevalence. In contrast, private companies such as seed and agrochemical companies provide extension services to farmers based on their area of specialization. The services are mainly commercial and profit oriented and they mostly work with successful farmers in high potential areas (Muyanga and Jayne, 2008).

Stakeholders in extension provision on green grams, sorghum and pigeon peas in Machakos County include the MoALF which provides inputs and extension services to farmers and Kenya Agricultural Productivity Project (KAPP) in collaboration with KALRO where they facilitate and offer technical support to farmer empowerment.

Comment [SK1]: Abstract should contain results with data (statistical data for example)

Comment [SK2]: Rewrite for better understanding

Comment [SK3]: Introduction is too long. This part should include general observations on this field, the problem that aroused the initiation of this study, the main objective and specific objectives.

Comment [SK4]: Various approaches used in Kenya include the top down approaches such as training and visit approach and farm visits, and bottom up approaches such as commodity based approach (Chimoita et al 2017).

Comment [SK5]: Public extension service providers, in Kenya, include the Ministry of agriculture, livestock and fisheries (MoALF), Universities and Kenya Agricultural and Livestock Research Organisation (KALRO). Private service providers include non-commercial extension service providers such as non-governmental organisations, faith-based initiatives and community-based organisations (CBOs), and commercial providers such as private practitioners and input suppliers.

Various climate smart technologies, innovations and practices have been developed by KALRO in collaboration with other partners to improve green grams, pigeon peas and sorghum productivity and yields in the country (Emongor*et al.,* 2022). These include varieties, integrated pest and disease and soil fertility management practices and use of ITK in production and postharvest management. Increased adoption of these TIPMs is important for poverty reduction and increased food and nutrition security for farming households especially in Machakos County. To increase sorghum, pigeon peas and green grams production, therefore, farmers need to be updated on information available regarding the various production processes and management practices.

Comment [SK6]: These include varieties, integrated pest and disease, soil fertility management practices and use of ITK in production and postharvest management.

Consequently, one or more effective crop extension approach is required to deliver new technologies to farmers in Machakos County. However, more often, the technologies, innovations and practices do not reach the farmers. This is attributed to the weak link between research, extension and farmer resulting to inadequacy in accessing the technologies, innovations and management practices.

Additionally, use of inappropriate dissemination approaches, the problem of duplication of information from different service providers and challenges facing the public extension sector results to poor adoption of the recommendations by farmers (Munyua &Stilwell, 2010). This affects production of these crops and consequently the overall household income. Therefore, the objective of this study was to determine and validate dissemination approaches that enhance sustainable adoption of climate resilient TIMPs in the pigeon peas, sorghum and green grams value chains among farmers in Machakos County.

Dissemination approaches for extension services

Extension approaches refers to how knowledge and skills are shared with farmers (FAO,2008). Extension is an informal educational process directed toward the rural population. This process offers advice and information to help them solve their problems. Extension also aims to increase the efficiency of the family farm, increase production and generally increase the standard of living of the farm family. The aim of extension is to change farmers' outlook toward their difficulties. Extension is concerned not just with physical and economic achievements but also with the development of the rural people themselves. Extension agents, therefore, discuss matters with the rural people; help them to gain a clearer insight into their problems and to decide how to overcome these problems. Extension is a process of working with rural people in order to improve their livelihoods. This involves helping farmers to improve the productivity of their agricultural value chains and developing their abilities to direct their own future development. They also underline extension as an educational process, which works with rural people, supports them and prepares them to confront their problems more successfully. The main elements within the process of extension includes: knowledge and skills, technical advice and information, farmers' organization as well as motivation and self-confidence. The main approaches for extension service provisions have been identified and briefly described. The ultimate goal of adoption of extension approach is to increase farmers' productivity and income (Waddington *et al.,* 2010). On the other hand, extension programs perform a significant part in enhancing the flow of data from farmers to researchers (Anderson, 2007).

Farmer to Farmerapproach involves provision of training by farmers to farmers, often through the creation of a structure of farmer-trainers. Farmers can learn about alternative or newer methods by sharing their experiences with one another. In this approach, farmers share information and knowledge and aims to increase awareness of the many features of the technique and its benefits. Through farmer-to-farmer dissemination, communities can learn about the various aspects crop management, resource use, and how it can reduce labour costs, aspects of moisture retention, soil and water conservation, and climate change adaptation.Farmer to farmer approach adopts use of lead farmer, model farmer, volunteer farmer, farmer trainers, community knowledge worker to train/offer extension services to others. The Lead farmers get training about the approach, the initiative (technology/tools/methods), and various extension methods. They are the first to experiment the approach on their field first. Further, they transfer the knowledge and skills to other farmers of the community through model farms, community networks and practical trainings

Training and Visitis a fairly centralized approach that involves a series of tightly planned visits to farmers. Pre-service and in-service training programmes designed and conducted for both field and supervisory staff. The training is mainly in the form of short pre-service and in-service courses at the Extension Training Centres (ETCs). The short courses last from one to four weeks, and cover topics such as management and planning Extension Officers, instructional skills for Subject Matter Specialists and Extension Officers) and pre-season and monthly training (FEAs). The system results in greater farmer contact and entails better trained extension agents (Hamisu *et al.,* 2017). The system is quite costly and somewhat inflexible in its timing of scheduled visits (Chambers et al., 2013). At times it can be more procedural than message oriented. Training and Visits (T&V) is among the earliest methods which concentrated on the transmission of knowledge through a top to the bottom (Davis et al., 2016).

A farmer field school takes place in one of the farmer's fields for the duration of one cropping season. It is a form of participatory research that uses a season-long group-based learning process. Farmers come together periodically to increase their knowledge and skills of crop management. Most learning in the field school takes place in the field. Learning is based on doing experiments in the field in which e.g. the IPM practice is compared with their own practice and on sharing of observations and experiences between farmers and facilitators. Through experimentation, observation, discussion and decision making farmers increase their crop management skills. The field school trains farmers in analyzing their own environment and farming practices, thereby enabling them to make decisions on crop management based on observations and to use the resources that fit with their environment and farming systems. Through this process of experimentation and improved decision making, the school aims to assist the farmers in solving their production problems and developing a more sustainable farming system. Farmers observe available options and make decisions on the most appealing practice or technology. High costs and high time requirements can affect sustainability of the system.

The commodity based approach is mostly planned through private sector organizations. In this approach, the production scheme is vertically combined from the contribution source to the knowledge acceptance and selling of the harvest (Hamisu *et al.,* 2017). Commodity based approach focuses on a single crop or on only one aspect of farming. Farmers produce a particular amount and value of products, and trade with the firm to which they are affiliated. In response, the firm delivers inputs, credit and information amenities, supervision, and marketing facilities. This approach is also referred to as contracted farming (Mukasa *et al.,* 2016). Its benefits comprise great earnings on crops or livestock, growing the revenue of farmers and their practical and decision-making abilities whereas decreasing farmers' threats and worries. It may moreover offer small and intermediate farmers with admission to lucrative ambitious markets to farming resources, skills, and guidance from which they would else be omitted. However, the information material is restricted to the practical and managerial or business side of the specific product. This approach addresses everything from extension and research to input supply, marketing and prices to increase production in the selected crop. Planning is controlled by a commodity organization whose interests might not match others. The approach typically does not provide support on other aspects of farming.

General Agricultureapproach assumes that technology and knowledge that are appropriate for local people exist but are not being used by them. The approach is usually fairly centralized and government-controlled. Success is measured in the adoption rate of recommendations and increases in national production. This approach is considered as a top to bottom government. Decision making, resources, and major assistance to the farming communities are supervised by the government arm responsible for extension services in different regions zones, and at the county level.

The Focal Area/ProjectConcentrates efforts on a particular location, for a specific time period, and is usually supported by outside resources. Part of its purpose is to demonstrate techniques and methods to farmers with the expectation that adoption will continue farmer to farmer after the project ends. Project targets can add pressure to make non-relevant changes in the short term. There are issues of sustainability once a project withdraws

Farmer ParticipatoryInvolves active participation of farmers in planning and execution of the various research-extension activities. Program planning is typically controlled and implemented locally by farmers' associations and community organizations. Implementation is often decentralized and flexible. High time, participatory skills and cost required

Research and extension farmer linkageorganisations operate at the same status in a country or county, using a bottom-up approach in decision-making on research and extension activities. Farmers are involved in planning and their feedback is important in designing the linkage activities. Activities include: Joint planning, joint on-farm trials, joint demonstrations and joint exhibitions, field days and M&E

Farming systemsfocuses on bringing appropriate technology to small-scale farmers with farmers engaged in the technology development and delivery process. A key characteristic of the approach is the farm being viewed as a system using a holistic approach at the local level. The approach requires close ties between research, extension and farmers with technology developed locally through an iterative process. Expensive and time consuming (given the broad range of issues to consider)

Cost sharingassumes that cost-sharing with local people will result in a program that can better meet local situations and be more accountable to local interests. Success is dependent on farmer willingness to pay. Financial management and other aspects of administration tend to be complex and difficult.

Education Institutions approach relies on educational institutions with the technical knowledge and research ability to meet extension service demands. Effectiveness of implementation is often dependent on those who determine overall school curricula and thus determine the extent of the focus on extension. Funding directions and issues of staff promotion and institutional mandates can often push people to do work that does not focus on farmers' needs

The Innovation platforms focuses on multiple actors (farmers, NGOs, service providers, traders, agro-dealers, researchers, policy makers) interact and share their ideas, knowledge and opinions to come up with new solutions. Innovation platforms are used by advisory services and other actors as a means to bring different actors together to discuss and negotiate collectively or for coordinated action. Innovation platforms are generally value chain based and they can be as many as the value chains of interest in a county.

The effectiveness of extension dissemination approaches for the TIMPs were evaluated using the following criteria; Increased technology uptake, Increased Production, Increased food availability, The Multiplier effect inn information sharing, Increased sales of commodities, Training Sessions, Workshops held, Research extension linkage meetings, Input Provisions, Credit Provision, Marketing outlets, Provision of essential services, Adoption of technology, farmer participation and Farm Productivity or Yield.

The objective was to determine and validate dissemination approaches that enhance sustainable adoption of climate resilient TIMPs for Sorghum, Green grams and pigeon peas value chains among farmers in Machakos county.This paper reports the dissemination approaches for TIMPS in sorghum, green grams and pigeon peas in Machakos county

Comment [SK7]: Main and Specific objectives should be stated

2. MATERIALS AND METHODS

Comment [SK8]: There is no material in this part

2.1 Study sites

The study was carried out in Machakos County which is part of the KCSAP Counties covered in the KCSAP Project. The county has an area of 6208.2 Km² most of which is semi-arid. The county has eight Sub counties/ constituencies namely; Masinga, Yatta, Kangundo, Matungulu, Kathiani, Mavoko, Machakos Town/ Kalama and Mwala. The county has a total of 40 Wards and 69 Locations. It lies between latitudes 0º45´South and 1º31´South and longitudes 36º45´East and 37º45´East. Kalama, Mwala, and Yatta Sub-counties were selected for the study (these are shown in figure 1). The three sub-counties fall within agro-ecological zones UM2-UM4 and LM2-LM5 (Jaetzold et al.,2006). Rainfall is bimodal with short rains from October to December and long rains from March to May. Rainfall varies between 500-750mm per annum. The soils are mainly sandy loam with marrum. The slope of the land ranges from gentle to fairly steep. The major economic activities in the Sub-counties include livestock production (dairy, local zebu animals, sheep, goats and indigenous poultry) and crop farming. The major crop enterprises include maize, beans, cow peas, pigeon peas, green grams, sorghum and horticultural crops such as mangoes, pawpaw, onions and tomatoes. The study focused on dissemination approaches for three values chains pigeon peas, green grams and sorghum.

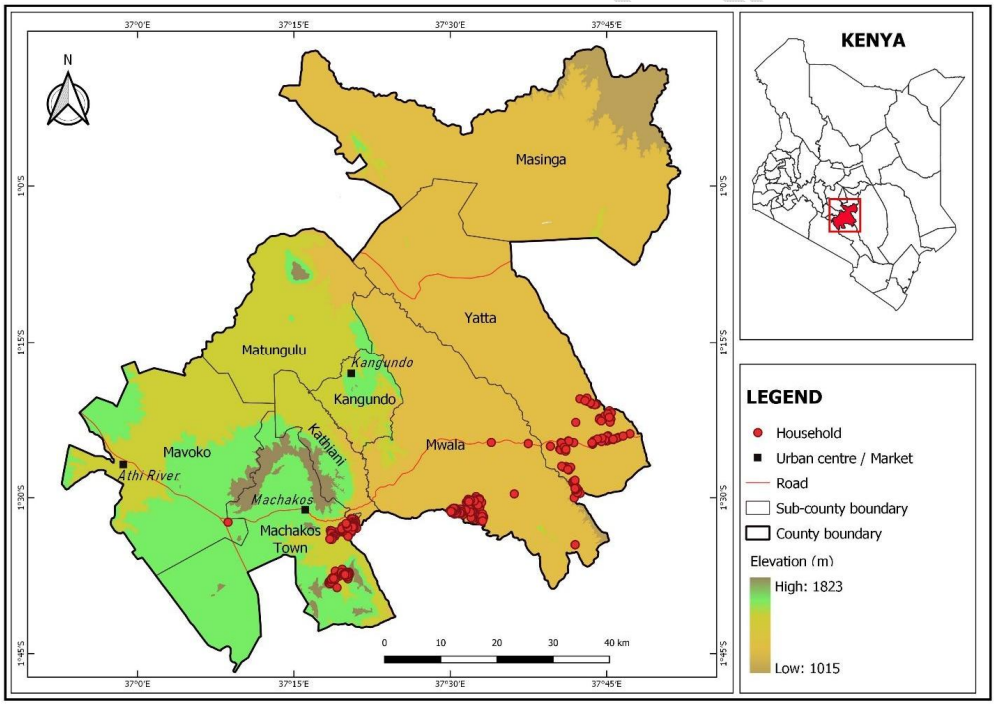

Fig.1: Map of Machakos showing the study sites
Source: Survey data, map prepared by KALRO GIS Lab

2.2 Sampling frame, Sampling and sample size determination

The sampling frame consisted of champion farmers and extension service providers in the three sub-counties; Kalama, Mwala and Yatta in machakos county. The three sub-counties each had two KCSAP Wards where the targeted TIMPs were disseminated and were being produced in the selected sub-counties. The sub county agricultural officers guided the purposeful selection of champion farmers and extension service providers for each of the value chain.

2.2.1 Data collection

The tool used for data collection was a questionnaire that was administered to the champion farmers and the extension service providers. The questionnaire was designed in search away that the respondent would identify a dissemination approach and score on the effectiveness of the criteria as listed. The scores scale was: 1 = decreased, 2= remained the same and 3= increased.

The enumerators were engaged and trained to assist in questionnaire administration and data collection. The training was conducted by the project PIs and the agricultural extension officers. The enumerators were drawn from the pool of individuals identified in KCSAP project areas and who were familiar with the project.

2.2.2 Data analysis methods

Descriptive analysis of the data collected was done using the statistical package for social sciences. The indices were generated for weighting and ranking of the dissemination approaches based on the aggregated score for each dissemination approach. Using the weighted mean as per the equation below, the ranking was done to show the preferred dissemination approach for each value chain.

W= sum(Wi. xi) / sum(n*wi)

W= weighted average
n= number of terms to be averaged
w=weights applied on x-values
x= data values to be average

Descriptive statistics was generated using SPSS version 16. Data was analysed to generate means and frequencies which gave the description of categories and the criteria pathways.

Comment [SK9]: The method should be designed according to specific objectives

3. RESULTS AND DISCUSSIONS

Comment [SK10]: There is no discussion in this part. Explanations should be given according to the obtained results.
And these results should be compared to other results from other authors.

3.1 Identification of dissemination approaches for TIMPS in sorghum, green grams and pigeon peas in Machakos county

According to the results of the key informants' interviews, various dissemination approaches were identified for the selected value chains as follows; Farmer to farmer, Training and visit (T&V), General agriculture approach, Research Extension farmer linkage, Commodity based approach, Farmer participatory approach, farming systems, Demand driven, Farmer Field School, Innovation platform, Cost sharing, Education institution. These approaches were used in different proportions by different stakeholders in the selected value chains.

Comment [SK11]: According to the questionnaire results, some data should be presented

3.2 Assessment of the frequency of use of dissemination approaches for TIMPS by stakeholders

The results of the pooled use frequency of the different dissemination approaches by the different user categories (champion farmers and extension service providers) showed that farmer-to-farmer was the most used (96%), followed by T&V (88.9%) and Demand driven approach (70.4%) as shown in table one. In the championed farmer category, the same pattern was observed while in the extension service providers' category, the third dissemination approaches frequently used were farmer participatory and focal area. The user frequency of some of the dissemination approaches were less than 50%. These included Educational institution, cost sharing, focal area, farming systems, commodity based and farmer field school.

Table 1: Frequency of use of dissemination approaches by the champion farmers and extension service providers in Machakos county

Dissemination Approaches	Champion farmers		Extension service provider		Pooled	
	Frequency	%	Frequency	%	Frequency	%
Farmer to farmer	18	94.74	8	100	26	96.30
T&V	16	84.21	8	100	24	88.89
Demand driven	13	68.42	6	75	19	70.37
General agriculture approach	11	57.89	6	75	17	62.96
Research Extension farmer linkage	10	52.63	4	50	14	51.85
Farmer participatory approach	7	36.84	7	87.5	14	51.85
Innovation platform	8	42.11	6	75	14	51.85
Farmer Field School	7	36.84	6	75	13	48.15
Commodity based approach	9	47.37	3	37.5	12	44.44
Farming systems	6	31.58	5	62.5	11	40.74
Focal area/project	3	15.79	7	87.5	10	37.04
Cost sharing	3	15.79	4	50	7	25.93
Education institution	1	5.26	3	37.5	4	14.81

The results of the use frequency of the different dissemination approaches by the selected value chains showed that farmer-to-farmer (100%) was the most used in green gram, followed by T&V (87.50%) and Demand driven approach (75%). In the pigeon pea value chain, the most frequently used dissemination approach was farmer-to-farmer (90%), followed by T&V (90%) followed by demand driven (80%). In the sorghum value chains the most frequently used was the farmer-farmer extension approach (100%), followed by T&V (90%), followed by driven approach (100%) as shown in table 2.

Table 2: Frequency of use of dissemination approaches in the selected value chains in Machakos county

Comment [SK12]: What means these numbers (8 7 6 3 3 5 2 2 4 2)?

Dissemination Approaches	Green Grams		Pigeon peas		Sorghum	
	Frequency	%	Frequency	%	Frequency	%
Farmer to farmer	8	100.00	9	90.00	9	100.00
T&V	7	87.50	9	90.00	8	88.89
Demand driven	6	75.00	8	80.00	5	55.56
General agriculture approach	3	37.50	7	70.00	7	77.78
Research Extension farmer linkage	3	37.50	7	70.00	4	44.44

Farmer participatory approach	5	62.50	7	70.00	2	22.22
Innovation platform	2	25.00	6	60.00	5	55.56
Farmer Field School	2	25.00	6	60.00	5	55.56
Commodity based approach	4	50.00	4	40.00	4	44.44
Farming systems	2	25.00	4	40.00	5	55.56
Focal area/project	3	37.50	4	40.00	3	33.33
Cost sharing	1	12.50	3	30.00	3	33.33
Education institution	0	0.00	2	20.00	2	22.22

3.3 Determination of the stakeholders' perception on the effectiveness of the dissemination approaches for TIMPS

The results on the effectiveness of the dissemination approaches per value chains according to the perceptions of the champion farmers and the extension service providers were reported according to the effectiveness index.

3.3.1 Sorghum Value chain

Number of dissemination approaches were identified in the sorghum value chain. According to the perceptions of champion farmers, the most effective dissemination approaches was farmer to farmer, followed by T& V which was followed by General agriculture approach respectively Weighted effectiveness as shown in table 3. The use of farmers to train farmers has been widely used especially in the context of a project and has been found successful in disseminating knowledge and technologies to other farmers. Study carried out in Uganda (Ssemkula&Mutimba, 2011) showed that it depended on the farmer facilitators for its success. For the current study, the questions on the effectiveness targeted the champion farmers and extension providers

Table 3: Ranking of the effectiveness of dissemination approaches for sorghum value according to the Champion farmer in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
Farmer to farmer	6	6.78	1
T&V	6	5.83	2
General agriculture approach	6	4.75	3
Research Extension farmer linkage	6	3.75	4
Commodity based approach	6	3.61	5
Farmer participatory approach	6	3.61	6
Farming systems	6	3.42	7
Demand driven	6	2.42	8
Farmer Field School	6	2.31	9
Innovation platform	6	2.17	10
Cost sharing	6	1.25	11
Education institution	6	1.11	12

Comment [SK13]: What is "n"?

According to the perceptions of the extension provider, the most effective extension approach in the sorghum value chain in Machakos County was the Focal area approach followed by general agriculture approach followed by Farmer field school approach as shown in table 4.

Table 4: Ranking of the effectiveness of dissemination approaches for sorghum value chin according to the Extension Provider in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
Focal area	3	7	1
General agriculture approach	3	6.39	2

Farmer Field School	3	6.22	3
Farmer to farmer	3	6.22	4
Innovation platform	3	6.17	5
T&V	3	5.89	6
Demand driven	3	5.17	7
Farmer participatory approach	3	4.67	8
Farming systems	3	4.56	9
Cost sharing	3	3.89	10
Commodity based approach	3	1.89	11
Education institution	3	1.39	12
Research Extension farmer linkage	3	1.06	13

When the pooled sample was used (champion farmer and extension provider), the most effective approach changed. The farmer-to-farmer approach was ranked the best followed by T&V which was followed by general agriculture approach respectively as shown in table 5.

Table 5: Ranking of the effectiveness of dissemination approaches for sorghum according to the perspective of both Extension Provider & in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
Farmer to farmer	9	6.59	1
T&V	9	5.85	2
General agriculture approach	9	5.30	3
Farming systems	9	3.80	4
Farmer Field School	9	3.61	5
Innovation platform	9	3.5	6
Demand driven	9	3.33	7
Commodity based approach	9	3.04	8
Research Extension farmer linkage	9	2.69	9
Focal area	9	2.33	10
Cost sharing	9	2.13	11
Farmer participatory approach	9	1.56	12
Education institution	9	1.20	13

3.3.2 Pigeon pea value chain

In the pigeon pea value chain, the weighted effectiveness index indicted that farmer-to-farmer extension approach was the most effective, followed by T&V and which was followed by demand driven approach according to the perceptions of the champion farmers involved in the pigeon pea value chain in Machakos County as shown in table 6.

Table 6: Ranking of the effectiveness of dissemination approaches for Pigeon pea according to the perspective of the Champion farmer in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
Farmer to farmer	7	5.81	1
T&V	7	5.76	2
Demand driven	7	5.10	3
Farmer participatory approach	7	4.00	4
Research Extension farmer linkage	7	3.98	5
General agriculture approach	7	3.45	6
Farmer Field School	7	2.21	7
Commodity based approach	7	2.07	8
Focal area	7	1.95	9
Innovation platform	7	1.86	10

Farming systems	7	1.00	11
Cost sharing	7	1.00	12
Education institution	7	0.00	13

According to the perceptions of the extension providers in the pigeon pea value chain, the most effective extension approach was FFS followed by Research –extension-farmer linkage, followed by T&V and fourth was demand driven approach as shown in table 7.

Table 7: Ranking of the effectiveness of dissemination approaches for Pigeon pea according to the perspective of the Extension Provider in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
Farmer Field School (FFS)	3	7.11	1
Research Extension farmer linkage	3	7.06	2
T&V	3	7.00	3
Demand driven	3	7.00	4
Farmer participatory approach	3	6.94	5
Farmer to farmer	3	6.83	6
Innovation platform	3	6.83	7
General agriculture approach	3	6.33	8
Farming systems	3	6.06	9
Focal area	3	4.61	10
Commodity based approach	3	4.56	11
Education institution	3	4.56	12
Cost sharing	3	3.33	13

According to the ranking by both Champion farmers and Extension providers, the most effective extension approaches were T&V, followed by demand driven extension approach followed by Research-Extension-Farmer-linkage respectively as shown in table 8.

Table 8: Ranking of the effectiveness of dissemination approaches for Pigeon pea according to both champion farmers and Extension Providers in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
T&V	10	6.13	1
Farmer to farmer	10	6.12	2
Demand driven	10	5.67	3
Research Extension farmer linkage	10	4.90	4
Farmer participatory approach	10	4.88	5
General agriculture approach	10	4.32	6
Farmer Field School	10	3.68	7
Innovation platform	10	3.35	8
Commodity based approach	10	2.82	9
Focal area	10	2.75	10
Farming systems	10	2.52	11
Cost sharing	10	1.70	12
Education institution	10	1.37	13

3.3.3 Green gram value chain

In the green gram value chain according to the ranking done by the champion farmers, the most effective extension approach was demand driven approach followed by farmer-to-farmer extension approach followed by T&V extension approach respectively as shown in table 9

Table 9: Ranking of the effectiveness of extension approaches for Green gram according to the Champion farmer in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
Demand driven	6	6.50	1
Farmer to farmer	6	6.25	2
T&V	6	5.42	3
Commodity based approach	6	4.36	4
Research Extension farmer linkage	6	3.28	5
Farmer participatory approach	6	3.22	6
Innovation platform	6	3.19	7
General agriculture approach	6	2.36	8
Farming systems	6	2.28	9
Farmer Field School	6	2.19	10
Cost sharing	6	1.22	11
Focal area	6	0.92	12

According to the ranking done by extension providers, the most effective extension approach in the green gram value chain was T&V followed by Farmer- to-farmer extension approach and thirdly Farmer participatory approach as shown in table 10. In the case of green value chain, there were only four approaches, which the extension providers identified and ranked.

Table 10: Ranking of the effectiveness of dissemination approaches for Green gram according to the Extension Provider in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
T&V	2	6.50	1
Farmer to farmer	2	6.25	2
Farmer participatory approach	2	6.25	3
Focal area	2	6.08	4

According to the ranking by both Champion farmers and Extension providers, the most effective extension approaches in the green gram value chain were T&V, followed by demand driven extension approach followed by Research-Extension-Farmer-linkage respectively as shown in table 11.

Table 11: Ranking of the effectiveness of dissemination approaches for Green gram according to the perspective of both champion and Extension Provider in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
Farmer to farmer	8	6.25	1
T&V	8	5.69	2
Demand driven	8	4.88	3
Farmer participatory approach	8	3.98	4
Commodity based approach	8	3.27	5
Research Extension farmer linkage	8	2.46	6
Innovation platform	8	2.40	7

Focal area	8	2.21	8
General agriculture approach	8	1.77	9
Farming systems	8	1.71	10
Farmer Field School	8	1.65	11
Cost sharing	8	0.92	12

3.4 Dissemination approaches per category

3.4.1 Champion farmers' category

Ranking of effectiveness of the extension approaches according to categories in Machakos County. For the category (champion farmers), the most effective extension approach was farmer-to-farmer, followed by T&V and thirdly demand driven extension approach as shown in table 12.

Table 12: Ranking of the effectiveness of dissemination approaches for the champion farmers in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
Farmer to farmer	19	6.25	1
T&V	19	5.68	2
Demand driven	19	4.69	3
Research Extension farmer linkage	19	3.61	4
General agriculture approach	19	3.52	5
Commodity based approach	19	3.28	6
Farmer participatory approach	19	2.49	7
Innovation platform	19	2.38	8
Farmer Field School	19	2.24	9
Farming systems	19	2.17	10
Cost sharing	19	1.15	11
Focal area	19	1.01	12
Education institution	19	0.35	13

3.4.2 Extension service providers' category

In the category (Extension service providers), the most effective extension approach was farmer-to-farmer, followed by T&V and thirdly Farmer participatory extension approach as shown in table 13. In both the champion farmer and the extension category, the most effective extension approaches re the same that is the most effective approach was farmer-to-farmer followed by T&V extension approaches.

Table 13: Ranking of the effectiveness of dissemination approaches for the extension provider in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
Farmer to farmer	8	6.46	1
T&V	8	6.46	2
Farmer participatory approach	8	5.92	3
Focal area	8	5.88	4
Farmer Field School	8	5.00	5
Innovation platform	8	4.88	6
General agriculture approach	8	4.77	7
Demand driven	8	4.56	8

Farming systems	8	3.98	9
Research Extension farmer linkage	8	3.04	10
Cost sharing	8	2.71	11
Commodity based approach	8	2.42	12
Education institution	8	2.23	13

3.4.3 Combined categories

In this category (combined champion farmers and Extension providers), the most effective extension approach was farmer-to-farmer, followed by T&V and thirdly demand driven extension approach as shown in table 14. In combined (both the champion farmer and the extension) category, the most effective extension approaches are the same that is the most effective approach was farmer-to-farmer followed by T&V extension approaches.

Table 14: Ranking of the effectiveness of dissemination approaches for both the champion farmers and extension providers in Machakos County

Extension approaches	n	Weighted effectiveness index	Rank
Farmer to farmer	27	6.31	1
T&V	27	5.91	2
Demand driven	27	4.65	3
General agriculture approach	27	3.89	4
Farmer participatory approach	27	3.51	5
Research Extension farmer linkage	27	3.44	6
Innovation platform	27	3.12	7
Farmer Field School	27	3.06	8
Commodity based approach	27	3.02	9
Farming systems	27	2.70	10
Focal area	27	2.45	11
Cost sharing	27	1.61	12
Education institution	27	0.91	13

4. CONCLUSIONS

Comment [SK14]: Should include some data

The champion farmers' and extension service providers' analysis showed that generally, all extension approaches were in use in Machakos County. Regarding the effectiveness criteria used in the analysis, green grams, sorghum and pigeon peas extension approaches tended to be more participatory. The most common extension approaches used by both champion farmers and extension service providers key informants were farmer to farmer, T&V, farmer participatory, research extension linkage, general agriculture and farmer field schools.

Various dissemination approaches were used in different proportions by different stakeholders in the selected value chains as follows; Farmer to farmer, Training and visit (T&V), General agriculture approach, Research Extension farmer linkage, Commodity based approach, Farmer participatory approach, farming systems, Demand driven, Farmer Field School, Innovation platform, Cost sharing, Education institution.

The farmer-to-farmer, T&V and demand driven dissemination approaches were the frequently used dissemination approaches whereas education institution was the least used dissemination approach in the three value chains in the county. Enhanced utilization of farmer-to-farmer, T&V and demand driven dissemination approaches for enhanced adoption of green grams, pigeon peas and sorghum for improved productivity and household income was recommended.

REFERENCES

Comment [SK15]: References should have number (1.) and stated in the text by this number [1] according to manuscript template.

Abdu-Raheem, K. A., & Worth, S. H. Suggesting a new paradigm for agricultural extension policy: The case of West African Countries. *South African Journal of Agricultural Extension*. 2016; 44(2), 216–13. https://doi.org/10.17159/2413-3221/2016/v44n2a425 [Google Scholar]

Akpabio, I. A., Okon, D. P., & Inyang, E. B. Constraints affecting ICT utilization by agricultural extension officers in the Niger Delta. *The Journal of Agricultural Education and Extension*. 2007; 13(4), 263–272. https://doi.org/10.1080/13892240701630986 [Taylor & Francis Online], [Google Scholar]

All Agricultural Commodities Programmes (AACP). *Experiential and Participatory Learning Methodology in Organic Cotton production, Training module for the trainer/facilitator that will manage/guide the learning process, WP3, Related to the LoA PR. NR. 42592 binding ICEA to FAO. Food and Agriculture Organization.* 2010

Anastasioa, M., Koutsouris, A., & Konstadinos, M. Information and communication technologies as agricultural extension tools: A survey among farmers in West Macedonia, Greece. *The Journal of Agricultural Education and Extension*, 2010; (16), 249–263. https://doi.org/10.1080/1389224X.2010.489767 [Taylor & Francis Online], [Google Scholar]

Anderson, J. R. *Agricultural advisory services*. Background Paper for the World Development Report 2008. The World Bank. 2007

Azumah, S. B., Donkoh, S. A., & Awuni, J. A. The perceived effectiveness of agricultural technology transfer methods: Evidence from rice farmers in Northern Ghana. *Food Science and Technology, Research Article, Cogent Food & Agriculture*. 2018; 4(1), 1503798. https://doi.org/10.1080/23311932.2018.1503798 [Taylor & Francis Online], [Web of Science ®], [Google Scholar]

Bembridge, T. J. *Guidelines for the Rehabilitation of Small-Scale Farmer Irrigation Schemes in South Africa*. Paper Presented at The International Seminar on the Performance of Large and Small-Scale Irrigation Schemes in Africa. Abuja, Nigeria. 15–19 November.1999 [Google Scholar]

Bentley, J., Van Mele, P., Touré, S., & Van Mourik, T. *Fighting striga and improving fertility with videos in mali*. Access Agriculture. Agro-Insight. 2013

Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., Mbabu, A., Spielman, D. , Horna, D., Benin, S., & Cohen, M. . 'From "Best Practice" to "Best Fit": A framework for analyzing pluralistic agricultural advisory services worldwide', DSGD Discussion Paper No. 37, IFPRI. *Journal of Agricultural Education and Extension*. 2006; 15(4), 341–355. https://doi.org/10.1080/13892240903309595

Braga, R., Labrada, R., Fornasari, L., & Fratini, N. *Manual for training of extension workers and farmers on alternatives to methyl bromide for soil fumigation, FAO and UNEP.*2001

Chambers, D. A., Glasgow, R. E., & Stange, K. C. *The dynamic sustainability framework: Addressing the paradox of sustainment amid ongoing change*. Implementation Science. 2013; 8, 117

Chipeta, S. . *Demand driven agricultural advisory services*. Swiss Center for Agricultural Extension and Rural Development, for the Neuchatel Initiative Group. 2006

Chiwasa, H., & Kambewa, D. *Demand-based extension models for smallholder farmers in Malawi, Theme 1 – Learning and knowledge systems, education, extension and advisory services*. 13th European IFSA Symposium, Chania Greece 1–5 July, 2018.

Christoplos, I., Sandison, P., & Chipeta, S. *Guide to evaluating rural extension*. Global Forum for Rural Advisory Services (GFRAS). 2012

Davis, K., Nkonya, E., Kato, E., Mekonnen, D.A., Odendo, M., Miiro, R., &Nkuba, J. *Impact of farmer field schools on agricultural productivity and poverty in East Africa*. IFPRI Discussion Paper 00992. International Food Policy Research Institute.2010

Davis, K., Faure, G., Nahdy, M. S., & Chipeta, S. . *Institutional changes and challenges for agricultural advisory services in Africa*. Theory and practice of advisory work in a time of turbulences. XIX European Seminar on Extension Education, 15–19, Assisi, Italy, 2009; (pp. 41–45).

Emongor, R. A., Matiri F. M., Magana,A. , Wamaitha, J., Daniel, A. M. and Mulindo, J. Factors Influencing Adoption of Pigeon Pea and its Impact on Household Food Security in Machakos County, Kenya. Asian Journal of Agricultural Extension, Economics & Sociology. 2022; 40(4): 29-38, 2022; Article no.AJAEES.84510 ISSN: 2320-7027

Ssemakula E. &Mutimba, J. K. Effectiveness of the farmer-to-farmer extension model in increasing technology uptake in Masaka and Tororo districts of Uganda. S.Afr. Tydskr. Landbouvoorl./S. Afr. J. Agric. Ext.,2011; 39 Nr 2, 2011: 30 – 46, ISSN 0301-603X.