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Pre-scaling up of Improved Maize Technology in the Lowland and Moisture Stress Areas, Borena Zone, Southern Oromia, Ethiopia

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ABSTRACT

Today, maize grows from moisture-stress areas to high rainfall areas and vice versa. The purpose of this study was to improve the productivity, local capacity and linkage among relevant stakeholders. The study was conducted in Yabello district, selected purposively based on the convenience and potentiality of maize production. A total of 18 trial farmers selected purposively. A land size of 0.25ha was used at each site of the trial farmers. All agronomic practices applied. Both quantitative and qualitative data were generated and analyzed using descriptive statistics and narration, respectively. The result revealed that the mean yield of Melkassa-1 was significant ($p<0.05$) across production years. High demand observed and therefore, it was recommended for further promotion until alternative variety released.

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INTRODUCTION

Maize grows from sea level to over 3000 meters above sea level (MoANR, 2017). In Ethiopia, it grows from moisture-stress areas to high rainfall areas and from lowlands to the highlands. It is largely produced in Western, Central, Southern and Eastern parts of the country. In the 2017 cropping season, 2,135,571.85 hectares of land was covered by maize with an estimated production of 784.7tone (CSA, 2017). The national average of maize production in the country was estimated to be 42.37qt/ha (CSA, 2020).

Maize is produced mainly for food, especially in major maize-producing regions, particularly for low-income groups, it is also used as a staple food in the country. In the food system, it is consumed as "*Injera*," porridge, Bread, and "*Nefro*." It is also consumed roasted or boiled as vegetables at the green stage. In additions to the above, it is used to prepare local alcoholic drinks known as "*Tella*" and "*Arekie*." The leaf and stalk are used for animal feed and also dried stalk and cob are used for fuel. It is also used as industrial raw materials for oil and glucose production (MoANR, 2017).

In agro-pastoral areas of Borena Zone, maize is the dominant stable food among the cereals. In relation to consumption pattern, maize is the sole dominant staple food among cereal crops in the area (Dirriba Mengistu *et al.*, 2017). However, the yield obtained from maize is low due to drought, lack of early maturing maize varieties, diseases, and appropriate agronomic management practices. In recognizant of these problems and following policy directions, YPDARC has undertaken adaptation trials of different maize varieties (in-situ study). The result of adaptation revealed that the Melkessa-1 maize variety was recommended for its early maturing (87 days) and high yielder (38qt/ha) in moisture stress areas of Borana Zone (Belda Edeo, Ejigu Ejara, Ibsa Jibat and Dejene Legese, 2022). It should be noticed that moisture stress area was known by receiving the annual rain fall less than 800mm and altitude 500 to 1800 m.a.s.l. (Kebede *et al*., 1993) cited in Bakala *et al*. (2019). Currently, the Borena area was characterized by an average RF of <600mm with erratic (Belda *et al.*, 2022).

It was appreciated that the previous studies mostly emphasised on the biological context (adaptability, seed type, yield performance etc.) whereby successfully generate paramount information. However, those studies didn't considered the wider scope, performance under farmers' condition and demand creation options. Therefore, this study was aimed to improve the productivity, local capacity and linkage among relevant stakeholders in the selected district of Borena zone under farmers' condition.

THEORETICAL REVIEW

Technology Acceptance Model/Theory

The Technology Acceptance Model (TAM) was the first model to identify psychological factors affecting technology acceptance amongst farmers, proposed by (Davis, 1989). It was developed from the Theory of Reasoned Action postulated by authors (Fishbein and Ajzen, 1980). The TAM model is an information system that the users (farmers) come to adopt and put into practice a technology. It argues that when farmers are presented with new technology, a number of motivating factors influence their decisions about how and when they will implement and use the technology. Some constructs of this model are explained as follows:

⇒ **Perceived Usefulness:** According to Lederer et al. (1998), perceived usefulness refers to the degree to which a person believes that using a particular system would result in enhanced job performance and output efficiency.

⇒ **Perceived Ease of Use:** Another concept of TAM that refers to the degree to which a person feels that the technology will need little or no effort determines Perceived Ease of Use (PEU). Both perceived use and perceived ease of use influence the farmers' attitude toward new technology, which affects the intention to adopt the technology (Liu and Ma, 2006).

In its wider concept, Technology Acceptance Model also suggests that users could choose to adopt a specific improved technology based on individual cost-benefits thoughtfulness (Compeau et al., 1999). This signifies that individuals are more likely to adopt or accept technology if there is added value to a process (Figure 1). The underlying correlation between two key constructs and users' attitudes, intention, and actual technology usage behavior, were specified using the theoretical underpinning of the previous version of the Theory of Reasoned Action developed by (Davis, 1989). Usefulness is likewise seen as being impacted by perceived ease of use (Davis, 1989). Moreover, the TAM has been widely studied by many researchers for various technology adoption situations and has perhaps become the most influential theory. It has also been upgraded to TAM2 and TAM3 (Venkatesh and Davis, 2000).

The major contribution of TAM2 was that it incorporates additional theoretical constructs spanning social influence processes such as subjective norms, voluntariness, and image and cognitive instrumental processes such as job relevance, output quality, result demonstrability and perceived ease of use (Venkatesh and Davis, 2000; Venkatesh and Bala, 2008). The TAM3 has also been proposed in the context of e-commerce (Venkatesh and Bala, 2008). Basically, it focuses on the determinants that influence Perceived Usefulness and Perceived Ease of Use of an innovation/new technology.

Therefore, this study employed technology acceptance theory to explain the relationship of farmers, use of improved maize technology and other enabling factors (facility) done by stakeholders.

H1: All farmers perceived usefulness and ease of use of improved maize technology.

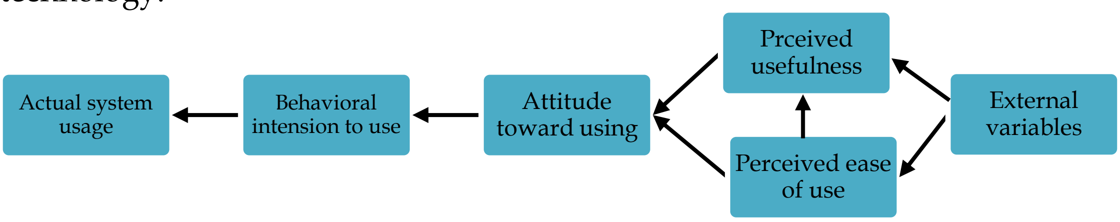

Figure 1. Technology Acceptance Model, adapted from (Davis, 1989).

METHODOLOGY

Description of the Study Area

The study was conducted in Yabello district of the Borena zone located in southern Ethiopia. Yabello district is located at 570km from south of Addis Ababa, Ethiopia. Geographically, it is located at 04° 52' 49'' and 038 ° 08' 55'' latitude and longitude, respectively, at an altitude of 1656 m.a.s.l. The district will be selected purposively as being representative of the extensive agro-pastoral farming systems of southern Ethiopia. The study area has a semi-arid climate with a highly unpredictable bimodal rainfall pattern (Coppock, 1994; Viste *et al.*, 2013) and an absence of permanent surface water (Coppock, 1994). The area is prone to periodic droughts (Lins, 2012). Though livestock production is the dominant farming practice, the pastoralists have gradually taken up crop farming since the mid-1980s (Coppock, 1994) and crop cultivation is now expanding.

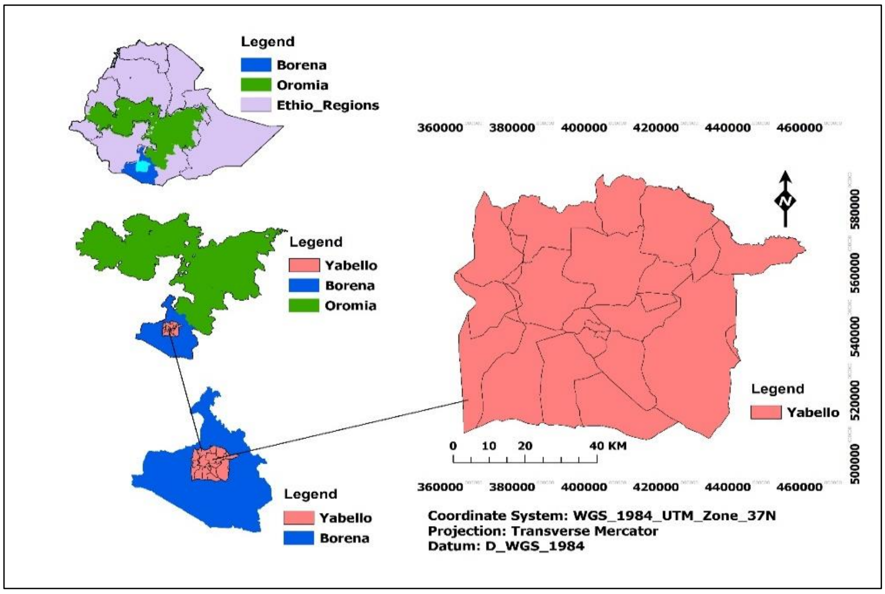

Figure 2. Map of the study area

Site and Farmers Selection Method

The study was conducted in Yabello District of Borena Zone. The site was selected purposively with two potential maize producing kebeles called Dharito and Kukuba. A total of 18 model farmers (9 from each PA's) were selected purposively through close consultation of the respective Agriculture Office and DAs in the district. The study used the selection criteria of trial farmers like experience of the farmer, efficiency of farmer based on the previous yield obtained, accessibility of the farm land and willingness of the farmer to be included in farmer research group (FRG), share experience and provide land for demonstration. Then, two FRGs consisting of 10 members (men, women, and youths) were established. Maize technology which characterized by an adaptable, early maturing and high yielder so called Malkassa-1 was used for this activity. An area coverage of 2500m^2 (0.25ha) was used at each selected farmers' field. A total area coverage for the study was 4.5ha where 2.25ha per each kebele was used. Both theoretical and practical training was given for the selected farmers, DA's and experts basically on the overview to production process, field selection and design, and management practices (weeding, fertilizer application, tillage, pre and post-harvest management and pest control techniques).

Technology Transfer Approaches

The study employed participatory approach through which maize production process conducted in drought stress area of Borana Zone. To do so, farmers research group (FRG) was established and different stakeholders such as DAs, Expert, farmers (non-FRG members) were involved in the intervention. The group composed of ten (10) members which have different age category of farmers like adult male and female, and youth. For these groups, YPDARC was distributed maize seed (Malkassa-1) for each group empowered them to handle all management activities. The best mechanism to transfer the technology was training of participants, demonstrating performance of the technology on the farm, field day, and mass media coverage on the production of the technology and linking them with other stakeholders.

Study Design

Improved maize (Malkassa-1) variety was used during the main cropping season and the field of 18 experimental farmers used. Local variety was used as control treatment at each farm in the study area. Based on the national recommendation for Malkassa-1 variety, the seed rate of 25kg/ha, fertilizer rate of 100kgNPS (at the time of sowing) and 120kgUrea (after sown) was applied timely. The row and plant spacing will be kept at 75cm and 25cm, respectively. Hand weeding was used to control weeds. After matured, harvesting was done by hand while threshing was done manually. Training was provided for trial farmers as well as experts and DAs at the respective FTCs. The activity was monitored by researchers and Development Agents assigned at each kebele. Whereas all other managements were conducted by responsible farmers in at experimental sites.

Data Collection Methods

Both primary and secondary data were used for this study. Appropriate primary data collection methods such as simple survey using check lists (maize production status and feedback), personal observation, and direct record using data sheet (yield measurement in kg) were employed to generate both qualitative and quantitative data. Whereas, secondary data (published and unpublished) was collected through critical review of annual report documents, journal articles, proceedings and journal books. Quantitative data such as yield data, total number of farmers participated on extension events (training, demonstration and field day), and stakeholders participated in the study were collected and triangulated with qualitative data including farmers' opinion/feedbacks on malkassa-1 production process.

Data Analysis Methods

Both quantitative and qualitative data were generated for this study. Quantitative data was analysed through descriptive statistics such percentage, mean and SD using SPSS software (version 21) whereas qualitative data was analysed using narrative explanation.

RESULTS

Capacity Buildings

The table 1 below shows that the provision of the training to stakeholders who could influence and benefited from the intervention. A total of 41 participants involved in the training at the beginning and terminal phases (exit) of the intervention.

Table 1. Stakeholders training on Malkassa-1 production

Stakeholders	Number of participants across production years						Grand Total
	2019/20			2021/22			
	Male	Female	Sub-total	Male	Female	Sub-total	
Experts	2	1	3	3	1	4	7
DA's	2	1	3	2	2	4	7
Farmers	7	3	10	7	3	10	20
Others	2	1	3	2	2	4	7
Total	**13**	**6**	**19**	**14**	**8**	**22**	**41**

Field Day

Field day has been conducted as tool for communicating the technology among stakeholders. Considering gender, a majority of participants (70.6%) were farmers where experience shared and suggested to the agriculture technology communication through field day event (Table 2).

Table 2. Number of participants on field day

Stakeholders	Participants by gender			
	Male	Female	Total	Percentage
Farmers	19	5	24	70.60
DA's	2	1	3	8.82
Experts	2	0	2	5.88
Others	5	0	5	14.70
Grand total	**23**	**8**	**34**	100

On farm yield performance of Malkassa-1 variety

The result in table 3 revealed that the higher mean yield was produced in both 2019/20 production season which accounts 16.51qt/ha. Whereas, the mean yield in 2021/22 production year was 14.60qt/ha (Table 3). The mean yield was statistically significant across years at 5% precision level. However, the recurrent drought in Borena zone had affected the agricultural crops since the last five production seasons. Hence, the production of malkassa-1 was far below the national average production. This was consistent with (United States Department of Agriculture (USDA), 2017) which explained drought effect on maize productivity.

Table 3. Mean yield performance of Malkassa-1 variety across years (qt/ha)

Year	N	Mean	SD	Min.	Max.	Std. Error Mean	t-value (sig.)
2019/20	18	16.51	2.32	12.64	20.28	0.55	2.104(0.043)**
2021/22	18	14.60	3.05	8.64	19.52	0.72	
Total	36	15.56	2.84	8.64	20.28	0.47	

Note: ** significant at 5% probability level.

Overall, the pooled mean yield (15.56qt/ha) was relatively far below both national average and adaptation results (Figure 3). The possible reason was due to the drought occurrence and erratic characteristics of rainfall patterns in the locality. This was in lined with the study (Belda *et al*., 2022) in the similar production area.

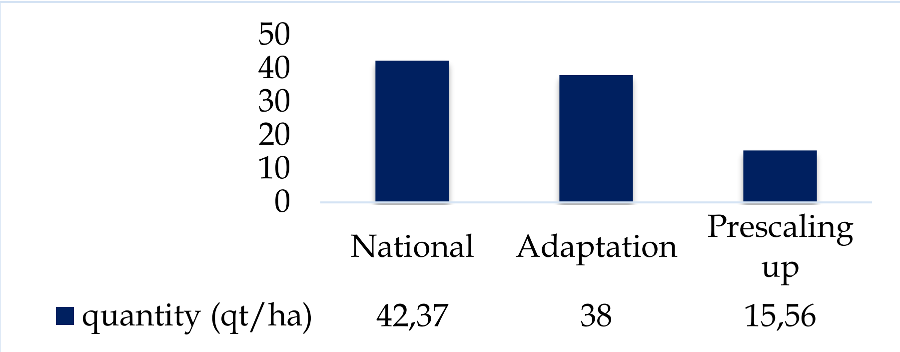

Figure 3. Relative mean yield across production stages

Linkage

Among a sets of objectives, strengthening improved linkages between stakeholders was one of the intention in this study which helps to promote agricultural technology, information dissemination, and share responsibility. So that this study used stakeholders' role to show both material and technical linkages (Table 4). Most of the stakeholders have participated during training and mini-field day. In the production seasons, hosting farmers in FRG played a central roles in responsibility and cost sharing with YPDARC across the phases of the intervention. This was consistent with the finding by Kebede *et al*. (2021), explained that linkage needs multi-stakeholders who had common goal for improvement of agricultural production.

Table 4. Stakeholders' roles on Malkasa-1 production

Stakeholders	Roles	Linkage types		
		Material (a)	Technical (b)	Both (c)

YPDARC	Seed provision, training, monitoring, site and farmers selection, information delivery	✓
DAs	Monitoring, site and farmers selection, information delivery	✓
Experts	Monitoring, site and farmers selection, information delivery	✓
Farmers	Management, information, follow up farm, land provision	✓
Agricultural cooperatives	Input provision (seeds, pesticides, fertilizer, herbicide), information etc.	✓
Other farmers	Information/experience, seeds etc.	✓

As shown in figure 4, both technical and material interactions were developed among YPDARC, experts, DAs and District Agri. Office in site and farmers selection. The selected farmers prepared their land thereby the seed distributed for farmers via YPDARC. Every management activities such as weeding, fencing, pest controlling etc. were done by famers while monitoring and follow up was done in collaborative with YPDARC. Material linkage was observed as farmers accessed farm inputs from local Agricultural Cooperatives with fair price. In addition, technical linkage via information flow was created.

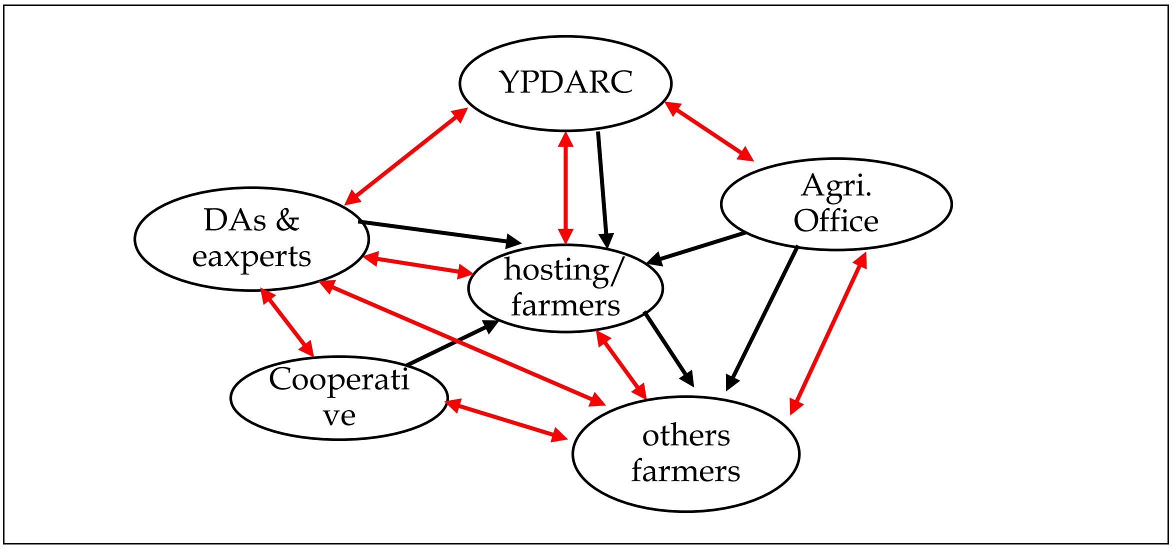

Figure 4. Stakeholders' linkage structure
Source: Own sketch, 2023/24

Hint — red double arrow: *Technical linkage*; black arrow: *Material linkage*

Farmers' Feedback on pre-scaled up Malkassa-1

Farmers' opinion regarding maize production and productivity, marketability and its uses in local food process was assessed. A lists of checklist was used to collect and record farmers' opinion. Accordingly, 18 trial farmers confirmed that Malkassa-1 variety is early mature, disease and pest resistant and high yielder as compared to the local variety. Respondents have explained their opinion/views based on its advantages and drawbacks. According to farmers' view, Malkassa-1 was characterized by early maturity and yielder which fits the conditions of Borena zone, moisture stress areas.

The seed was highly demanded in the local market due its valuable in the local food system and improved seed. In Borena areas, maize is locally known as *"Badala" and produced mainly for food purpose and staple food for low-income groups. In food process, maize was used to prepare different food items such as porridge (locally called Boshe), Nefro and buluk in the locality. It was tasty (sweeter) as compared to the local maize. In addition, farmers said "its leaf and stalk also used as animal feed."*

However, respondents observed the drawbacks of malkassa-1 as it takes the longer hours for ripen during cooking and its hardness trait when gridding manually.

Exit Strategy

It was proven that technology generation, agro-ecology base adaptation and demand creation through demonstration and pre-scaling up activities were the mandate and scope of Yabello Pastoral and Dryland Agricultural Research Centre (YPDARC) whereby participatory approach was used to conducted study under farmers' circumstances. The main collaborator of YPDARC, District Office of Agriculture played a vital role in the success of the intervention. Moreover, the sustainability of the intervention also remained under Office of Agriculture. Therefore, the wider scope dissemination of improved maize technology (Malkassa-1) should be handover and implemented by Office of Agriculture in Yabello district. To effect this, a meeting was held at Yabello District in the presence of leaders, DAs, experts, researchers at which the discussion conducted and agreement signed on exit strategy on how to be promoted sustainably so as to reach out wider scale. Hence, the responsibility of further technology dissemination has been given to Yabello district agriculture office with minimal research centre intervention in sustainable diffusion of the technology.

DISCUSSION

For success of the intervention implementation, the multidisciplinary researchers at Yabello Pastoral and Dryland Agriculture Research centre were participated in training provision. The professional basis of the team members involved in the training delivery were research-extension, cereal crop, socio-economic and crop agronomics researchers. The training was provided on different sub-topics such as improved maize production packages, agronomic practices, market information, experience sharing and technology transfer approaches.

One of the information/technology dissemination mechanism is field day where in jointly organized with district level Agriculture Office so as to create opportunities for all relevant stakeholders', create awareness on the importance and availability of the technology, the way the technology promoted, evaluate the performance of improved variety under farmers' condition, enhance farmers' knowledge on maize production and management and share production ideas for further way forwards.

Maize productivity has been enhanced through applying agronomic practices based on seasonality. The activity was conducted during the main rain season starts from March to June on farmers' field by which the data of two consecutive years collected using data sheet. It was remarkably noticed that a favourite environmental conditions and best management practices would help to enhance the better production. Three production stages such adaptation, demonstration and pre-scaling up has been compared to show the significant difference in mean yield. This helps to examine production constraints, technology pass ways and dissemination problems.

Improving linkage was also another intention of this activity whereby material and technical linkages were developed among stakeholders. Hence, the linkage among Yabello Pastoral and Dryland Agricultural Research Centre, Abaya District Agricultural Offices, Agricultural Cooperatives, Development Agents and farmers were strengthened via seed distribution, provision of agricultural inputs (pesticides, herbicides, fertilizers etc.) and information flow for maize production.

It was also observed that both material and technical linkages among farmers was strengthened through horizontal seed distribution, agricultural information and experience shared with other famers in the locality. In general, a complex interactions between/among Agriculture Office, Farmers, Cooperative and Research Centre was brought a desired linkage. Due to the fact that high demand of Malkassa-1 variety was created. Data verification have been made through triangulation of qualitative narration of opinions. In the exception of drawbacks, malkassa-1 was the most valuable and stipple food in the locality.

CONCLUSIONS AND RECOMMENDATIONS

Among others, Malkassa-1 variety performed well by grain yield and early maturity to the spread of severe low rainfall distribution pattern which has a negative effect on yield and yield components. The demonstration activity on malkassa-1 technology was conducted to reach the wider scope and users in moisture stress areas of Borena Zone. To effect this, participatory approach has been used that involved and strengthen stakeholders' linkage. Using this technology helps to minimize risks associated with it and maximizes farmers' benefits.

In general,

- The overall mean yield across years was lower (15.56qt/ha) than both national and adaptation results due to recurrent drought.
- But the technology was still demanded with the exception of limited production.
- The interaction between/among stakeholders mainly rely on material and technical linkage types.

Therefore, this study was intended to strengthen the linkage and popularized the technology. The improved maize (malkassa-1) variety was well appreciated by farmers because of its early maturity, pest resistant and high yielder in the area. Moreover, farmers said "using these variety is alleviating the existed problems (seed shortage, food security) on production and productivity in the area." Farmers also extended their views in general as maize not only for grain yield but also its stalk used for animal feed and fire wood. Therefore, the researchers concluded that the variety was well accepted and suggested to widely promote and make farmers beneficial through the Office of Agriculture of Borena Zone. This could be achieved through applying appropriate extension approaches such as providing training to DAs and farmers, experience sharing, field day organizing and collaborative work with stakeholders, private producers, and NGOs that with close supervision of research centre.

Based on the findings of this study, the researchers recommended the following points:

- Participatory extension approach should be used to further scale up of improved maize (Malkassa-1) in similar agro-ecology until the alternative seeds released. Every extension events including training, mass media and demonstration should be used to share experience among farmers and technology promotion.
- District-level seed multiplication and distribution should be conducted using the fina project as opportunity.

Linkage among stakeholders should be strengthened to help farmers' access to market, farm inputs (seeds, fertilizers, pesticides, herbicides etc.) delivery, advisory services and the likes. The linkage would help to solve information gap in appropriate sowing seasons (early sowing).

FURTHER STUDY

Currently, improving the productivity of our farmers remained under multiple production challenges such as recurrent drought, seasonal variation, improved/adaptable technology, unfair price of farm inputs, and limited access to information (technical linkage), and so on. Therefore, there is a need for future studies to deep insight for empirical research to know other factors that predict and affects productivity of maize. Future study should focus to examine the institutional commitment and motivation levels of farmers as they are the main actors in agricultural activity. It was also suggested that future study should be undertaken to examine further linkage type that can be beneficial to upgrade farmers' knowledge which in turn be used in further technology uptake.

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