EFFICIENCY AND EFFECTIVENESS OF PARTICIPATORY RESEARCH APPROACHES AMONG SMALLHOLDER FARMERS IN BABATI DISTRICT; TANZANIA

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DECLARATION AND APPROVAL

Declaration

I declare that this thesis is my original work and it has not been submitted in this or any other university for the award of a degree.

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DEDICATION

I dedicate this work to my parents, siblings and relatives for their support.

ABSTRACT

Participatory research approaches are widely being used for promoting the uptake of agricultural integrated innovations. The methods encourage greater knowledge sharing among farmers and give them more confidence in the technology being promoted which in turn brings about wide adoption of the technology in question. Therefore, understanding efficiency and effectiveness of participatory research approaches can further the ultimate aim of encouraging sustainable technology adoption. This study sought to evaluate the efficiency and effectiveness of the participatory research approaches used in Babati. The study objectives included determining the characteristics of the popular participatory research approaches, comparing the socio-economic factors of farmers participating in the participatory research approaches, determining the effectiveness of the popular participatory research approaches and determining the economic efficiency of these participatory research approaches. Finally the incentives/ dis-incentives to farmers' participation in the popular participatory research approaches were determined. The target population for this study was maize-legume-livestock small-holder farmers and the organizations involved in the implementation of the participatory research approaches under the study in Babati District. Cross-sectional data was collected from a sample of 120 farmers by the use of multi-stage sampling. Questionnaires, semi-structured interviews and focus group discussion were used in collecting primary data. Secondary data was collected through documentary analysis from public and private organizations involved in the implementation of the popular PRAs in the district. SPSS, DEA software and Excel were employed to analyze the collected data. The smallholder farmers were characterized using descriptive statistics. In addition the data was subjected to Data envelopment analysis to determine the efficiency of the PRAs. *Chi*-square statistic was used to determine the effectiveness of the PRAs. The results showed that gender of household head, marital status, education level, farm size, income status and age of the household heads were significantly different among the smallholder farmers participating in the participatory research approaches while family size, credit access, group membership, extension services and livestock ownership and were not. With regard to effectiveness of the PRAs, mother-baby trials and mobile demonstration plots were effective in reaching the targeted farmers while farmer research groups and coupon agro-inputs were effective in both reaching farmers and making them to become adopters. Data envelopment analysis revealed that the mean technical efficiency score for the participatory research approaches was 0.64 and 0.53 in reaching farmers and making them to become adopters of the AIIs respectively. On average, the approaches were operating below the efficient scale suggesting that adjusting the scale of operation would probably improve the overall efficiency of the pathways. Since there is still a scope for the institutions running the PRAs to increase the number of farmers trained for each pathway using the current levels of resources. This study therefore, recommends that government and other stakeholders should formulate and implement effective policies in order to make the participatory research approaches more efficient and effective in boosting the uptake of agricultural integrated innovations.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIIs	Agricultural Integrated Innovations
ANOVA	Analysis of Variance
BRAC	The Bangladesh Rural Advancement Committee
CAIs	Coupon Agro-Inputs
CIAT	Centro Internacional de Agricultural Tropical
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Centre
CRDB	Cooperative Rural Development Bank
DEA	Data Envelopment Analysis
EI	Effective Index
FDs	Field Days
FFS	Farmer field schools
FHHs	Female Headed Household
FRG	Farmers Research Group
HH	Household
ICM	Integrated Crop Management
ICT	Information and Communication Technology
ICRISAT	International Crops Research Institute for the Semi-Arid-Tropics
IPM	Integrated Pest Management
ISFM	Integrated Soil Fertility Management
MBT	Mother-baby trial
MHHs	Male Headed Households
MVIWATA	Mtandao wa VikundivyaWakulimawadogo Tanzania
MSIM	Multiple Source of Innovation Model
NGOs	Non-Governmental Organizations
NMB	National Microfinance Bank
OFD	On farm Demonstration
PETs	Participatory Evaluation Trials
PRAs	Participatory Research Approaches
PRIDE	Promotion of Rural Initiatives and Development Enterprises
RS	Respondent Scores
SACCOs	Saving and Credit Cooperatives

SEDA	Small Enterprises Development Agency
SFA	Stochastic Frontier Analysis
SPSS	Statistical Package for Social Science
SSA	Sub - Saharan Africa
TSH	Tanzania shillings
URT	United Republic of Tanzania

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Agriculture is essential for Sub-Saharan Africa's economic growth and for achieving the Millennium Development Goal of halving poverty by 2015.Tanzania being one of the Sub-Saharan Africa countries, agriculture accounts for 32 percent of the Gross Domestic Product (GDP). About 70% of the population gains its livelihood directly or indirectly from agricultural production (FAO, 2013). Although agriculture is very important in Sub-Saharan countries, many factors such as unpredictable weather conditions, complex social and economic conditions, rapid population growth and natural resource degradation impede agricultural development. In order to overcome these challenges and ensure agricultural development, environmentally friendly and applicable technologies are required. Over the years, there has been a tremendous breakthrough in innovations and dissemination of technologies targeted at enhancing sustainable agricultural intensification. These technologies include agricultural integrated innovations which include but not limited to integrated soil fertility management (ISFM) practices.

1.1.2 Integrated innovations and agriculture

Large numbers of poor farmers continue to practice extensive agriculture. Inevitably, they continue to encroach on hitherto uncultivated lands and do not have access to productive inputs. As such, their agricultural productivity is still low leading to food insecurity. To overcome this, there is need for adoption of innovative systems that allow for agricultural intensification (Getnet*et al.*, 2012). Agricultural innovation is essential to address environmental problems in a world that must soon support more than nine billion humans who suffer from food insecurity and poverty (Getnet*et al.*, 2012). However, much agricultural research already focuses on increasing land productivity. Improved efficiency in the use of land and agricultural inputs is already contributing to environmental goals. In as much as increasing productivity is necessary, it is not sufficient to ensure food security, reduce poverty, improve nutrition, and maintain the natural resource base for sustainable development. Consequently, innovations across a broad spectrum of policies and technologies are needed to confront the complex array of challenges at the agriculture-environment nexus (Befort *et al.*, 2011). The aim of agricultural integrated innovations is to maximize and improve productivity in a sustainable manner. Therefore, agricultural integrated innovations confer more benefits to smallholder farmers than those based on a single component.

1.1.3 Agricultural integrated innovations in Babati

Babati District was seen as a grain basket up until the 1980s and people remember how the farmers made maize pyramids outside their houses and on what today is the football field in Babati town (Löfstrand, 2005). According to village leaders in Mamire, some farmers even left some crops in the fields during some years. According to Lindberg (1996) draughts and the oil crisis in 1973 resulted in low yields and crisis for the whole country. This shows that fluctuations in yields are something that has happened even during periods remembered as good. During the 80s village storages were built and in Babati town three big storages were built (Löfstrand, 2005). Several donors and NGOs tried to boost the agricultural production. These NGOs and projects include Farm Africa, Africa Research in Sustainable Intensification for the Next Generations (Africa RISING) that are working in the District to promote the use of integrated agricultural innovations such as Conservation agriculture (CA), integrated soil fertility management (ISFM) and Integrated Pest Management (IPM).

Conservation agriculture is based on the principles of minimum soil disturbance, permanent soil cover and crop rotation. Conservation agriculture practices can improve, conserve and use natural resources in a more efficient way through integrated management of available soil, water and biological resources, in combination with external inputs (FAO, 2005). The impacts of CA have been markedly positive both in agricultural, environmental, economic and social terms (Garcia-Torres *et al.,* 2003). CA is also often stated to be labour-saving and presented as a potential solution to farm power shortages. The last decade several new agricultural practices have been introduced in Babati district, which include CA practices. The introduced agriculture methods have had a positive effect on yields, work load and the environment. Farm yard manure and intercropping with legumes showed to improve the fertility and application of rock phosphate increased availability of phosphor and increased soil PH.

Integrated soil fertility management(ISFM) is a set of agricultural practices adapted to local conditions to maximize the efficiency of nutrient and water use and improve agricultural productivity(Vanlauwe, 2010). ISFM strategies center on the combined use of mineral fertilizer and locally available soil amendments (such as lime and phosphate rock) and organic matters (crop residuals, compost and green manure) to replenish lost soil nutrients. This improves both soil quality and the efficiency of fertilizer and other agro-inputs. It is assumed that farmers who adopt ISFM technologies have the chance of doubling their agricultural productivity and increase their farm-level incomes by 20 to 50 percent. In Babati, ISFM practices such as the use of farm yard manure, crop cover, crop residues, leguminous plants and *minjingu mazao* fertilizer have been introduced in order to increase soil fertility.

Integrated Pest Management (IPM) is an approach to pest control that focuses on pest prevention by eliminating the root causes of the pest problems. Incorporating IPM into a production system involves adopting a sustainable and environment-friendly management strategy to reduce pests (Harris, 2010). The strategy usually involves incorporating several methods for maximum pest control. For each crop an IPM package has been designed to most effectively control for a variety of pests. These methods vary in complexity, cost, and associated risk. When a farmer is introduced to IPM, the entire package is usually described. Often the farmer tests the feasibility of IPM by adopting the simplest practice, which is usually the less risky than more complex practices. If the simple technologies are effective and profitable, the farmer may adopt increasingly complex technologies and eventually incorporate the entire package into his production activities. In Babati many IPM technologies have been implemented, these include intercropping and altering of planting dates, crop rotation and modification of cropping periods, trapping, hunting of the pests that were bringing problems, weeding and crop hygiene.

1.1.4 Participatory research approaches and agricultural integrated innovations

The linear view of innovation in agricultural contexts leads to the limited real world application of the technologies developed. This leads to low adoption rates. As a result of this, the linear view of innovation is being replaced by systems approaches (Von Braun *et al*., 2008). In this approach, agricultural producers are seen as important actors rather than merely consumers of the technologies that are generated by agricultural research and transferred by education and extension services for subsequent adoption. Following the above challenges, participatory action research approaches were developed and applied to address the challenge of up-scaling from local learning and innovation networks to a regional, support framework for innovation in sustainable agriculture. These approaches involve identifying some of the challenges of trans-disciplinary research and finding ways of addressing them and critically reflecting on the role of the researcher in participatory action research. The approaches allow an active involvement of farmers in the research process (Heidrum, 2011). Most of them have been hypothesized to lead to quicker and sustainable use of the adopted technology compared to the linear model of technology transfer approaches. It is believed that the use of participatory approaches such as on-farm demonstrations, farmer field schools and mother-baby trials, among others, offer far-reaching benefits to all stakeholders in agricultural research and development.

Moreover, it has been argued that the approach fosters greater efficiency and effectiveness of research investment and contributes to a process of empowerment of rural farmers. Therefore, various participatory research approaches (PRAs) namely local committees for agricultural research (Braun *et al*.,2000), participatory technology development (Conroy and Sutherland, 2004), participatory plant breeding, participatory variety selection (Sperling*et al*., 2001; Gabriel *et al*., 2004), participatory research for plant genetic resources (Friis-Hansen and Sthapit, 2000), participatory research and development for sustainable agriculture and natural resources management (Gonsalves*et al*., 2005), farmer field school (FFS) approach among others were developed.

In Tanzania, various participatory research approaches are being used to promote the adoption of agricultural integrated innovations. These approaches include farmer field schools that was introduced in 1998 (Mvena *et al*., 2013), on-farm demonstration, farmers research groups that was introduced in 2000 (Richard, *et al*., 2007) and mother-baby trials among others. However, limited literature is available on the efficiency and effectiveness of these approaches.

1.2 Statement of the problem

Many smallholder farmers face problems of low productivity. To address this, new agricultural technologies have been introduced to enhance productivity in Tanzania. The uptake of these technologies has been low. As a way of improving the uptake of agricultural technologies, researchers and NGOs have encouraged the use of participatory research approaches. In Babati district, many NGOs and researchers have used different participatory research approaches for promoting uptake of agricultural integrated innovations. However, little is known about the efficiency and effectiveness of these approaches in boosting technology uptake. Therefore, this study aims at evaluating the efficiency and effectiveness of the participatory research approaches (PRAs) in promoting development and uptake of agricultural integrated innovations among smallholder farmers in Babati district.

1.3 Research objectives

1.3.1 General objective

The general objective of this study was to contribute towards enhancement of food security and poverty alleviation among smallholder farmers through the use of participatory research approaches.

1.3.2 Specific objectives

The specific objectives of the study were:

1) To compare socio-economic characteristics of smallholder farmers participating in the participatory research approaches.

2) To determine the characteristics of the participatory research approaches.

3) To determine technical efficiency of the participatory research approaches.

4) To determine the effectiveness of the participatory research approaches.

5) To determine the incentives/dis-incentives to farmers' participation in the participatory research approaches.

1.4 Research questions

1) Are there socio-economic characteristics differences amongst smallholder farmers involved in the participatory research approaches?

2) What are the characteristics of the participatory research approaches?

3) What is the technical efficiency of the participatory research approaches under study?

4) What is the effectiveness of the participatory research approaches understudy?

5) What are the incentives /dis-incentives to farmers' participation in the participatory research approaches?

1.5 Justification of the study

The use of participatory research approaches such as on-farm demonstrations, farmer field schools and mother-baby trials among others in agricultural technology development and dissemination do offer far-reaching benefits to farmers. Moreover, the approaches can lead to greater effectiveness of research investment and contribute to agricultural productivity enhancement as well as improve the quality of agricultural products through technology adoption (Abdoulaye *et al*., 2012). Therefore, evaluating the efficiency and effectiveness of the participatory research approaches is of great importance since it will provide insight of the participatory research approaches which are effective in promoting the uptake of agricultural integrated innovations. This will have a positive impact on farmers' likelihood to adopt the technologies thereby improving agricultural productivity and the quality of agricultural products. The study will also provide feedback to researchers, extension service providers and policy makers who are involved in the dissemination of improved agricultural technology in order to enhance food security and poverty alleviation and hence promotion of rural agricultural development.

1.6 Limitation and scope of the study

This study focused on selected smallholder farmers participating in the implementation of selected participatory research approaches, particularly within maize-legume-livestock systems, in Babati district where agricultural integrated innovations were introduced. Moreover, the study specifically concentrated on the participatory research approaches as a determinant of adoption of integrated system innovations. Therefore, six participatory research approaches namely mother-baby trials, farmer research groups, mobile demonstration plots, coupon agro-inputs, farmer field schools and on-farm demonstration plots were considered and evaluated. Moreover, local government, a research programme (Africa RISING) and NGOs (Farm Africa and MVIWATA) were involved in the study.

1.7 Definition of terms

Agricultural integrated innovations (AIIs)-Set of agricultural innovations that aim at maximizing and improving agricultural productivity in a sustainable manner (Getnet*et al.,* 2012).

Adopters-A farmer is said to become an adopter of the AIIs if he/she uses the technology for at least one season after participating in the PRAs' activities.

Adoption-Degree of use of new technology by a farmer in the long run period when he/she has all the information about the new technology and its potential benefits (Feder*et al.,*1985).

Effectiveness-Ability of participatory research approach to meet its key objectives technology such as reaching large number of farmers, transferring technology quickly and making farmers to adopt the technology in question (Adger*et al.,* 2003).

Technical efficiency-Reflects the ability of a participatory research approach to obtain maximum output from a given set of inputs.

Farmer Field Schools-Group based learning process that is being used by a number of government, non-governmental organizations (NGOs) and international agencies to promote agricultural technologies (Bartlett, 2005).

Farmers reached-Refers to the number of farmers trained per participatory research approach.

Farmers research group-Model that involve farmers in technology generation, verification and transfer process (Hauli, 2007).

Household-A person or group of persons who reside in the same homestead/compound but not necessarily in the same dwelling unit, have same cooking arrangements, and are answerable to the same household head (URT, 2013).

Integrated soil fertility management (ISFM)-A set of agricultural practices adapted to local conditions to maximize the efficiency of nutrient and water use and improve agricultural productivity (Vanlauwe, 2010).

Mother-baby trial-Model used to evaluate and disseminate agricultural technologies. Mother trial is managed by researchers and extension officers while baby trials are managed by farmers under their field conditions (Snapp *et al.,* 2001).

On-farm demonstration-These are plots used by researchers to display certain agricultural technology being promoted but the plots are owned by farmers.

Participatory research approaches-Methods directed towards planning and conducting the research process with those people whose life-world and meaningful actions are under study (Reason and Bradbury, 2008).

CHAPTER TWO
LITERATURE REVIEW

This chapter presents the reviews of the studies that relate to this work. The reviews involve concepts, principles and evolution of the participatory research approaches and the role of participatory research approaches in adoption of agricultural technologies. Moreover, the study also reviews different participatory research approaches implemented in Tanzania and studies on efficiency and effectiveness, theories that underlay this study and the conceptual framework.

2.1 Participatory Research Approaches; Concepts, Principles and Evolution

In the 1980s, pioneer social scientists proposed the idea of involving farmers more systematically and actively in the research process to take advantage of farmer skills to innovate. Among the most influential work, Rhoades and Booth (1982) introduced the farmer-back-to-farmer concept which starts by identifying farmers' problems and going back to them with alternatives. Chambers *et al.* (1989) compiled the work of several researchers and introduced the idea of 'farmers first' where farmer participation in agricultural research was justified from different points of view. There are different typologies for participatory research. These include contractual, collaborative and collegial (Biggs, 1989). These typologies go from low to high farmer involvement and control of the participatory process. Another way of participatory research classification considers 'innovation development' where the main goal is to develop or evaluate new technologies, and 'process-oriented' PRAs where the learning process is adapted to a wider range of circumstances aiming at social change (Selener, 1997). Probst *et al*., (2000) classify participatory research according to the objective of the intervention which include transfer of technology, supply-on-demand, farmers-first and participatory learning.

In more recent years, the concept of participation is absorbed in wider concepts related to innovation systems, which go beyond the farm-gate. This includes but is not limited to multi-stakeholder systems such as livelihoods, food systems and value chains (Hall, 2009; Scoones and Thompson, 2009).Participatory approaches were developed in order to put right some of the problems of classical approaches to agricultural research whereby researchers used to go to a community, study their subjects, and take away data without adequately giving back to local communities who participated in the research (Salas *et al*., 2003).Participatory approaches are therefore believed to enhance the efficiency of agricultural research in delivering more suitable and easily adoptable technologies and continuous interaction between scientists and smallholder farmer. Moreover, participatory approaches allow feedback from farmers to be integrated into the research program reviews, and major responsibilities for adaptive research are devolved to farmers, who also share costs of research so that they can demand accountability and transparency from the public research systems (Ashby, 1990).

2.2 Role of participatory research approaches in adoption of agricultural technologies

The use of participatory approaches in agricultural development is assumed to offer far-reaching benefits to all stakeholders in agricultural research and development. Moreover, some authors have even argued that the approach fosters greater efficiency and effectiveness of research investment and contributes to a process of empowerment of rural farmers (Abdoulaye *et al*., 2012).Participatory research proved to be effective in enabling small-scale farmers and local decision makers to identify, develop and disseminate technologies (Gleick, 2003; Fraiture *et al.*, 2007).

Many studies have been conducted on participatory research approaches for technology development and wide-scale dissemination. Abdoulaye *et al*. (2012) did a study on the use of participatory research approaches in wide-scale dissemination of technologies. In their study, they used the probit regression model in analyzing the data. The results revealed that, participation in project activities had a positive and significant effect on household food security at 0.05 significant level. Moreover, the study concluded that development interventions that involve multiple stakeholder partnerships use of participatory research and extension approach can help increase technology adoption among resource-poor farmers as well as increase in food production and food security (*ibid*).

Another study, done by Pedzisa *et al.*(2010) on the use of participatory processes in wide-scale dissemination of micro-dosing and conservation agriculture in Zimbabwe, descriptive statistics (means and cross tabs) were used to analyze the data. The study revealed that use of demonstration trials encouraged the most participation and subsequent adoption and adaptation of the technologies to suit specific needs. The participatory nature of the process encouraged greater knowledge sharing among farmers and gave them more confidence in the technology. Moreover, the study by Ortiz *et al.* (2004) on evaluating the benefits of farmer field schools employed t-test to evaluate the benefits of farmer field schools by comparing the productivity of participants’ farms with non-participants’ farms. The study indicated that farmer field schools program participants had significantly higher average levels of productivity.

Moreover, the work conducted by ICRISAT (2008), in Zimbabwe employed participatory approaches on a wide-scale promotion of fertilizer micro-dosing as well as Conservation Agriculture. They specifically used participatory evaluation trials (PETs) which were hosted by farmers selected by the community. The study revealed that participatory research approaches provided a platform for the wide scale promotion of improved soil fertility and water management. From the above literature, it can be concluded that participatory research approaches play an important role in technology development, dissemination and adoption. Therefore, this study is aiming at exploring different selected participatory research approaches in order to evaluate efficiency and effectiveness of these approaches.

2.3 Review of the Participatory Research Approaches

2.3.1 Mother-baby trials

The term 'mother-baby' was coined by Malawian farmers in 1990's when one of the researchers went to Malawi to introduce the concept but did not have a simple non-technical name for it that could be easily understood by farmers. So a farmer came up and said, "This is a 'mother' trial because it gives birth to other 'baby' trials". Since then, the concept has been known (CIMMYT, 2002). Mother trials are researcher-designed and managed trials while baby trials are located around mother trials, and consist of a few treatments chosen from the mother trial by the farmers. Therefore, "mother" trials test many different technologies, while the "baby" trials test a subset of three or fewer technologies, plus one control (Snapp, 1999). The baby trials allow farmers to see for themselves the performance of treatments at different trial sites and allow for faster and larger-scale testing at different locations under different management conditions (Rusike *et al.*, 2006). The design makes it possible to collect quantitative data from mother trials managed by researchers, and to systematically crosscheck them with baby trials on a similar theme that are managed by farmers (Bellon *et al.*, 2002). In addition, mother-baby trials are widely being used as communication and dissemination strategy thereby boosting the adoption of different agricultural technologies. For example, the Africa RISING Southern and East Africa project uses the mother-baby trials approach as a communication and dissemination strategy.

2.3.2 Farmer Field Schools

The term Farmer Field Schools comes from the Indonesian expression *Sekolah Lapangan* meaning field school. The first field schools were established in 1989 in Central Java during a pilot season by plant protection officers to test and develop field training methods as part of an integrated pest management (IPM) training of trainers' course. The approach was designed to overcome the difficulty of training small-scale rice farmers on the complex and novel concept of integrated pest management (Gallagher, 1999). Farmer Field School (FFS) usually take place in the fields of participating farmers hence it is a school without walls. The Farmer Field School (FFS) approach is a widely practiced participatory model that integrates farmers into the technology development and transfer process (Ross, 2007). The principal component of any FFS is that it emphasizes experiential learning, with a participatory approach. Hands-on training is important to attract both literate and illiterate farmers and to keep them interested in learning about IPM. Farmer field schools are run by facilitators rather than instructors in order to create a group learning environment rather than a classroom setting with a teacher giving instructions. Godtland *et al*. (2004) investigating FFS for potato farmers in the Peruvian Andes controlled for selection bias and other factors influencing integrated pest management (IPM) knowledge and yield, using a propensity score matching model. The researchers concluded that farmer field schools (FFS) participants have significantly more knowledge about IPM than those who did not participate in farmer field schools (FFS). The study also concluded that increased agricultural knowledge leads to higher yields and FFS participants are more likely to have a higher output on their farms.

A study conducted by Feder*et al.* (2003) using time series data in Indonesia found no significant difference in change in yields or pesticide use when comparing FFS participants with non-participants. Another study by Feder *et al*. (2004) found that farmer field schools trained farmers had a greater knowledge of IPM than non FFS farmers. However that knowledge of IPM was not spreading to farmers in villages with farmer field schools (FFS) who did not attend the training. Quizon *et al.* (2001) found that the average cost for training a farmer about integrated pest management (IPM) through farmer field schools (FFS) was USD 47.50 in Indonesia and USD 62.00 in the Philippines. These findings were significant because if farmer field schools (FFS) graduates did not share their knowledge of integrated pest management (IPM) with their neighbors, then the lack of secondary spread and the high cost of training farmers through farmer field schools (FFS) calls into question whether farmer field schools are cost-effective and can be a sustainable method for diffusing integrated pest management at a national level.

2.3.3 Farmers research groups

The main objective of Farmers Research Groups (FRG) is to involve farmers in technology generation, verification and transfer process. The model allows open participation of farmers in the research system thereby improving communication and information exchange and hence it empowers farmers both technically and economically (Hauli,2007).Farmers research groups act as focal points for on-farm observation, problem identification and prioritization, experimentation, analysis and monitoring together with evaluation of the planned activities. Under this approach, there are attempts to involve farmers in the whole process of technologies development and dissemination. All research efforts are also being directed towards solving the major priority problems identified. Working with farmer research groups in both livestock and crops research considerably improved communication and information exchange, empower farmers both technically and economically and opened doors for on-farm participatory research approaches (Hailu, 2007). If the farmer research groups approach can be managed properly it can provide a significant contribution to research and development activities of developing countries *(ibid*).

2.3.4 On-farm demonstration plots

The need for demonstrations was first recognized nearly a century ago by Seaman A. Knapp, an extension pioneer. Knapp's theory was that farmers would not change their methods as a result of observing farms operated at public expense, but that demonstrations conducted by farmers themselves on their own farms under ordinary farm conditions were the answer. In 1903, Knapp proved his point through demonstration on small farms in which half was planted corn and half cotton. Many researchers in developing countries have been employing on-farm demonstrations in evaluation and dissemination of different agricultural technologies. Most of these researchers confirmed the important role of demonstration plots for evaluation and scaling of most technologies. A study on impact of participatory research approaches specifically on farm demonstration and technology uptake revealed that, when farmers are actively involved in on-farm demonstrations, the demonstrations act as an avenue for the diffusion of new technology (Pedzisa *et al.*, 2010). David *et al*. (1990) conducted a study on field trials as an extension technique in Swaziland. In their study, the probit model was used to determine factors that influenced farmers' participation in the field trials. The results showed farmers with more land were more likely to be in field trials, presumably reflecting their greater social status. On the contrary, the study revealed that, field trial participation was not positively influenced by having a male household head on the farm (*Ibid*).

2.3.5 Mobile demonstration plot

Mobile demonstration plot is an approach that disseminates agricultural technologies through the use of information and communication technologies (ICT) based tools such as tablets and mobile phones. Information and communication technologies can play a crucial role in benefiting the resource-strapped farmers with up to date knowledge and information on agricultural technologies, best practices, markets, price trends, and weather conditions. The experiences of most countries indicate that rapid development of information and communication technologies (ICT) which facilitates the flow of data and information and has tremendously enhanced the knowledge management practice in agriculture.ICT can play a critical role in facilitating rapid, efficient and cost effective knowledge management. For instance, in a number of Sub-Saharan African countries, smallholder farmers get technology-related advice as well as location-specific market information on inputs and outputs through ICT-based service such as kiosks. Furthermore, mobile telephone service is being used to deliver agricultural information to users. Using available ICTs does not only improve information and knowledge management for extension workers and farmers but also it optimizes and rationalizes public resources devoted to agricultural extension services (UNDP, 2012).The rapid spread of mobile phone coverage in developing countries provides a unique opportunity to facilitate technological adoption via ICT-based agricultural extension programs.

Modern information and communication technology systems have been utilized to deliver effective public extension service in the agricultural sector in different developing countries. For example, ICT has enabled the Ethiopian Commodity Exchange to transmit commodity prices to farmers in real time via mobile phone, message board or online; similar market based extension services exist in Kenya, Malawi, Uganda and Mozambique amongst others (Farm Africa, 2015). In Tanzania, Farm Africa implements the sesame production and marketing project with the aim of improving income for small holder farmers. The project employed an ICT-based tool to disseminate agricultural technologies to farmers. Specifically, the project employed tablets in delivering different agricultural technologies such as land preparation, plant care and post-harvesting handling to farmers (Farm-Africa, 2015).Therefore, to speed up agricultural technology adoption, the governments of developing countries including Tanzania need to quickly review and modernize the public agricultural extension service delivery system.

2.4 Review of studies on efficiency and effectiveness

Many studies have been done on the effectiveness and efficiency of technologies. Amudavi *et al.*(2012)evaluated the effectiveness of dissemination pathways on adoption of Push-Pull technology in Western Kenya. In their study, a two limit Tobit regression was used to analyze data from 491 respondents randomly selected from four districts in western Kenya. The results indicated that chronologically field days (FD), farmer field schools (FFS) and farmer teachers (FT), had the greatest impact on the probability that a farmer in the study area would adopt the push technology.

Another study done by Dhiraj *et al.* (2014) on the effectiveness of training programmes under agricultural technology management in Bihar district, they used effectiveness index (EI) to measure the effectiveness of trainings. The results showed that animal husbandry and vegetable cultivation were the major areas in which most of farmers attended training. The overall effectiveness of training was found to be 54.6 per cent which came under medium effectiveness category. A study by Mustafa *et al*. (2012) aimed at identifying the major constraints that reduce the effectiveness, efficiency and sustainability of fertilizer use in South Asia. Their results pointed out that, economical, physical, technological and institutional factors were the major constrains. Moreover, the study revealed that current pattern of fertilizer use with heavy reliance on nitrogenous fertilizer coupled with poor nutrition management, lack of complementary inputs, declining soil fertility, and weak marketing and distribution systems were major impediments to improving the effectiveness in fertilizer use in the region. This shows that one of the important pathways that matters most in South Asia for poverty reduction and food security is to enhance the efficiency and effectiveness of fertilizer use in agriculture and increase productivity from technological advances. The gains from improved fertilizer use is likely to be large as there has been a considerable expansion of fertilizer use in all South Asian countries resulting from wide adoption of the green revolution technology(*ibid*).

Maina and Mwangi (2011) conducted a study on the effectiveness of agro-dealers in enhancing dissemination and adoption of push-pull technology among smallholder farmers in western Kenya. Their study used a *Chi*-square analysis. The results showed that agro-dealers' effectiveness in communicating push-pull technology was independent of their knowledge of the push-pull and seriousness of the Striga problem. However, the results also showed that the agro-dealers' effectiveness depended on frequency at which farmers sought advice from them; gender, education and years in business. Generally, agro-dealers are appropriate for educating both males and females therefore spreading the push-pull technology through them enhances adoption. As a result, extension providers should train and involve agro-dealers in disseminating the push-pull technology and selling certified seeds. Moreover, Mustapha *et al.* (2012) used frequencies percentages, mean scores and *ch*i-square analysis to assess the effectiveness of the adopted village scheme. The results showed that there was high awareness of improved technologies by more than 80 percent of the respondents. Findings also revealed that most of the respondents (70 percent) became aware of improved farm technologies. The result equally indicated that result/method demonstration and farmer field school were statistically significant in effectiveness of dissemination of improved farm technologies in the study area.

2.5 Theoretical framework

2.5.1 Multiple source of Innovation Model (MSIM)

The Multiple Source of Innovation Model (MSIM) seeks to understand the client's diverse needs and resources. The MSIM views the user not merely as adopters but as an active participant in the process of technology development and adoption. This model emphasizes that agricultural innovations are derived not only from agricultural research institutions, but from multiple sources. These sources include farmers, innovative research practitioners, research-minded administrators, NGOs, private corporations and extension agents (Biggs, 1990). In this model perspectives of the user of technology are seen as important in helping redefine the role of farmers from being simply recipients to actors, who influence and provide input to the process. Moreover, the farmer's decision to adopt a given technology would require that a farmer evaluates the new technology in terms of its incremental benefit. If the monetary benefit of using the technology is higher than the old technology, the preference or utility (*U*) for that technology (assuming a monotonic relationship between utility and benefits) will be higher than the old technology. This study assumes that adoption of integrated systems of innovations would enhance the incomes of the smallholder farmers thus making it to be preferred to the conventional farming activities.

2.5.2 Economic efficiency Model

Economic efficiency is about making people better off. Pareto efficiency optimization condition is economically efficient if no one can be made better off without making someone else worse off. Conversely, if someone can be made better off without making anyone else worse off, that would be an efficient change. A win-win situation is clearly economically efficient if no third party is made worse off. Economic efficiency is different from technical efficiency. Technical efficiency means that the maximum amount of a good is being produced from the inputs being used to produce it, all else equal. Technical efficiency is concerned with the physical production from a given amount of inputs, but cost efficiency allows comparison across different technical processes that may have different inputs. Economic efficiency requires technical efficiency and cost efficiency for production of a good, but it also allows comparison across different types of goods. This study, will specifically consider economic efficiency in term of cost efficiency. Therefore, the study will determine the technical efficiency of the popular participatory research approaches used in the study area for the promotion of agricultural integrated innovations. Hence the benefits will be the number of small holder farmers adopted the agricultural integrated innovations. The cost variable include supervision, training, labour, improved seeds, fertilizer among others.

The measurement of economic efficiency has been intimately linked to the use of frontier functions. The modern literature in both fields begins with the same seminal paper, namely Farrell (1957). Farrell (1957), greatly influenced by Koopman´s (1951) formal definition and Debreu's (1951) measure of technical efficiency, introduced a method to decompose the overall efficiency of a production unit into its technical and allocative components. Farrell characterized the different ways in which a productive unit can be inefficient either by obtaining less than the maximum output available from a determined group of inputs (technically inefficient) or by not purchasing the best package of inputs given their prices and marginal productivities.

These techniques can be classified in different ways. The criterion followed here distinguishes between parametric and non-parametric methods, that is, between techniques where the functional form of the efficient frontier is pre-defined or imposed a priori and those where no functional form is pre-established but one is calculated from the sample observations in an empirical way. The non-parametric approach has been traditionally assimilated into Data Envelopment Analysis. The Data envelopment analysis is a mathematical programming model applied to observed data that provides a way for the construction of production frontiers as well as for the calculus of efficiency scores relatively to those constructed frontiers. With respect to parametric approaches; these can be subdivided into deterministic and stochastic models. The first are also termed 'full frontier' models. They envelope all the observations, identifying the distance between the observed production and the maximum production, defined by the frontier and the available technology, as technical inefficiency.

2.5.2.1Stochastic frontier model

Stochastic frontier analysis involves the use of econometric methods to estimate either primal or dual representations of the production technology. The choice of functional representation is often determined by data availability. For example if we only have data on input and output quantities then we can only estimate production frontiers and distance functions; if we only have data on input prices and output quantities then we can only estimate cost frontiers. Stochastic Frontier Analysis also involves assumptions about the regularity properties of the frontier such as monotonicity, and concavity, the functional form of the frontier such as linear, translog and the distributions of error terms representing inefficiency and statistical noise such as means variances etc. The unknown parameters of these functions and error distributions are usually estimated using the method of maximum likelihood. Aigner, Lovell and Schmidt (1977), Meeusen and Van den Broeck (1977) and Battese and Corra (1977) simultaneously developed a Stochastic Frontier Model that, besides incorporating the efficiency term into the analysis (as do the deterministic approaches) also captures the effects of exogenous shocks beyond the control of the analyzed units. Moreover, this type of model also covers errors in the observations and in the measurement of outputs.

Many studies have been done on assessing the technical efficiency in the use of resources in agriculture. Girei *et al*. (2013) assessed the resource use efficiency of Fadama beneficiary crop farmers in Adamawa state, Nigeria. In their study the stochastic frontier production function was employed to analyze the collected data. The maximum likelihood estimates (MLE) for the stochastic production function results showed, coefficients of farm size, inorganic fertilizer, hired labour and expenses on ploughing, significantly affected food crop output of the respondents. Further the study revealed that, mean technical efficiency was 0.71, the mean allocative efficiency was 0.76 and the mean economic efficiency was 0.54.

A study by Djokoto (2012) on technical efficiency of agriculture in Ghana used a Stochastic Frontier Estimation Approach on time series data from 1961 to 2010.The study revealed that technical efficiency of the sector was mean of 82 percent with a minimum of 59 percent and maximum of 96 percent with the sum of the elasticities of 1.74, which implies increasing returns to Ghana's Agriculture over the period.

A study by Haider *et al*. (2011) in Khulna, Bangladesh used the stochastic frontier approach to measure technical efficiency level of the agricultural farms. The study considered rice cultivation, fish cultivation and livestock rearing sub-sectors. The study indicated that, about76 percent, 81 percent, and 73 percent variations in output are due to technical inefficiency for the farms of these three sub-sectors respectively with fish sub-sector having the highest variation in output. Further the results revealed that, farming experience of the farmers and the availability of the credits significantly and positively affect the efficiency level of the farms and all the three sub-sectors have a chance to increase their production level with the same set of technologies. Itam *et al.* (2014) conducted a study on analysis of resource use efficiency among small scale fish farms in Cross River State, Nigeria. The study used stochastic production frontier model to analyze the resource use efficiency among small scale farms. The study revealed that, the small scale farms had a mean efficiency of 0.89 which indicates a room for farm efficiency improvement by 11 percent. Gender, family size, farming experience and education were the major contributing factors. Further the study found that, quantity of feed, farm size (pond size), labour and capital has significant influence on fish production in the study area, with positive coefficients of feed quantity and farm size while that of labour and capital were negative. The study also revealed a return to scale (RTS) of 1.055which indicates increasing returns to scale, that implied that farmers may need to increase the use of productive resources.

2.5.2.2 Data Envelopment model

Data envelopment analysis (DEA) uses linear programming methods to estimate the production technology. Primal and dual representations of the technology can be estimated using this approach. DEA requires assumptions concerning the regularity properties of the production frontier. The functional form assumption underpinning data envelopment analysis is that the production or cost frontier is locally linear. Data envelopment analysis is often described as a non-parametric approach because it does not involve any error terms, so does not involve any assumptions about the parameters (means, variances) of the distributions of those error terms.

Based on the work of Farrell (1957), Data envelopment analysis was developed by Charnes *et al*. (1978) as an empirical frontier analysis technique. Data Envelopment Analysis is a non-parametric method of efficiency analysis that employs linear programming to estimate the best practice or most efficient production frontier. Consequently those decision making units lying on the frontier are referred to as technical efficient, with a score of 1, while those below the frontier are regarded as inefficient, with a score of less than 1. All efficiency scores in data envelopment analysis range between 0 and 1 and lower scores indicate lower efficiency. Data envelopment analysis can be either input or output orientated. The original Data envelopment analysis model by Charnes *et al*., (1978) was an input orientated model, whereby under the assumption of constant returns to scale, inputs were minimized, output remained constant and inefficiencies were calculated in terms of the inputs. Alternatively, output orientated data envelopment analysis models were developed whereby the model is set up to maximize output and inputs remain at a constant level with inefficiencies calculated in terms of the outputs**.**

Many scholars conducted studies on technical efficiency and they employed a DEA model to measure the efficiencies of the decision units in question. Ren and Alemdar (2006) conducted technical efficiencies of tobacco farms in Southeastern Anatolia. Data envelopment analysis was employed to estimate technical efficiency of the farms. The DEA model results indicated that, the mean efficiency of tobacco farmers was found to be 0.45 and 0.56 for constant and variable returns to scale (CRS and VRS) assumptions, respectively. Further the study revealed that, the sampled tobacco farms would be able to increase their technical efficiency by 45 percent through better use of the available resources, while applying current technology. In addition Ismail *et al*. (2013**)** compared technical efficiency of paddy farming in east coast and west coast of Peninsular Malaysia by using data envelopment analysis (DEA) and Stochastic Frontier Analysis (SFA). The results indicated that the differences in methodologies employed produced different efficiency estimates. The DEA result showed that efficiency score for Peninsular Malaysia is 56 percent, which was lower from the efficiency score obtained using the SFA at 69 percent. Due to the large differences in technical efficiency results, recommendation for policy purpose should not depend on only one method as it is inaccurate.

Heidari *et al.* (2011) conducted a study to determine the economic efficiency of resource utilization in broiler production farms. The study employed non-parametric production function, data envelopment analysis (DEA) in determining economic efficiency of the broiler producers. In DEA models the farmers that produce their level of output with the least amount of input serve as benchmarks against which the input use inefficiency of all other farmers can be measured. The study revealed that, the total variable costs, net return and benefit cost ratio were 3506.29 USD (1000 bird)$^{-1}$, 1386.53 USD (1000 bird) $^{-1}$ and 1.38, respectively. Further, the DEA model results revealed that, the average values of technical and scale efficiencies of farmers were 0.92 and 0.93respectively.Moreover, Mevlut *et al*. (2009) conducted technical efficiency analysis of cotton farms in Çukurova region in Turkey. The study used an input oriented DEA model to estimate the technical efficiency of cotton farms whereas the Tobit regression analysis was used to identify determinants of technical efficiency. The study revealed that cotton farmers can save inputs by at least 20 percent while remaining at the same production level while farmers' age, education level and groups of cotton growing areas were found to strongly affect the efficiency level of the farmers**.**

Efficiency in data envelopment analysis model is defined as the ratio of the weighted sum of outputs to its weighted sum of inputs. Given *n* outputs and *m* inputs, efficiency (*h*i) for a decision making unit is defined as follows:

Max u, v $h_i = \frac{\sum_{r=1}^{s} Ur1Yr1}{\sum_{j=1}^{m} Vj1Xj1}$ … . . (1)

Subject to: $\frac{\sum_{r=1}^{s} Ur1Yr1}{\sum_{j=1}^{m} Vj1Xj1}$ … ...(2)

h_i= Technical efficiency to be estimated

Y_r=Quantity of outputs

U_r =Weight attached to output

V_j= Weight attached to inputs

i = indicates the n different units

r=indicates the s different outputs

j= indicates the m different inputs

2.6 Conceptual framework

Figure 1 below illustrates the conceptualized interrelationship of key variables in the study. The study posits that the decision to adopt agricultural integrated innovations (AIIs) practices is subject to the information constraints. The information threshold, which is a product of an underlying utility maximization, is arrived at through a process of information gathering. This information reaches the farmers via different approaches such as mother-baby trials, farmer field school, farmer research group, on-farm demonstration which are likely to influence the decision to adopt a technology at different levels. However, other socio-economic, institutional and spatial factors may influence the farmers' decision to adopt. This study hypothesized that the use of efficient and effective participatory research approaches (such as mother-baby trials, farmer field school, farmer research group, on-farm demonstration) on promoting integrated soil fertility management has a positive impact on the probability of farmers to adopt the technology. The agricultural integrated innovations such as ISFM practices have an impact on improving land productivity thereby increasing output per land under cultivation. Therefore, there is a possibility that farmers become food secured when they adopt AIIs practices.

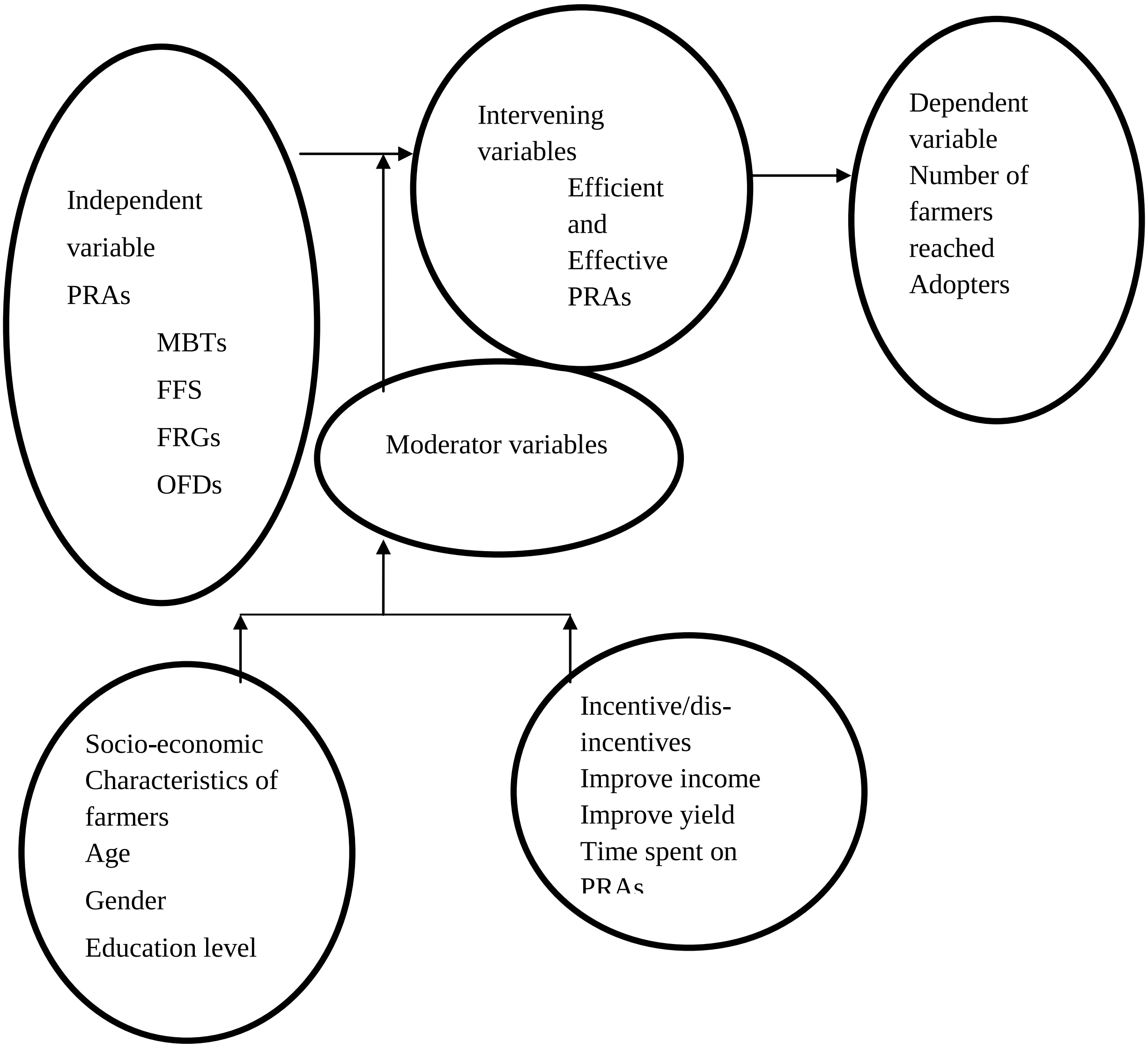

Figure 1: Conceptual framework of efficiency and effectiveness of the PRAs

Source: Author, 2015

CHAPTER THREE

METHODOLOGY

3.1 Study area

This study was conducted in Babati district in Tanzania. Babati district is situated in Northern Zone of Tanzania, and located between latitude 3º and 4º south and the longitude 35º and 36º. The District is one of five districts in Manyara region. Babati district consists of four divisions, 25 wards and 104 villages. The population of Babati district in 2012 was 405,500 (312,392 for Babati District Council and 93,108 for Babati Town Council) (URT, 2013).The intercensal growth rate for the district was about 3.0 % per year between 2002 and 2012. The agricultural survey of 2007/08 revealed 63,816 agricultural households, of which 15% were female-headed (URT 2012b).

The district has a total land area of 4969 km^2 where about 180,000 ha (36%) is arable land (Lofstrand, 2005). Babati is well documented as a place with the most shifting landscape and growing conditions. This area also attracts many people from different parts of Tanzania and beyond, because of the fertile land. Different crops are grown in Babati ranging from maize, pigeon peas, cotton, wheat, Irish potatoes and rice. Livestock keeping is an essential activity in this predominantly agro-pastoral area (Hillbur, 2013). The map of the study area is shown in Figure 2.

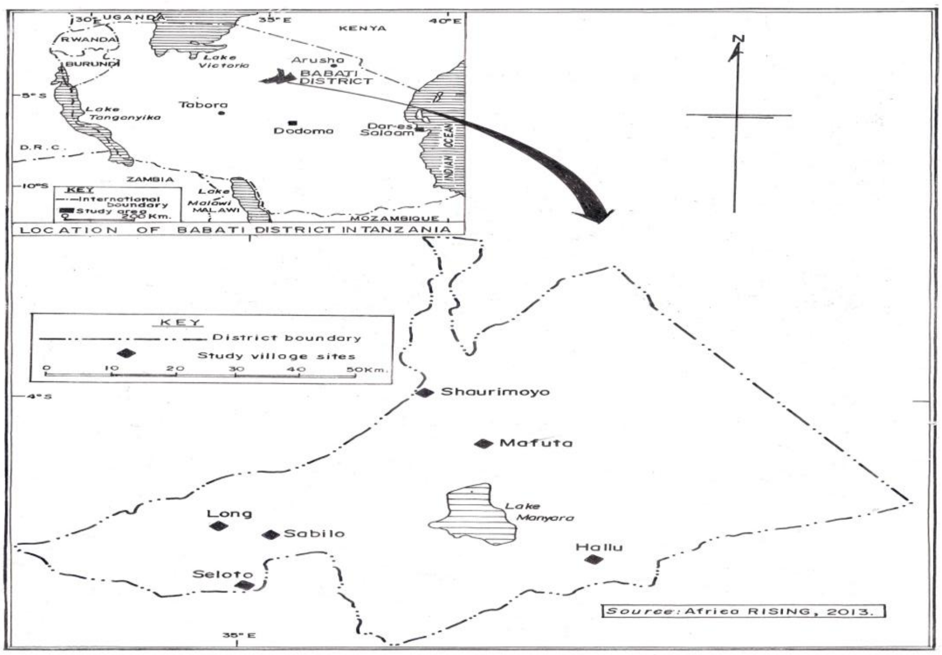

Figure 2: A map of Babati District, and villages of the study.

3.2 Sampling procedure

The target population for this study was maize-legume-livestock smallholder farmers in the study area. The study employed a multi-stage sampling technique where the first stage involved purposive selection of the Babati district from Manyara region. In stage two, nine villages where the participatory research approaches were implemented (Seloto, Sabilo, Long, Ayamango, Tsamasi, Endadoshi, Dareda-kati, Matufa and Hallu) were purposely selected from Babati District. Finally, the maize-legume-livestock smallholder famers involved in the participatory research approaches were systematically selected from the given source list to make a sample of 120 smallholder farmers. The sample size was determined following proportionate to size sampling approach (Groebnerand Shannon, 2005).

This is specified as follows: $n = \frac{(pqz^2)}{d^2}$ where, 'n' is the sample size, 'z' = 1.96 (standard variate at a given confidence level α = 0.05), 'P' is proportion of the population of interest. Based on the participation in the participatory research approaches rates of 50% from previous studies P was set at 0.5, d' is the margin of error which is set at 0.0895 as this was enough to remove 95% bias in sampling, q' is the weighting variable and is computed as *1-P*.

Therefore, the sample size to be used is determined as:

$$n = \frac{\{(0.5 \times 0.5 \times (1.96)2\}}{(0.0895)2} = 120$$

3.3 Data collection

Primary data were collected by using questionnaires, semi-structured interviews and focus group discussions. The questionnaire was used to collect data on socio-economic factors of the beneficiaries of participatory research approaches. Moreover, semi-structured interviews were held with key informants involved in facilitation of the participatory research approaches in the study area. These key informants were from Farm Africa, Africa RISING and Babati agricultural offices. The semi-structured interviews with key informants helped to understand the strengths and weaknesses of participatory research approaches in enhancing the uptake of agricultural integrated innovations from organizations' point of view. The focus group discussions were also employed to collect data on incentives/dis-incentives to farmers' participation in the participatory research approaches. Ten focus group discussions (one in each and every village) were conducted with farmers from the villages. The discussions were held at the village offices. The groups consisted of between five to nine participants. The focus group discussions took between 45-60 minutes each and followed the checklist. During the discussion, data were recorded and noted.

Secondary data was collected through documentary analysis from the Farm Africa, Africa RISING and Babati district agriculture office. The documents that were analyzed included budgets, expenditure statements to estimate the cost incurred in running the participatory research approaches and the number of adopters. The costs data collected was on researchers' allowances, expenses incurred during field visits, price of seed and fertilizer, labour, training and field days. Determining how many farmers each approach reaches for a given budget requires information on the number of people who participate in the various types of training. Information on the number of attendees at each training session was obtained from the institutions that sponsor each participatory research approach (PRA). Statistics on how many people were reached by mother-baby trial were collected from the Africa RISING project office in Arusha. Data on the reach of mobile demonstrations was obtained from the Farm Africa sesame project coordinator. Data on number of farmers reached by farmer research and the costs was obtained from Farm Africa on their farmer participatory approach project.

3.4 Data analysis

Data collected were cleaned, organized and analyzed using SPSS and Microsoft Excel. Specifically content analyses, descriptive statistics, inferential statistics and data envelopment analysis were used to analyze data and address the study objectives.

3.4.1 Determining the characteristics of PRAs

Descriptive statistics such as percentages and frequencies were employed. Moreover, documents from the organizations involved in the implementation of the PRAs were critically reviewed and analysed to determine characteristics of the PRAs.

3.4.2Comparing socio-economic factors of smallholder farmers

In addressing this objective descriptive and inferential statistics were employed. Specifically, percentages, frequencies, *chi*-square and F-test were used in comparing socio-economic characteristics of smallholder farmers involved in the popular participatory research approaches.

3.4.3 Determining the effectiveness of the PRAs

In addressing this objective, *ch*i-square test was employed. The test was done at0.05 significant levels in order to test the differences in the effectiveness of the participatory research approaches in term of number of farmers reached and those who became adopters.

The generic *Chi*-square model is given as:

$$\chi^2 = \sum \frac{(O - E)^2}{E} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where

$\sum$ = summation sign

χ^2 =*Chi-square*

O=Actual number of farmers reached

E=Expected number of farmers

3.4.4 Determination of technical-efficiency of the PRAs

In determining the technical efficiency of the participatory research approaches, the study employed Data Envelopment Analysis model. According to Charnes *et al*., (1978), Data envelopment analysis (DEA) is a non-parametric linear programming model for the development of production frontiers and the measurement of efficiency relative to the developed frontiers. The advantage of DEA method is that it allows efficiency to be measured without pre-specification of a functional form and distributional form for the different inputs and outputs used. Moreover, Data envelopment analysis can accommodate multiple inputs and outputs and does not require input or output prices in order to identify the best practice production frontier. Data envelopment analysis is also less data demanding than econometrics methods because it does not require a large sample size. Hence, it works well with small sample size and it does not require knowledge of the proper functional forms. In this study, the output orientated data envelopment model was undertaken which sought to proportionate increase in output to its maximum level of production, with input levels held fixed. To measure the efficiency of participatory research approaches, the study analyzed six approaches (mother-baby trials, mobile demonstration plots, farmer field schools, farmer research approach, on-farm demonstration plots and coupon agro-inputs) used for promoting the uptake of agricultural integrated innovations.

DEA model specification

Under the standard DEA approach, the efficiency of $PRA_i$is defined as:

Efficiency of PRA $_i$ = (weighted sum of PRAi's outputs)/ (weighted sum of PRAi's inputs).

$$E_1 = \frac{U_1Y_{11} + U_2Y_{21} + \cdots U_sY_{s1}}{V_1X_{11} + V_2X_{21} + \cdots V_MX_{M1}} = \frac{\sum_{r=1}^{s} Ur1Yr1}{\sum_{j=1}^{m} Vj1Xj1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Supposing we have *N* decision making units(DMUs) (five PRAs in this case), each with *n* inputs and *m* outputs, the DEA relative efficiency score of a given PRA is obtained by solving the following linear programming model:

Max u, v $h_i=\frac{\sum_{r=1}^{s} Ur1Yr1}{\sum_{j=1}^{m} Vj1Xj1}$ … . . (5)

Subject to: $\frac{\sum_{r=1}^{s} Ur1Yr1}{\sum_{j=1}^{m} Vj1Xj1}$ …(6)

$U_{r1}V_j \geq 0$.. (7)

Where

h_i= Technical efficiency of farmer field school (FFS) to be estimated

Y_i=Outputs (Number of AIIs)

U_r and V_j= Variables to be estimated

i = indicates the n different units

r=indicates the s different outputs

j= indicates the m different inputs

The U's and V's are variables of the problem and are constrained to be ≥0

The efficiency of a unit 1 for example would be computed according to

Where

E_1,The efficiency of unit 1

U_r, The weight given to output r

Y_{r1},The amount of output r from unit 1(Farmer field school)

$V_{j1,}$The amount of input j from unit 1 (Farmer field school)

Constant returns to scale (CRS) model

Under the restrictions that each unit's efficiency is judged against its individual criteria, efficiency of target unit h_i can be obtained as a solution to the following problem.

Maximize the efficiency of unit 1, under the restrictions that the efficiency of all units is ≤ 0

The solution of the above model in relation to unit 1 gives the value of h_i the efficiency of unit 1 and the weight U and V leading to efficiency. The DEA problem of equation (5) and (6) is a fractional linear program in which the numerator has to be maximized and denominator minimized simultaneously. Set the denominator=constant and maximizing the numerator. The transformation developed by Charnes and Cooper (1962) for fractional programming allows the introduction of a constraint $\sum VXi = 1$, meaning that, the sum of all inputs is 1.

Then the equation becomes,

$\text{Max}_{uv}h_i\sum_{r=1}^{s} U_{r1}Y_{r1}$ ……………………………………………………………….. (8)

Subject to

$\Sigma_{r=1}^{s} U_{r1}Y_{r1} - \Sigma_{j=1}^{m} U_{j1}Y_{j1}$………………………………………………………… (9)

≤ 0 for each unit i………………………………………………………………....... (10)

$\Sigma_{j=1}^{m} V_{j1}X_{j1}=1$…………………………………………………………………… …(11)

$U_rV_j\geq 0$...…………(12)

3.4.5 Determining incentives / dis-incentives to farmers' participation

In determining the incentives/dis-incentives to farmers' participation in the participatory research approaches, content analysis was employed. Content analysis is a procedure for analysis of qualitative data for purposes of classification, summarization and tabulation. The purpose of content analysis is to make sense of the data collected and to highlight the important messages, features or findings. Therefore, in this study both descriptive account of the data and higher level of content analysis were undertaken. Specifically, the data gathered from the focus group discussion were transcribed to get the related themes.

Table 1: Description and measurements of variables used in the study

Variable	Variable description	Variable type	Units of measurement
Household composition			
Gender	Gender	Dummy	1= Male, 0 = Female, +/-
Aghh	Age of household	Continuous	Number of years +/-
Educlevel	Education level	Categorical variables	1 = None,2 = Primary incomplete 3 = Primary complete 4= Secondary incomplete 5= Primary complete 6= Middle level college 7= University +/-
Hhsize	Household size	Continuous	Number of persons in the household +/-
Farmsize	Farm size	Continuous	Farm size in acres +/-
Tassetvalue	Total asset value	Continuous	Total value of assets TSH
TOfarmincome	Total value of farm income	Continuous	Total income from farm TSH +/-
TOtherincome	Total value of other income	Continuous	Other incomes and transfers TSH +/-
Occupation	Occupation of the household head	Ordinary	1 = Agriculture self,2 = Non-agriculture self, 3 = Salaried,4= Retired +/-
Distancprappro ach	Distance to where a participatory research approach is held	Continuous	Distance in kilometers +/-
Popular participatory research approaches under the study			
FFS	Farmer field schools	Nominal	Non
OFD	On farm demonstration	Nominal	Non
FRG	Farmers research group	Nominal	Non
MBT	Mother-baby-trials	Nominal	Non
Expenses of Participatory research approaches (TSH)			
Expenses of farmer field schools(TSH)			
AMSFLabor	Amount of money spent on labor for FFS	Continuous	Amount of money spent on labour (TSH)

AMSFFertilizer	Amount of money spent on fertilizer for FFS	Continuous	Amount of money spent on fertilizer(TSH)
AMSFSeeds	Amount of money spent on seeds for FFS	Continuous	Amount of money spent on seeds (TSH)
AMSFResearcher's allowance	Amount of money spent for researcher's allowance for FFS	Continuous	Amount of money spent for researcher's allowance (TSH)
AMSFField monitoring	Amount of money for field monitoring for FFS	Continuous	Amount of money for field monitoring (TSH)
Expenses of On-farm demonstrations (TSH)			
AMSOLabor	Amount of money spent on labor for OFDs	Continuous	Amount of money spent on labor (TSH)
AMSOFertilizer	Amount of money spent on fertilizer for OFDs	Continuous	Amount of money spent on fertilizer(TSH)
AMSOSeeds	Amount of money spent on seeds for OFDs	Continuous	Amount of money spent on seeds (TSH)
AMSOResearcher's allowance	Amount of money spent for researcher's allowance for OFDs	Continuous	Amount of money spent for researcher's allowance (TSH)
AMSOField monitoring	Amount of money on field monitoring for OFDs	Continuous	Amount of money for field monitoring (TSH)
Expenses of Farmers research groups (TSH)			
AMSRLabor	Amount of money spent on labor for FRGs	Continuous	Amount of money spent on labor (TSH)
AMSRFertilizer	Amount of money spent on fertilizer FRG	Continuous	Amount of money spent on fertilizer(TSH)
AMSRSeeds	Amount of money spent on seeds for FRGs	Continuous	Amount of money spent on seeds (TSH)
AMSRResearcher's allowance	Amount of money spent for researcher's allowance for FRGs	Continuous	Amount of money spent for researcher's allowance (TSH)
AMSRField monitoring	Amount of money on field monitoring for FRGs	Continuous	Amount of money for field monitoring (TSH)
Expenses of mother baby trials			
AMSMLabor	Amount of money spent on labor for MBTs	Continuous	Amount of money spent on labor (TSH)
AMSMFertilize	Amount of money spent on fertilizer for MBTs	Continuous	Amount of money spent on fertilizer(TSH)
AMSMSeeds	Amount of money spent on seeds for MBTs	Continuous	Amount of money spent on seeds (TSH)

AMSMResearcher's allowance	Amount of money spent for researcher's allowance for MBTs	Continuous	Amount of money spent for researcher's allowance (TSH)
AMSMField monitoring	Amount of money on field monitoring for MBTs	Continuous	Amount of money for field monitoring (TSH)
Expenses of coupon agro-inputs			
AMSMLabor	Amount of money spent on labor for CAIs	Continuous	Amount of money spent on labor (TSH)
AMSMFertilize	Amount of money spent on fertilizer for CAIs	Continuous	Amount of money spent on fertilizer (TSH)
AMSMSeeds	Amount of money spent on seeds for CAIs	Continuous	Amount of money spent on seeds (TSH)
AMSMResearcher's allowance	Amount of money spent on researcher's allowance for CAIs	Continuous	Amount of money spent on researcher's allowance (TSH)
AMSMField monitoring	Amount of money on field monitoring for CAIs	Continuous	Amount of money for field monitoring (TSH)
Expenses of mobile demonstration plots			
AMSMLabor	Amount of money spent on labor for MDPs	Continuous	Amount of money spent on labor (TSH)
AMSMFertilize	Amount of money spent on fertilizer for MDPs	Continuous	Amount of money spent on fertilizer (TSH)
AMSMResearcher's allowance	Amount of money spent on researcher's allowance for MDPs	Continuous	Amount of money spent on researcher's allowance (TSH)
AMSMField monitoring	Amount of money spent on field monitoring for MDPs	Continuous	Amount of money spent on field monitoring (TSH)
Number of adopters through the participatory research approaches			
NuAIIsAFFS	Number of AIIs adopters through farmer field schools	Discrete	Number of adopters of AIIs through FFS
NuAIIsAOFD	Number of AIIs adopters through on-farm demonstrations	Discrete	Number of adopters of AIIs through OFDs
NuAIIsAFRG	Number of AIIs adopters through farmers research group	Discrete	Number of adopters of AIIs through FRGs
NuAIIsAMBT	Number of AIIs adopters through the mother-baby trials	Discrete	Number of adopters of AIIs through MBT

NuAIIsAMDPs	Number of AIIs adopters through the mobile demo plots	Discrete	Number of adopters of AIIs through MDPs
NuAIIsACOUPON	Number of AIIs adopters through the coupon agro-inputs	Discrete	Number of adopters of AIIs through CAPs

CHAPTER FOUR
RESULTS AND DISCUSSIONS

This chapter presents results and discussion of this work. The chapter is divided into five major sections. The sections comprise of descriptive results for the socioeconomic characteristics of household participating in the PRAs, whereby comparisons are made among the PRAs' participants. Then the characteristics of the participatory research approaches are also discussed followed by the discussion of the results on the effectiveness of the participatory research approaches. Lastly the results for efficiency of the participatory research approaches and the incentives/dis-incentives to farmers participating in the participatory research approaches are discussed.

4.1 Comparison of socio-economic characteristics of smallholder farmers participating in PRAs

Table 2gives the descriptive results on the comparison of socio-economic characteristics of the smallholder farmers involved in the participatory research approaches in Babati district. The socio-economic characteristics discussed here are age, family size, farm size, total assets and farm income.

Table 2: Comparison of continuous variables among smallholder participating in PRAs

Variable (Mean)	**FFS N=21**	**COUPON N=13**	**MDPs N=10**	**MBTs N=60**	**FRGs N=14**	**F-Sig**
Age (Years)	49.59	48.08	50.90	46.21	48.79	0.597
Overall mean	47.50					
Familysize(no)	7.00	6.00	6.00	8.00	7.00	0.931
Overall mean	7					
Farmsize(acre)	3.29	2.92	20.50	5.55	10.54	0.000***
Overall mean	6.25					
Farmincome(ave						
Overall mean	1,053,680 3,586,077	817,110	7,959,743	2,067,274	6,032,579	0.981
Totalasset(ave)Tshs Overall mean	22,637,120 18,013,306	9,809,950	34,987,910	10,970,870	11,660,680	0.041**

***Significant at 1%, ** significant at 5%

Source: March, 2015

Table 2 shows results of selected continuous socio economic variables. The overall average age for the sampled households was 47.50 years. The results further revealed that the mean age for the participants in the different participatory research approaches were 49.59 year for farmer field schools, 48.08 years for coupon participants, 50.90 years for mobile demonstration plots participants, 46.21 years for the mother-baby trials and 48.79 years for the farmer research group participants. It is thus evident that participating farmers in the mobile demonstration plots were older than the participants in the remaining participatory research approaches. In addition mother-baby trials' participants were younger than the participating farmers in the remaining participatory research approaches. The older farmers in the mobile demonstration plots could be explained by fact that these farmers had large land sizes and higher total asset value than the participating farmers in other PRAs. According to Masuki *et al*. (2003) older farmers are receptive towards new agricultural technologies due to adequate experience and accumulated capital, which would enable the farmers to acquire new farming technologies more easily as they come up. The F-test, indicated that the mean age was significantly different for the participants of the different participatory approaches ($p<0.05$). Age factor was found to be significant in agricultural information accessibility and utilization (Meera *et al*., 2004).

Results on farm size showed that the overall mean for land holding size was 6.25 acres. Farmers who participated in farmer field schools had a mean land holding of 3.29 acres. Those who participated in coupons had a mean land holding of 2.92 acres. The results also indicate that the farmers who participated in mobile demonstration plots had a mean land holding of 20.50acres.Moreover, those who participated in mother-baby trials had a mean farm size of5.55 acres while those who participated in farmer research groups had a mean farm size of 10.54 acres. This implies that mobile demonstration plots' participants had large farm size followed by the participants in the farmer research groups and then the mother-baby trials' participants. The participants in the mobile demonstration plots had large farm size (10.54 acres), because most of them do grow sesame which requires large farm size due to its low productivity and it cannot be intercropped with other crops. Hence farmers need to grow large area of sesame for them to realize the profit from the enterprise. This was contrary to the participants of the mother-baby trials, farmer research groups, farmer field schools and coupon agro-inputs who had small farm size that ranged from 2.92-5.55 acres. This is because most of them do grow crops include maize, beans, pigeon peas and rice in which most of the time the crops are intercropped in the same piece of land hence small farm size. In addition, the Africa RISING's PRAs and FFS operate in villages that are densely populated, with relatively small farm size. Further the F-test results revealed that the mean farm size was significantly different ($p<0.01$) among the participants of the different PRAs. These findings concur with the national census results which indicated that the national average farm size ranged from 2.5 to 7.5 acres per household (URT, 2012).

It was also found that the average household size was 7 for the sampled households, with the participants in the mother-baby trials having larger household size of 8 people. The farmer field schools and farmer research groups' participants had an average household size of 7 people while the participating farmers in the coupon agro-inputs and mobile demonstration plots had the mean of household size of 6 people in the house. This implies that average household size in Babati is above the national average of 5 people according to the national census (URT, 2012).However, the F-test results pointed to no significant difference ($p>0.05$) in the mean household size among the PRAs' participants. Other studies have also shown that household size is associated with participation in PRAs activities which result into adoption of the promoted technology due to provision of sufficient labour thus, relaxing the labour constraint during the introduction of new technologies (Amsalu and De Jan, 2007). Larger households may also need to improve land productivity through adoption of integrated innovation so as to obtain sufficient food.

The mean on farm-income per annum among all households was Tsh.3,586,077. In addition, the mobile demonstration plots' participants had an average on farm-income of Tsh. 7,959,742followed by the participants of the farmer research groups who had an average on farm income of Tsh.6,032,578. Farmer participating in the farmer field schools had a mean farm income of Tsh.1,053,681 while mother-baby trials and coupon agro-inputs' participating farmers had an average farm income of Tsh.2,067,273 and Tsh. 817,196 respectively. These results imply that the mobile demonstration plots' participants had the highest average farm income compared to the participants of other participatory research approaches. However, F-test revealed that the mean difference was not significant, indicating that the average farm income was not significantly different among the PRAs' participants.

The total asset value owned by the sampled household was obtained by calculating the total value of the assets in the household which were identified to have a direct use in production, or an indirect effect through improving the awareness of the farmer. These included farm equipment, bicycles, motorcycles, cars, radios, televisions, phones, tractors, furniture, vehicles, fenced farms and food stores among others. The findings showed that the mean value of asset endowment among all the respondents sampled was Tsh. 18,013,306.These figures indicated that the sampled households were well endowed with adequate assets necessary to guarantee higher liquidity that would enable them adopt the agricultural integrated innovations hence participation in the PRAs. The results also show that farmers in the mobile demonstration plots had the highest asset endowment with the mean of Tsh. 34,987,910 compared to the asset value of the farmer field schools (Tsh. 22,637,120) mother-baby trials (Tsh. 10,970,8700, coupon agro-inputs (Tsh. 9,809,950) and farmer research groups (Tsh. 11,660,680) participants. The F-test for mean difference was significant at 5% level hence the mean value of assets owned by mobile demonstration plots' participant farmers was significantly greater than the mean for participant farmers in the remaining participatory research approaches. This is due to the fact that the participating households in the mobile demonstration plots grow sesame which fetches higher price (up to Tsh. 300,000 per bag) in the market hence higher on farm income.

Table 3: Comparison of categorical variables among smallholder farmers in PRAs using *Chi*-square test

Variable	FFS N=21		COUPN N=13		MDPs N=10		MBTs N=60		FRGs N=14		Sig
Gender HH											0.02**
Male	16	76	13	100	10	100	59	98	11	79	
Female	5	24	0	-	0	-	1	2	3	21	
Marital status											0.042**
Married	16	76	11	86	10	100	54	90	12	86	
Single	0	-	1	7	0	-	4	7	0	-	
Divorced	0	-	0	-	0	-	2	3	1	7	
Widowed	5	24	1	7	0	-	0	-	1	7	
Education level											0.005*
None	0-		0	-	2	20	1	1.7	0	-	
Primary incom	0	-	0	-	3	30	2	3.3	0	-	
Primary complete	18	86	10	77	3	30	44	73.3	14	100	
Secondary incom	0	-	0	-	1	10	1	3.3	0	-	
Secondary comple	3	14	2	15	1	10	9	15.0	0-		
College	0	-	1	8	0	-	1	1.7	0	-	
University	0	-	0-		0-		1	1.7	0	-	
Credit access											0.600
Yes	4	19	3	23	0	-	12	20	2	14	
No	17	81	10	77	10	100	48	80	12	76	
Livestock owship											0.288
Yes	19	90.4	11	84.6	7	70	50	83	14	100	
No	2	9.6	2	15.4	3	30	10	17	0	-	
Exten services											0.47
Yes	20	95	13	100	9	90	59	98	14	100	
No	1	5	0	-	1	10	1	2	0	-	
Gmembership											0.726
Yes	6	28	6	46	2	20	19	32	5	35	
No	15	72	7	54	8	80	41	68	9	65	
Income status											0.024** 0.024**
<= 100000	8 8	38 38	6 6	46 46	4 4	40 40	13 13	22.0 22.0	5 5	35.8 35.8	
110000-200000	13 13	62 62	5 5	38 38	1 1	10 10	25 25	42.0 42.0	4 4	28.6 28.6	
210000-500000	0 0	- -	2 2	16 16	3 3	30 30	16 16	26.0 26.0	4 4	28.6 28.6	
510000-1000000	0 0	- -	0 0	- -	1 1	10 10	6 6	10.0 10.0	1 1	7.0 7.0	
>1000000	0 0	- -	0 0	- -	1 1	10 10	0 0	- -	0 0	- -	

*** indicates significance at 1 %, ** at 5%

Source: March, 2015

Table 3 shows comparison of categorical socio-economic characteristics of smallholder farmers participating in the participatory research approaches. The socio-economic characteristics discussed here are income status, education level, land tenure, extension services, credit access, livestock ownership and group

The results show that, 93 percent of the sampled households were male headed with female headed households comprising 7 percent. Disaggregating this by the different PRAs, the results indicated that 98 percent of the households participating in the mother-baby trials' activities were male headed followed by the participants of the farmer research groups which had 79 percent of male household heads. The farmer field schools approach had 76 percent of the male headed households while all participants in the coupon agro-inputs and mobile demonstration plots were male headed households. Moreover, it was found that farmer field schools approach had the highest number (24 percent) of female headed households compared mobile demonstration plots, farmer research groups and the mother-baby trials approaches. This could have resulted from the fact that, the FFS approach promoted conservation agriculture practices which involved crop cover, use of crop residual, minimum tillage, use of manure from livestock which needs time and patient during training. Since women are very patient curious to learning process hence more number of women in the FFS. IICD (2013) reported that women are generally experienced, more curious and motivated to learn.

This is an indication that many of the people who control resources in the household are male, thus they are the ones who are involved in farm business decision making hence participating in the PRAs' activities. The *chi*-square test indicated significant difference ($p<0.05$) in gender of the household heads among the PRAs participants. Tanellari *et al*. (2011) revealed that gender is a significant factor in the adoption of new peanut varieties, with males being more likely to adopt. Doss (2001) also indicated that women adopt improved varieties at a lower rate than men. Further, Xiaolan and Shaheen (2012) stated that the farming occupation was usually dominated by male though they were assisted by their female counterparts.

The results show that 87.5 percent of the households who participated in PRAs were married while 12.5 percent were divorced, widows and single. This finding is supported by the fact that in each and every participatory research approach about 76, 86, 100, 90 and 80 percent of the participants were married for the farmer field schools, coupon agro-inputs and farmer research groups, mobile demonstration plots and mother-baby trials respectively. The chi-square test revealed the significant difference ($p<0.05$) in the marital status among the participating farmers in the PRAs with most of them being married. This therefore implies that the married farmers were more likely to take part in the participatory research approach activities. This might be contributed by the fact that the married couples are settled and financially stable making them to fully participate in the PRAs activities so that they can adopt the promoted technology. In addition, division of labour between husbands and wives might also contribute to increased participation of the married couples in the participatory research approaches' activities. These results suggest that the contribution of both men and women was important in involving in the PRAs. In the marriage set up, the men were in a better position of accessing the information while the women supported in actual farming activities hence contributing to higher participation in the PRAs hence adoption. The results concur with Ojo and Jibowo (2008) who reported that married people being responsible, their views are likely to be respected within rural communities as they take decision to participate in the participatory research approaches' activities.

The education variable was categorized into various levels from those farmers who did not attain any formal education to those who attained university level. The study found that generally 97.5 percent of farmers involved in the PRAs activities had at least incomplete primary education. The results further showed that all participating farmers (100 percent)in the farmer research groups had attained primary education followed by the participants of the farmer field schools in which 86 percent of them had completed primary education. About 77 percent of the participating farmers in the coupon agro-inputs had attained primary education, 73.3 percent of the mother-baby trials' participants had primary education while 30 percent of the farmers participating in the mobile demonstration plots had attained primary education. It was also found that participating farmers in the coupon agro-inputs had higher level of education than other participating farmers in the farmer field schools, farmer research groups, mother-baby trials and mobile demonstration plots. This could be caused by the fact that in the coupon agro-inputs approach, participants were offered with the subsidized improved seeds of beans and *minjingu mazao* fertilizer for them to evaluate the performance in the field. This did influence most of the educated farmers in the study area to engage in the coupon agro-inputs' activities so that they would be able to observe the performance of the promoted technologies in their field and hence adopting the same. Lin (1991) also reported that education level of the household head has a positive effect on the probability of adoption of hybrid rice by farmers. The *Chi*-square results showed significant difference ($p<0.01$) in education level among the household heads participating in the PRAs' activities. The effect of education on participation in PRAs/ adoption has been argued by several researchers. For instance, in separate studies, it was reported that education of the household heads was found to have significant relationship with their ability and interest to access agricultural information and its adoption (Ango *et al*. 2013;

Rehman, 2013; Ani *et al*. 2004; Okwu and Umoru, 2009)**.**Abdullahi and Abdullahi (2011) also indicated that formal education facilitates the adoption of modern technologies and improved farm practices such as through the participation in the PRAs' activities.

This study found that about 97.5 percent of participants accessed extension serviceswhile2.5 percent did not. In addition, it was found that all the participating farmers in all the participatory research approaches had accessed extension services in the last one year. This is supported by the fact that about 95 percent of the farmer field schools' participants accessed the services, 98 percent for the participating farmers in the mother-baby trials approach while all participants (100 percent) of the coupon agro-inputs and farmer research groups respectively accessed extension services in the last one year. The extension services were mostly being provided by government officers, NGOs and projects. However, the *chi*-square test found that there was no significant difference among farmers participating in the PRAs' activities in accessing the services in the study area. This implies that extension services were a vital determinant of farmers participating in the PRAs' activities. Damisa and Igonor (2007) indicated that the higher the number of contacts the farmers had with extension agents, the more the participation of farmers in training such participatory research approaches hence, the higher the acceptance of new technologies.

In terms of credit access, the findings revealed that only 17.5 percent of farmers involved in the PRAs had applied for a loan in the last one year while 82.5 had not. In fact it was further found that 23 percent of households participating in the coupon agro-inputs applied loans followed by the participants of the mother-baby trials approach in which 20 percent of them had applied for it. In addition 19 percent and 14 percent of the farmers participating the farmer field schools and farmer research groups had applied for the loans respectively while none of the participating farmers in the mobile demonstration plots applied for it. These findings are in agreement with the Manyara sample census report 2008, which indicates that very few (2.8 percent) agricultural households accessed credit in the region (URT, 2008). This low percentage of farmers who accessed credit in the past year might have been contributed by the fact that most farmers did not have land title deeds which could be used as collateral for them to access credit from the financial institutions. This is revealed by the fact that only 23 percent of the PRAs' participants owned land with title deeds while 77 percent had land with no title deeds. Majority of households sourced loans from microfinance institutions such as Pride, Brac, SEDA, Banks (NMB and CRDB) and SACCOS. The funds were used for farming activities, school fees and business purpose.

The *chi*-square test found that access to credit was not significantly different among farmers participating in the PRAs' activities. This means that access to credit was not a prerequisite for the farmers to engage in the participatory research approaches. Miller (1977) posited that if credit is provided under proper conditions, well managed production credit can give agricultural development a rapid growth by accelerating the rate of adoption of improved technology by farmers who would otherwise be prevented from using it. This is contrary to the results of the study by Yusuf *et al*. (2013) which revealed that all the participants had access to credit which aided them in the adoption of improved maize varieties in the study area. The study also revealed that the non-participant farmers said they had no access to credit, that was why they were unable to participate in the production of improved maize. During the introduction of the variety, access to credit was very important for the purchase of necessary inputs by the farmers.

Household income affects positively the decision of farmers on adoption of agricultural technologies hence participation in the participatory research approaches' activities. The results show that participating farmers had monthly average income between Tsh. 110,000 and Tsh.200,000. It is also shown that participating farmers of mobile demonstration plots had the highest level of monthly income which ranges from Tsh. 210,000 to Tsh. 1,000,000. This might be attributed by the fact that most of the mobile demonstration plots' participants did grow sesame in which most of the time the crop fetches high price in the market due to collective marketing system. Most of the mother-baby trials' participants had a monthly household income that ranged from Tsh. 110, 000 to Tsh. 200,000 while participating farmers in the coupon agro-inputs had an average income of Tsh. 100,000 monthly. In addition, most of the participants (57.2 percent) of the farmer research groups approach were earning a monthly income of more than Tsh. 210,000.

Chi-square test showed a significant difference ($p<0.05$) in monthly household average income among the participants in the PRAs' activities. Further the result noted that the monthly income was used in different activities such as maize-legume farming, off-farm activities (school fees and building purposes) and other farming activities. Other studies have reported that household income that was higher would be able to prepare all the necessary inputs in a technology (Max, 2015). Further (Bello *et al*. 2012; Jamsari *et al*. 2012) indicated that income of farming affected the application of agricultural technology by farmers.

Groupmembership indicates whether the respondents belong to any association or not. The results show that 31.7 percent of sampled farmers had membership to groups other than

PRAs while 68.3 percent were not. It was found that, coupon agro-input approach had the highest (46 percent) number of participants who were members of other association compared to the participating farmers of the remaining approaches. Farmer research groups approach had 35 percent participants who were members of other associations, mother-baby trials had 32 percent and farmer field schools had 28 percent while mobile demonstration plots had 20 percent participants who had membership of other groups. Most of the PRAs' participants were the members of saving and credit societies, women groups, self-help groups, youth groups and other social groups. However, *chi*-square test shows no significant difference among the PRAs' participants in group membership. These organizations or associations probably enhanced farmers to fully participate in the PRAs since information is easily disseminated in groups and such development interventions by the government and non-governmental organizations mostly target groups rather than individuals. This conforms to other findings which reported that membership to group enables farmers to learn about new technology through other farmers and development agencies (Nkamleu, 2007). Moreover, farmers in groups wield a strong bargaining power when marketing their products and in turn receive better returns for their produce. They also enjoy better penetration to wider markets and improved chances of being offered contracts by major buyers. Collective marketing, allows small-scale farmers to spread the costs of marketing and transportation and improve their ability to negotiate for better prices, and increase their market power (Shiferaw *et al.,* 2006).

Further the results show that 85 percent of farmers involved in the PRAs kept livestock such as cattle, pigs, chickens, sheep and goats while 15 percent were not keeping them. Specifically, the findings revealed that almost all the participating farmers in different participatory approaches had livestock herds for the past one year. This can easily be seen by the fact that all the participants of the farmer research groups were keeping livestock followed by the participating farmers in the farmer field schools approach in which 90 percent of them kept livestock. Moreover 85 and 83 percent of the farmers participating in the coupon agro-inputs and mother-baby trials respectively were livestock keepers while 70 percent of the mobile demonstration plots' participants were keeping livestock in the last one year. However chi-square test revealed no significant difference in livestock ownership among the PRAs participants.

4.2 Characteristics of the participatory research approaches

The characteristics of six popular participatory research approaches are discussed here. The research approaches are farmer field schools (FFS) led by FAO, farmer research groups (FRGs) led by Farm Africa, mobile demonstration plot (MDPs) led by Farm Africa, coupon agro-inputs (CAI) led by Africa RISING, mother-baby trial approach (MBTs) led by Africa RISING and on-farm demonstrations plots (ODPs) run by Farm Africa. These research approaches were implemented by different organizations in the district at different times and they were used to disseminate agricultural technologies related to agricultural intensification.

4.2.1Farmer field schools

Farmer field schools (FFS) utilize contact farmers who train others and disseminate information which relies on participatory training methods that build farmer capacities. This model was used in implementation of a conservation agriculture project in Babati district from 2004 to 2010. The project involved the African Conservation Tillage Network (ACT) in partnership with Food and Agriculture Organization of the United Nations (FAO), and Ministry of Agriculture Food and Cooperatives (MAFC) of the United Republic of Tanzania. The farmer field schools approach based on a group learning approach for which farmers carried out experiential learning activities that helped them to understand the ecology of their crop fields and performance of conservation agriculture (CA) implements. The activities involved simple experiments, regular field observations and group analysis. The knowledge gained from these activities enables participants to make their own locally-specific decisions about crop management practices and the implements. The farmer FFS activities included the training of group conservation agriculture facilitators and extension officers which were then used to facilitate operations in the farmer field school groups. The project had an average of 37 farmer field schools in the district comprising an average of 28 farmers in which about 29.7 percent of members in the groups were women while 70.3 percent were men (Mkonga, 2010).The project also supplied some conservation agriculture (CA) implements to all groups for the purpose of training. The essential implements for each group were three jab planters and one ripper. Some groups received one Draft Animal Power (DAP) Direct seeder and a Zamwipe. Farmers received practical hands on training on use and advantages of the implements.

Each group was facilitated to establish one acre of farmer field schools plot for the training process. During the implementation process, farmers were trained based on conservation agriculture technologies which included maize + lablab+ no ripping, Maize + lablab + ripping, maize + pigeon peas+ no ripping, Maize + lablab + ripping and compared with the farmers' local practice. The plots were used as training blocks over the crop growing seasons. Moreover, the farmer field schools were facilitated by selected farmers trained in farmer field schools principles and practices through regional and national trainings. During the field training, farmers were exposed to different agricultural technologies such as recommended agronomic packages, reduced-tillage using rippers, sub-soilers, no-till direct planter or jab planters and potholing before the first rains, planting of cover crops mainly lablab, *mucuna*, pigeon peas, pumpkins or finger millet to enhance permanent soil cover and for soil fertility amelioration, crop residues retention after harvesting to maintain soil cover and soil organic matters, weed control using glyphosate(a systemic herbicide more effectively in relatively high rainfall areas and early weeding in area of low rainfall regimes) and crop livestock integration techniques including crop residue harvesting for feeding livestock and use of manure from livestock for soil fertilizing effects.

As part of the training process, farmers collected field data through a participatory monitoring and evaluation approach that incorporated the agricultural ecosystem analysis (AESA). Data collected included rainfall, labour input for the field operations, soil characteristic changes, crop diseases, insect attack and coping strategies. Other data included maize and cover crop grain yield. In order to out scale the effects of FFS training arrangement in the districts, some field days and farmers exchange visits were conducted within Tanzania and between farmer field school groups from and to Kenya. Most of the groups operate under credit and savings arrangement with regulated constitutions for which they also operated bank accounts. However, the participants mentioned high costs associated with conservation agriculture, time demanding and prevailing of rodents due to crop residues that were left in the field for soil fertilizing were some of challenges in adopting the CAs' practices.

4.2.2 Farmer research groups

The farmer research group model was implemented by Farm-Africa with the aim of achieving the organization's new strategy (2006). The model mainly aims at scaling up the impact of the work in Eastern and Southern Africa, thereby enabling many more rural Africans to benefit from the solutions to poverty reduction. The farmer research group model, started in the mid of 2000's in Babati district. The project's approach to FPR essentially involve a six-step process which includes group formation (two to three farmers per sub-village for a 12 member FRG) by village selection, leadership election, planning (including selecting technologies for testing and capacity building), design of on-farm trials, implementation of on-farm trials (including exchange between groups and training for agricultural innovation) and dissemination and information sharing to other farmers (each FRG member trains three to five other farmers, two field days/season, exchange visits) (Farm-Africa, 2008).

Practically, the group formation process based on the identification of typically 12 members (six men and six women, although in practice often more of each), using criteria such as ensuring representation of sub-villages (usually three to four per village), gender balance and the identification of research-minded farmers able to share results with others. Farmer Research Groups (FRGs) were formed through a process of village selection rather than by the project with the local extension officer and formally approved at a village assembly. Farm Africa facilitated planning meetings in order to identify alternative solutions to prioritize agricultural problems that could be tested under on-farm conditions. Farmers themselves identified problems such as crop diseases and low yields. The FRG members elected group leaders (a chair person and secretary) and began the work of developing their plan on matters such as training on improved agricultural practices, testing of improved seeds, soil and water conservation and preparing demonstration plots on their respective farms.

Farmer research group members were trained on timely preparation of land, crop spacing and planting of improved seeds (maize and beans), use of botanicals and plant "tea" (fertilizer from plants), use of farmyard manure, crop storage and use of ashes farm budgeting, composting (esp. for those without farmyard manure), field inspection, terracing and contour bunds, crop rotation, intercropping, seed production and certification, identification of pests a diseases, environmental conservation and improved stoves, vegetable production, among other activities.

In groups where SACCOS were introduced, training on group management issues such as group leadership, election of officials, constitutions and financial management were greatly enhanced. SACCOS training was on types of loans, shares and interest rates, record keeping, loan screening, establishment of association by laws, managing a bank account, establishing an association office, establishing an association shop for members among others.

The farmer research groups were able to produce quality seed, integrate use of farmyard manure and good leadership. Experience to date has given tangible results for members (send children to school, improve houses, buy SACCOS' shares, buy clothes, livestock, ox plough, radio, bicycles, mobile phones), hiring extra land for seed multiplication, improve the running of the input shop and good integration with extension staff. 70-75 percent of other farmers in the villages are now using improved maize seed and enjoys improved access to markets which in turn has improved price of maize sold from Tshs. 3,000- 6,000/bag to 12,000-25,000/bag by then.

Groups indicated that they were linked to seed suppliers in Babati and were accessing seed from these sources. Those groups with input shops had appointed shop managers who kept records on sales, for example, Tsamas group shop manager indicated a total of Tshs. 600,000 in the FRG account, with 80 per cent of seed sales so far within the village. The farmer research groups were linked to both seed multipliers and input shops to a variety of institutions including Multiflower, Selian Agricultural Research Centre (SARI) (who have trained seed farmers in production of maize, bean and potato seed), TOSCI (for seed certification), Arusha Foundation Seed Farm (for foundation seed supplies) and have ensured that these were linked to VEOs and the District Council. The group used to advertise their shop and items in stock at the VEO's office, at village assemblies and through kiosks in sub-villages. Groups also negotiated 60-day accounts with wholesalers once they had established a reputation as reliable customers. However, the groups are no longer operational because of some reasons such as the group's capacity to organize collective storage and transport for marketing, the sustainability of their research work, and the lack of an effective network with other groups and experts.

4.2.3 Mother-baby trials

The mother-baby trial got its name from one of the farmers involved in the trials. The mother trials test many different technologies while the baby trials test a subset of three (or fewer) technologies plus one control (Snapp, 2002). The design makes it possible to collect quantitative data from mother trials managed by researchers and systematically to cross-check them with baby trials on the similar theme that are managed by farmers. The design also allows local farmers to be actively engaged in all farmer-installed and managed trials.

Africa RISING project in Tanzania employed the mother-baby trial approach in testing and evaluating different best-bet technologies with farmers in Babati District. Research demonstration plots were used as training and learning centers and as a means to disseminate the technologies within the project communities and neighboring locale. For 2013/2014, mother-baby approach has continued to be utilized in the truthing studies, as these also allow for implementation of technology dissemination through participating farmers (farmer to farmer) and within farmers' groups (Africa Rising, 2014).

The project started its activities in 2012/2013 season in the implementing villages where by researchers designed the best-bet technologies to address different themes such as improving soil fertility, fodder production, vegetable production. The representative villages in the key agro-ecological zones were chosen based on the information from community meetings, consultations with extension officers and the village government. Moreover, the researchers involved in the mother-baby trials selected the farmers to participate in the trials through the community meeting (survey, 2015). They asked for volunteers and after getting them they consulted the extension officer and village government to recommend farmers who were committed. This would however have resulted into working with progressive farmers only and leaving out the very resource limited farmers.

The implementation of the trial design was geared to meet both researchers' and farmers' objectives which in this case was similar. Farmers initially chose their test technologies on the basis of introductory community meetings. Researchers assisted farmers with trial setups and measurement in collaboration with village extension officers. Plot size for mother and baby trials was approximately 16x16m. A wide range of cropping system technologies was compared to farmers' practices as described in Snapp *et al.* (2002). The mother trials were planted by extension staff with assistance from researchers. Data collected from trials included: plot size measurement, planting date, emergence date, population density, date when plot was weeded among other variables. The farmers provided quantitative feedback on their evaluation of technologies to researchers through surveys, paired matrix ranking, and by rating technologies. Qualitative feedback was obtained from meetings between farmers and researchers and comments recorded at field days. The mother trials were evaluated more informally during discussions held at field days. This made it possible to integrate the farmers' assessment and improve research priority settings for the next season. The mother-baby trial approach, if properly designed, can possibly foster the adoption process because the participant farmers might even start using the tested technology, thereby serving as a communication and dissemination strategy.

4.2.4 Mobile demonstration plots

Farm Africa worked with the Cambridge Malaysian Education and Development Trust and the Malaysian Commonwealth Studies Centre to design and implement a small pilot using tablet computers instead of demonstration plots in two of the project villages. Ten contact farmers and two government extension agents were trained in operating the tablets, which were loaded with locally-produced videos explaining best practice for each stage of the production cycle. The modules that were loaded include land preparations, planting, planting care, harvesting and post-harvest handling and marketing.

Between November 2013 and April 2014, tablets were given to ten contact farmers to take around to sesame farmers within their community as 'portable demo plots'. The farmers viewed training modules relevant to key milestones in the agricultural season, testing their understanding with inbuilt learning questions. Each farmer was visited several times as new modules were developed, giving them the chance to go back and repeat sessions, as desired. Potential benefits of using tablets includes greater control over the quality of material reaching farmers, farmers don't have to travel to fixed site at specific time hence can learn at a time that suits them, the contact farmers effectively become knowledge portals, not teachers and as new knowledge emerges (*e.g.* suitable responses to a new local pest or disease), tablets can be updated far more easily, and at lower cost, than physical retraining of the contact farmers.

According to Farm-Africa 2015 the results show that, at the baseline, knowledge questions were correctly answered by, on average, 36 percent of respondents. After the training, the proportion of questions answered correctly in the comparison villages was 71 percent, while the proportion of correct answers was 78 percent in the tablet group. Furthermore, nearly all farmers interviewed 96 percent introduced changes to their farming practices after viewing the tablet course, however most changes were confined to the land preparation and planting stages. 76 percent of respondents believed this change led to an increase in their income from sesame farming.

The ten contact farmers collectively reached 499 sesame farmers. The result on potential cost saving also indicates that using mobile technology could dramatically reduce cost per farmer reached and bring greater economies of scale. With demo plots, the main cost is CF training. These costs increase broadly in line with the number of farmers reached. With mobile technology, on the other hand, regardless of whether 1,000 or 100,000 farmers are reached, some of the costs (e.g. creating the training modules and maintaining the software) remain largely the same. This means, as the number of users increase, the total cost per person will fall. This implies that, with the same resources, delivering training with ICT could allow reaching 3-5 times as many farmers compared to using demo plots. The project aims at adding modules such as marketing and value addition, farming as a business, conservation agriculture and integrated pest management on the mobile demonstration plot. On top of that, the project will improve power source (now 6 km walk),connectivity (mobile internet) and establishing a functional reward system for the contact farmers such as linking the provision of education to aggregation of sales as a business opportunity; subscription in order to make the mobile demonstration plot in a business model way for the sustainability purpose.

However, the mobile demonstration plot model does face some challenges such as local logistics (energy, connectivity, transport, etc.), success dependent on commitment of individual contact farmers, and that information delivered needs to meet actual demand of users (Survey, 2015).

4.2.5 On-farm demonstration plots

On-farm demonstration plots are potentially powerful as a communication tool. In the adoption and diffusion of any new innovation within agriculture, some farmers have to take the lead and show others that the innovation is profitable. By subsidizing inputs or providing technical assistance, field trials can potentially encourage some farmers to become early adopters. Other farmers can then observe and learn from those participating in the field trials (Abler, 2002).

The on-farm demonstration plot model was used in the implementation of Sesame production and Marketing Project in Tanzania. The project was implemented by FARM-Africa from 2009 to 2012 in Babati district. This two-year project launched in December 2009 and worked with 46 farmer groups (920 farmers) and government officers in 23 villages in the district.

Farmers were selected based on farmer's interest, readiness to participate in the demonstration plot and lead farmer (accepted in the community and who have access to other farmers. The project trained about 920 farmers in planning, financial management skills, leadership and communications. Moreover, the project provided technical training on contour farming, soil conservation, controlling pests and diseases, post-harvest storage and capacity building of farmer groups to link markets, trader and buyers. The project also supported the 920 group members to disseminate their new skills to 5 non-group members, therefore bringing the benefits to a further 4,600 farmers.

On the trials, the varieties of high-yield sesame seeds (for which yields were expected to increase from 0.5 tons to 1.2 tons per hectare) were established in the 46 demonstration plots. The group members trained on the collectively warehouse storage systems, accessing up to date market prices and negotiation skills, so that they receive a fair price for their produce from traders and brokers.

Currently, farmers do store their sesame at the warehouse until market prices are favorable. The groups were also linked to micro finance institutions so that they can access agricultural credit. The project has managed to link farmers to different buyers such as Mohamed Enterprises who visit the co-op warehouse to negotiate. The company buys sesame in bulk and exports it as far as India and China. According to the Farm Africa project coordinator, group members are now earning more for their produce. For example before the co-operative was formed, traders used to pay farmers 25,000 Tanzanian shillings for an 85 kg bag. But the higher quality of the produce and the bargaining power of the co-operative have driven the price up to 153,000 Tanzanian shillings (Farm international radio, 2014). “Now we have better houses, education for our children, and can afford to eat three meals a day”(Mrs. Gobi, chairperson for one of the groups). The cooperative model, however, has not been replicated in other divisions of the district.

4.2.6 Coupon agro-input

Farmers were sensitized during a field day and randomly selected by the use of papers showing yes/no. Those with yes “won”, so they were naturally selected. Africa RISING provided those with planting materials and fertilizer (*Minjingu mazao/chenga*).In Babati, two of the selected technologies were randomly assigned to a larger number of farmers using the coupon approach. The purpose was to evaluate the impact of the technologies on livelihoods and to identify the adoptive and adaptive capacity by farmers with different resource endowments. The improved maize seed plus *Minjingu* phosphate rock (MPR) technology package was extended to 240 farmers across different agro-ecologies in the district, while a new climbing bean variety was extended to 50 farmers in the highland village of Long where it is most suitable to grow.

Out of the 240 farmers who won the maize-*minjingu* phosphate rock technology coupons, only 170 followed this up with implementing the trials. The rest planted seed alone, still hesitating in using fertilizer for fear of “spoiling the soil”. Of the 50 coupon farmers for climbing beans, only 9 implemented the technology because seed was delivered late. Farmers are keeping the seed. They pledged to conduct the trial in the upcoming season (Nov-Dec 2014–Jan 2015).Michael (2013) reported that real liquidity and other constraints blocked the use of the inputs (improved seeds and fertilizer) by small-scale farmers but the uptake and use of the voucher coupons was surprisingly low, well below 50 percent. These findings would imply that there was existence of additional constraints that must be addressed if higher uptake rates are to be obtained even in the short run (Michael, 2013).

4.3 Effectiveness of the participatory research approaches (PRAs)

In this study two evaluation criteria for assessing effectiveness were employed. These criteria are in terms of number of farmer the approach can actually reach against the targeted number and number of adopters from the farmers reached. Therefore, six participatory research approaches namely mother-baby trial, farmer research groups, farmer field schools, on-farm demonstration plots, mobile demonstration plot and coupon agro-input were evaluated. The approaches were evaluated in aspects of the ability to reach farmers and farmers who become adopters out of those who were reached.

4.3.1Measuring effectiveness of PRAs in reaching the number of targeted farmers

Effectiveness refers to the ability of a participatory research approach to reach greatest number of farmers as per target and within a given budget. The study used *ch*i-square to determine the overall effectiveness of the participatory research approaches under the study in reaching their targeted farmers. Moreover descriptive statistics were also employed to determine the effectiveness of each and every participatory research approach.

The *chi*-square results show that the participatory research approaches were significantly different in their effectiveness in reaching their targeted number of farmers at 0.05 level of significance. This implies that the approaches did differ in term of the effectiveness in reaching the targeted number of farmers. This might have been contributed by the fact that the PRAs had different budget and different methods were used to reach their targeted number of farmers. For example, mobile demonstration plots approach used paraprofessional farmers to train other farmers who did not get the chance to participate. In addition, the paraprofessionals were given an incentive of one USD per farmer trained. On the other hand, the coupon agro-input approach used the lottery procedures in which farmers were sensitized during a field day and randomly selected by the use of papers showing yes/no. Those with yes “won”, so they were naturally selected hence reached. For the case of on-farm demonstration plots and farmer research group approaches, it was a requirement for the participants to train other five farmers who did participate in the approaches.

Table 4: *Chi*-square results of the effectiveness of PRAs

PRAs	Expected	Observed	$(O-E)^2$	$(O-E)^2/E$
Farmer field schools	1680	503	1,385,329	824.600
Mother-baby trial	3037	1715	1,747,684	575.460
Farmer research group	2916	2808	11,664	4.000
Mobile demo plots	500	499	1	0.002
On farm demos plots	5520	2232	10,810,944	195.500
Coupon agro-inputs	290	170	14,400	49.650
Total	13,943	7,927	13,970,022	3412.210**

**Significance at 5%

Source: Field survey March, 2015

In this study, a research approach is said to be effective if it has managed to reach at least 50 percent of its targeted farmers. Results in Table 4 show that farmer field schools reached about 29.9 percent of its targeted farmers therefore the approach has not been effective. This might be attributed by the fact that, the project design and implementation, there was no incentive for the farmer-farmer trainers to task themselves towards reaching a larger section of farmers. This implies that, there was a higher dependence of extension officers who were working as group facilitators who could not make the needed impact. On-farm demonstration approach reached about 40.43 percent of its targeted number of farmers. On the other hand the farmer research groups reached about 96.6 percent of its targeted farmers. The approach managed to reach many of its targeted farmers because the participating farmers were told to spread the gained training to more than five farmers who did not get an opportunity to directly participate in the groups. The mother-baby trial approach reached about 56.47 percent of the number of farmers the approach targeted to reach while mobile demonstration plots managed to reach 99.8 percent. The mobile demonstration plots managed to reach almost all its targeted farmers because; the approach used the contact farmers to disseminate the technology to their fellow farmers so it was very easy for them to reach each and every farmer in the village.

On top of that the contact farmers (trainers) were given an incentive of 1 USD per farmer reached so this was the very motivating factor for the CFs to reach as many farmers so that they earned more. As the name of the approach implies, the tablets were used by the CFs to train other farmers as opposed to normal demonstration plots. This made the CFs to enjoy training their fellows and made them very flexible to conduct training anywhere as there was no requirement for them to take the trainee to the field. Coupon agro-input reached about 58.62 percent of its targeted farmers. This is because other farmers failed to redeem their vouchers hence they failed to get the seeds and fertilizer.

Generally the results indicate that farmer research groups, mother baby trials, mobile demonstration plots and coupon agro-input were effective in reaching the number of farmers they did target whereas farmer field schools and on farm demonstration plots were not. Other studies indicated that farmer field schools had reached 2.2 percent of the households in the study site, whereas the media campaign had reached 97 percent (Harris, 2011).Farm Africa (2015) reported that mobile demonstration plots method estimated to reach farmers at less than a quarter of the cost per head of demo plot approach. This implies that, with the same resources the approach could reach at least 4 times as many farmers.

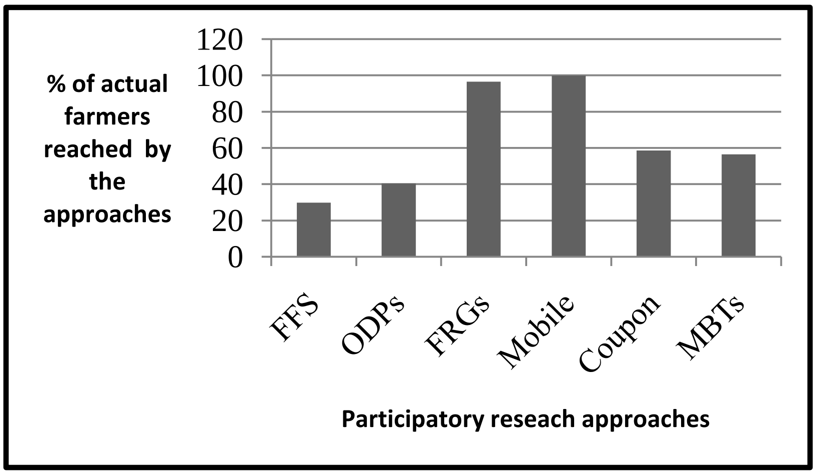

Figure 3: Actual number of farmers reached per participatory research approach

Source: Field survey March, 2015

4.3.2 Measuring number of adopters of integrated agricultural technologies

The *chi*-square results (Table 5) show that the participatory research approaches were significantly different in the effectiveness at 0.05levelin making the farmers reached to become adopters. This implies that, some of the participatory research approaches were effective in making the reached farmers to become adopters of the AIIs while others were not. The difference in PRAs in making the reached farmers adopters of AIIs might be resulted from the fact that each and every approach used different model of delivering materials and promoting the adoption process. For example coupon agro-inputs approach, participants were offered with the improved seeds, local inorganic fertilizer (*Minjingu Mazao*), or both to test and evaluate the performance of the same in their fields. Therefore, this might be a motivating factor for the participants and neighboring farmers to adopt.

For the case of mother-baby trial approach, as the name implies the design consists of two types of trials. The “mother” trial is replicated within-site to test a range of technologies and research hypotheses under researcher management is which the trial was located on on-farm at a central location in the village. The baby trial comprises a number of satellite trials of large plots under farmer management and farm resources. Each trial compares one to four technologies (usually a subset of those tested in the mother trial chosen by the farmer or researcher) with farmers’ technologies. Researchers indicate the recommended management for each technology, then monitor actual farmer practice and document farmer perceptions and ranking. In this approach, researchers test complex questions such as variety response to inputs at the central mother trial, while farmers gain experience with the subset of technologies. This might have an impact on adoption rate of the promoted technologies since farmers themselves fully participated in activities therefore they had a chance of observing and evaluating the performance of the same.

In farmer research groups approach, used the self-selection procedure in which farmers themselves identified the problems to be addressed, rather than the project and farmer research groups were formed through a process of village selection rather than by the project with the local extension officer. In addition, groups formation was based on the identification of typically 12 members (six men and six women, although in practice it was not the case. In addition, other criteria such as ensuring representation of sub-villages (usually three to four per village), gender balance and identification of research minded farmers able to share results with others. So these procedures might have contributed the approach to motivate more reached farmers to become adopters of AIIs.

Table 5:*Chi*-square results of the effectiveness of PRAs in terms of number of adopters

PRAs	Expected	Observed	$(O-E)^2$	$(O-E)^2/E$
Farmer field schools	503	133	136900	824.60
Mother-baby trials	1715	247	2155024	1256.57
Farmer research groups	2808	1685	1261129	449.12
Mobile demo plots	499	48	203401	407.61
On farm demo plots	2232	1000	1517824	680.02
Coupon agro-inputs	170	170	0	0
Total	7927	3036	3119254	2361.35 **

****** Significance at 5%

Source: Field survey March, 2015

The results (Table 6) show that 60 percent of the farmers reached by the farmer research groups became adopters of the technology promoted through it, especially the improved maize seeds. For the mobile-demonstration plot only 9.16 percent of farmer reached adopted the technologies such as land preparations, planting, use of improved varieties and plant care. This might result from the fact that this data was only obtained by interviewing only 50 farmers out the 499 farmers.

In addition to that, Farm Africa (2015) indicated that 96 per cent of farmers interviewed, introduced changes such as land preparation, use of improved sesame varieties in their farms. About 26.44 per cent of the farmers reached by the farmer field schools approach adopted the conservation agricultural technologies. This is because of the high cost and inaccessibility of the conservation agriculture implements. The most widely adopted conservation technology by farmers was intercropping. This is because of the advantages intercropping has which were clearly outlined by farmers perceptions such as food security insurance, risk coping strategy, provision of livestock feed and for adequate soil cover needed as a prerequisite condition for conservation agriculture (FAO,2012). About 44.8 percent of farmers who were reached through on-farm demonstration plot became adopters of the promoted technologies. This implies that the approach had not been effective in making the reached farmers to become adopters of the promoted technologies.

On the other hand all farmers who were reached through the coupon agro-input became adopters of the maize seed and beans. This is because the approach provided farmers with the inputs so farmers had the incentive to try the given seeds. The farmers did not however use the fertilizer (*Minjingu* rock) provided by Africa RISING because farmers claimed that the use of fertilizers would spoil the soil. Generally the results showed that coupon agro-inputs and farmer research groups were effective in making the farmers reached to become adopters.

Table 6: PRAs by number of targeted farmers, actual number of farmers reached, number of adopters and % of adopter

Participatory research approach	Targeted Farmers	Actual farmers reached	Farmers adapted/adopted	% of adopters
Farmer field schools	1680	503	133	26.44
On farm demo plots	5520	2232	1000	44.80
Farmers research groups	2916	2808	1685	60.00
Mobile demo plot	500	499	48	9.61
Coupon agro-inputs	290	240	170	58.62
Mother-baby trials	3037	1715	247	14.40

Source: Field survey March, 2015

4.4 Efficiency of the participatory research approaches (PRAs)

The study determined the efficiency of participatory research approaches by making cost comparison of the approaches under study and undertaking the data envelopment analysis. For the cost comparison, the study compared total costs, cost per farmer reached and adopter among the PRAs.

4.4.1Total costs comparison of PRAs

The costs criteria that were evaluated in this study were the costs to the institutions that administered the training to farmers who participated in the PRAs activities. Many costs are incurred when the participatory research approaches are conducted. Incorporating the different costs into the analysis helps determine the accurate expense of running the PRAs.

Accurate measuring the cost of running PRAs requires recognizing the fixed and variable costs along with the average costs of these programs. Fixed costs are incurred by the institutions that run the various training programs and do not increase when additional training is held or when more farmers participate in the training. Variable costs are the costs that increase when more training programs are held or when more farmers attend. The average cost of each method is the total cost of administering the training method divided by the number of farmers who participate in the training. Each of these types of cost provides a different aspect in the true cost of running the PRAs. The fixed costs for the PRAs include administering the national level program such as paying consultants and administrators' salaries and conducting research on the PRAs. Materials, food, and renting locations in the villages for the training were some of the variable costs associated with PRAs.

Results in Table 7 show that the total cost of running the farmer field schools was 50,185 USD, farmer research groups was 59,962.41 USD, coupon agro-inputs was 18,000 USD, mother-baby trials approach was 37,761.50 USD, on-farm demonstrations approach was 98,532.40 and mobile demonstration plots approach was 18,163 USD. From these results it can be seen that the on-farm demonstration plots had spent the highest (98,532.40 USD)amount of money, followed by farmer research groups which used (59,962.41USD) and farmer field schools used USD 50,185. In addition mother-baby trials and mobile demonstration plots used 37,761.50 USD and 18,163 USD respectively while the coupon agro-inputs used 18,000 USD.

Maina *et al*. (2011) revealed that Kenya Tea Development Authority factories spent an average of USD 2,145 to run participatory research approaches specifically the FFS per year in Kenya. The cost is low compared to this study, this is because they did not include other costs such as cost of hiring venues. However in the FFS members' opinion, this amount was inadequate and should be increased. They proposed an FFS budget of 2726.42 USD per year. Ricker-Gilbert (2008) indicated that costs of running the participatory research approaches were USD 45,742, USD 4,606 and USD 7,194 for farmer field schools, electronics media and field days respectively.

Table 7: Total costs (USD) comparison among PRAs

Participatory research approach	Total costs USD
Farmer field schools	50,185.00
Farmer research groups	59,962.41
Coupon agro-inputs	18,000.00
Mother-baby trials	37,761.50
On farm demonstration plots	98,532.40
Mobile demonstration plots	18,163.00

Source: Field survey March, 2015

Costs of running participatory research approach per farmer reached

The results given in Table 8 show the cost of running the PRAs per farmer reached. The findings reveled that average costs per farmer reached was 47.62 USD. Further, it was found that the cost per farmer reached were 44.14 USD for on-farm demonstrations, 99.77 USD for farmer field schools, 62.06 USD for coupon agro-inputs, 21.35 USD for farmer research groups, 22.01 USD for mother- baby trials and 36.39 USD for mobile demonstration plots. From these findings, it can be seen that the farmer field schools had the highest (USD 99.77) cost per farmer reached while the farmer research group approach had the lowest (21.35 USD) cost per farmer reached. The higher (99.77 USD) cost per farmer reached of the FFS approach might be caused by the fact that, the approach was promoting conservation agriculture which required whether to hire or buy the conservation agriculture implements which were expensive. As a result huge amount of money was spent in running the FFS and few number of farmers were reached hence high cost per adopter as compared to other PRAs whose cost per farmer reached were 44.14 USD for on-farm demonstrations, 62.06 USD for coupon agro-inputs, 21.35 USD for farmer research groups, 22.01 USD for mother- baby trials and 36.39 USD for mobile demonstration.

Studies conducted around the world found that the average cost of the farmer field schools program is very high. Quizon *et al.* (2004) found that the average cost of an FFS in the Philippines is USD 47.60 and USD 62.00 Indonesia for the integrated pest management. Other studies indicated that training a farmer in a tea-based FFS in a year USD71.00 per farmer (Maina *et al*., 2012). Another study by Maytak (2013) reported that the cost of FFS per farmer was USD 52.00 based on the assumption that the average number of farmers in each FFS is 30. In their cost-benefit analysis only cost items of FFS were included while items like the venue hire, fertilizer among others were not taken into account. Farm Africa (2015) indicated that mobile demonstration plots could dramatically reduce the cost per farmer reached. Further the results reported that with mobile demonstration plots, regardless of whether the approach reaches 1,000 or 100,000 farmers, some of the costs such as creating modules, maintaining software remain the same. This implies that as number of users increase, economies of scale would be realized.

Table 8: Average costs of running PRAs per farmer

Participatory research approach	Costs per farmer reached (USD)
Farmer field schools	99.77
Farmer research group	21.35
On farm demonstrations	44.14
Mother baby trial	22.01
Mobile demonstration plots	36.39
Coupon agro-input	62.06
Average	47.62

Source: Field survey March, 2015

Costs of running participatory research approach per adopter

Table 9 shows the cost of running a participatory research approach per farmers who became adopters out of those who were reached by the approach. The results revealed that, the average cost per adopter was 191.44 USD per year. Further, the results show that mobile demonstration plots had the highest cost per adopter (378.40 USD) followed by the farmer field schools whose cost per adopter was 377.33 USD. The cost per adopter of the mother-baby trials approach was 152.88 USD, for coupon agro-inputs was 105.88 USD while that of farmer research group was 35.59 USD. From these findings, it can be observed that, mobile demonstration plots had the highest cost per adopter. This is because the approach was under the pilot and it was tasted for only four months that is why even the number of adopters for the promoted technologies were only 48 of the targeted farmers out of those who were reached compared to the total costs hence high cost per adopter. For the case of farmer field schools, the cost per adopter was 377.33 USD per year.

In this case, the high cost per adopter might have been caused by the fact that, the approach was promoting conservation agriculture which required the prospective adopters to hire or buythe conservation agriculture implements which were expensive. As a result huge amount of money was spent in running the FFS and few farmers became adopters hence high cost per adopter. In addition, the approach had higher dependence of extension officers as group facilitators who had the responsibility of training farmers. Since extension officers were few for the whole district then they could not make the needed impact as compared to the expenditure hence high cost per adopter. On the other hand farmer research groups had the lowest (35.59 USD) cost per adopter among the PRAs. This is because the approach had the highest number of adopters which translate into low cost per adopter. This might be attributed by the fact that the farmer-farmer trainers were effectively tasked towards reaching a larger section of farmers and making them adopters of the AIIs hence low cost per farmer.

Harris (2011) reported that, the costs of running PRAs per adopter were 16.49 USD for paper media, 0.66 USD for electronic media, 1.09 USD for field days, 14.21 USD for agent visit and 11.33 USD for farmer field schools. These costs per adopter are very low compared to the cost per adopter obtained in this study. The low cost per adopter in Harris's study might have been as a result of the approaches used to reach a large number of farmers in order to become adopters of IPM. For example farmer field schools had 4039 adopters, agent visits had 68,296 adopters, field days had 6,629 adopters and electronics media had 6,927adopters while paper media had 292 adopters.

Table 9: Costs of participatory research approach per adopter

Participatory research approach	Cost (USD)
On-farm demonstration plots	98.53
Farmer field schools	377.33
Coupon agro-inputs	105.88
Farmer research groups	35.59
Mother-baby trials	152.88
Mobile demonstration plot	378.40
Average	191.4

Source: Field survey March, 2015

4.4.3 Efficiency of PRAs

In the Data Envelopment Analysis model, the study assumed personnel, land preparation, labour, allowance for researcher/extension officer, equipment and supplies, training and assets as inputs with the outputs as number of farmers the approach reached and farmers who become adopter as given in Table 10. This assumption on outputs is consistent with the study conducted by Murage *et al*. (2012) in western Kenya.

Table 10: Inputs and outputs for the PRAs

Inputs	**Outputs**
Personnel	Number of farmers reached
Land preparation	Number of farmers become adopters
Labour	
Transport	
Researcher/extension officers' allowance	
Equipment and supplies	
Training	
Assets	

Source: Field survey March, 2015

Table 11reports the results of DEA model applied to these six PRAs. Two DEA models were estimated using the assumption of variable returns to scale (VRS): Model one considered the number of farmers trained per participatory research approach as the output, while model two considered the proportion of adopters as the output. The findings revealed that the mean technical efficiency for six PRAs was 0.64 and 0.53 in VRS model for the first and second scenarios respectively.

The results further showed that in the first scenario, farmer research groups approach had the highest efficiency (72 percent), followed by mother-baby trials whose efficiency was 71 percent. In addition on-farm demonstration plots had efficiency of 67 percent, mobile demonstration plots had 63 percent efficiency while the efficiency of farmer field schools and coupon agro-inputs was 57 percent and 58 percent respectively. In the second scenario, the farmer research groups approach led with an efficiency score of 68 percent, followed by on-farm demonstration plots with the efficiency of 60 percent. Coupon agro-inputs and mother-baby trials had the efficiency of 52 percent while the efficiency of farmer field schools mobile demonstration plots was 45 percent and 39 percent respectively. From these findings, it can be seen that all the participatory research approaches were below the efficiency score of 1 which implies that the PRAs were inefficient in both reaching their targeted number of farmers and making them to become adopters of the agricultural integrated innovations in the study area. This implies that there is still a room for the NGOs and institutions running these PRAs to increase both the number of farmers trained and the adopters of the AIIs for each participatory research approach using the current levels of resources. This suggests that adjusting the scale of operation would probably improve the overall efficiency of the pathways in disseminating the push-pull technology in the study area.

These results are in line with Murage *et al*. (2012) who reported that with respect to the number of farmers reached, field days (FD) had the highest efficiency score (90 percent), followed by FFS whose efficiency was slightly above 60 per cent and finally FT with efficiency of 40 per cent. In the second scenario, field teachers (FT) had the efficiency score of 70 per cent, followed by FD, 58 per cent and finally FFS, 52 per cent. In their study, they generally concluded that, the pathways were operating below the efficient scale. In addition Khan *et al*. (2009) reported that the average technical efficiency by farmer teachers (FTs) approach was 78 percent while that of farmer to farmer extension was 71 percent. Their findings suggest that farmers operated below the frontier output levels. Further, Ogunniyi (2012) reported that, the maize farmers were not technically efficient. This is because the farmers operating in their farm with the mean efficiency of 56.9 percent and 64.9 percent under CRS and VRS specification, respectively. This indicates that there was 43.1 percent and 35.1 percent allowance for improving efficiency for the maize farmers.

Table 11: DEA Efficiency Scores of Participatory research approaches

Participatory research approaches	Efficiency scores	Efficiency scores
On-farm demonstration plots	0.67	0.60
Farmer field schools	0.57	0.45
Coupon agro-inputs	0.58	0.52
Farmer research groups	0.72	0.68
Mother-baby trials	0.71	0.52
Mobile demonstration plots	0.63	0.39
Average	0.64	0.53

Source: Field survey March, 2015

4.5 Incentives / dis-incentives to farmers' participation in the PRAs

The results about inventive/dis-incentives that determine farmers' participation in the popular participatory research approaches came from the semi-structured interview and focus group discussion with farmers involved in the participatory approaches. In this study, incentives are usually related to the benefits farmers expected to get by participating in the approaches while dis-incentives refer to the factors such as time farmers would have to devote during the course of implementation of the research approaches.

4.5.1 Incentives to farmers' participation in PRAs

The results in Table11 below provide details on the various incentives that make maize-legume smallholder farmers to be involved in the participatory research approaches. About 51.6 percent of the sampled households participated in the PRAs activities because they wanted to get training on improved agricultural technologies, some participated because they wanted to improve yield, income and getting connected to other farmers (36 percent) while others wanted to test whether the promoted improved technologies are profitable (7.5 percent), others were just appointed by fellow farmers/NGOs/extension officer(4.1percent)while0.8 percent wanted to know how a tablet works. These results concur with those from the focus group discussion where by most farmers said they did participate because they wanted to access the technology, others said they wanted to test the promoted agricultural integrated technologies and see if it would add value to their income. Some farmers said they participated because they got seed and fertilizer through lottery process from Africa RISING. From these results, it can be seen that most farmers (52 percent) participated PRAs' activities because they wanted to get training on improved agricultural technologies. This indicates that accessing new knowledge and skills on agriculture was an important factor that motivated participants to invest time in PRAs.

Several studies, such as Zuger (2004), Godtland *et al*. (2004) and Davis *et al*. (2010) are in agreement with these results and indicate that farmers get involved in PRAs for the purpose of accessing information and knowledge, which can later be applied to improve productivity and profitability. In addition, the participating farmers considered the importance of enhancing human capital that is why they saw it as a paramount for them to get trained on improved agricultural technologies including the integrated agricultural innovations. In other words, there cannot be sustainable outcomes if human capital is not enhanced as a first step, which is critical because 'sustainable intensification agriculture is knowledge intensive . . .' (Butler-Flora, 2010).

It was further found that, social networking with other farmers was also a motive for 6 percent of the participating in the PRAs' activities. This implies that, connecting to other farmers was another important incentive for farmers since it was easy for them to strengthen their own organization, group or collective action. Ortiz *et al*. (2011) pointed out that, farmers in Uganda valued empowerment and group action of the participants as one of the most important contributions they gained for them being the PRAs members. Having stronger social capital, leading to improved collective action and networking has been pointed out as a key factor that enhances the possibility of sustainable outcomes from interventions (Spielman *et al*., 2009;

Butler- Flora, 2010; Neef and Neubert, 2011). The results also indicate that 19 and 18 percent of the PRAs' participants had a motive of improving their yield and income through engaging in the PRAS' activities respectively. This is very true because through the PRAS' activities farmers could be able to gain improved agricultural technologies such as the use of improved fertilizer, fodder production improved seeds which will have an impact on improving productivity hence improve yield and their farm income in general. In addition, other participating farmers engaged in the PRAs' activities because they were just appointed by the fellow farmers/NGOs/ extension officer, wanted to test the profitability of the promoted technologies and knowing to operate the tablets that were used to disseminate the technology.

Table 12: Incentives for farmers' participation in the PRAs (n=120)

Incentives	Frequency	Percent
Getting training on improved agricultural technologies	62	51.6
Improve yield	19	16.0
Improve income	18	15.0
Social networking	6	5.0
Testing whether the promoted technologies are profitable	7	7.5
Just appointed by fellow farmers/ NGOs/extension officer	5	4.1
Knowing how tablet works	1	0.8
Total	**120**	**100**

Source: Field survey March, 2015

4.5.2 Dis-incentives to farmers' participation in PRAs

The dis-incentives here refer to factors that make farmers not to participate in the participatory research approaches. These data was captured during the focus group discussion with farmers who were involved in these approaches. The results revealed that most farmers said the very factor that would make them not to involve or to discontinue participating in the participatory research approaches too much time taken during the training session. On the other hand, other farmers said nothing would make them to stop from participating in the PRAs' activities. This implies that farmers do value their time, so they do prefer participating to the PRAs which would not take too much (the whole day of training) of their scarce time. In addition, time is very limiting factor especially to the female PRAs' participants in which most time they are time constrained when it comes to agricultural training which demands them to get out of their home to attend. This is because women are also involved in other obligations such as children care, looking for firewood which limits them to fully participate in the PRAs such as mother-baby trials, on-farm demonstration plots, farmer field schools and farmer research groups which demand them to take physically be present.

Other studies have mentioned time taken during the training, being a factor that might make farmers not fully participate in the trainings. For example Ortiz *et al*. (2011) reported that, if the technology being promoted/ training is time consuming in such a way that it hinders farmers from doing other income generating activities, then it would be wise not to participate. Ortiz *et al*. (2011) also highlighted that farmers investing their scarce time in PRAs was a disincentive and depended on the potential benefits from PRAs compared to those provided by other research organization and by other productive activities. Moreover, Neef and Neubert (2011) also highlighted the importance of time availability of local stakeholders who are involved in the participatory research approaches which they argued should be addressed carefully to balance inclusiveness, investment and the sustainability of potential benefits.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The aim of this study was to evaluate the efficiency and effectiveness of participatory research approaches among small holder farmers in Babati district. The specific objectives of the study were to compare social economic characteristics of participating farmers in the PRAs' activities, determine characteristics, technical efficiency and effectiveness of the participatory research approaches and the incentives/dis-incentive to farmers' participation in the PRAs' activities. Descriptive statistics were used to characterize the Participatory research approaches under the study. *Ch*i-square and F-test were used in the socio-economic characteristics of the participating farmers in the PRAs. To determine technical efficiency of the PRAs, the Data Envelopment Analysis model was used. The content analysis was used to determine the incentives to farmers to participate in PRAs' activities.

5.2 Conclusions

From the findings in this study, it can be concluded that, ender of household head, marital status, education level, farm size, income status and age of the household head significantly differed among the small holder farmers participating in the popular participatory research approaches while family size, credit access, group membership, extension services and livestock ownership were not.

The results revealed significant differences among the participatory research approaches in effectiveness in regard to the number of farmers reached and those who became adopters. Further, it was found that, the most effective PRA in terms of targeted farmers was mobile demonstration plots. The most effective PRA in terms of adopters was farmer research groups.

In terms of the efficiency of the PRAs, the most efficient amongst the PRAs studies in terms of both targeted farmers was farmer research groups however none of the PRAs had an efficiency level of 1.This indicates that resources devoted in implementation of the PRAs under the study were underutilized therefore there is still room for improvement in term of reaching the number of target farmers and making them to become adopters by using the current resources.

Further it was established that farmers participated in PRAs' activities with a motive of getting training on improved agricultural technologies, improve yield and household income and getting connected to other farmers in the study area. Most participant of PRAs mentioned that time spent in the PRAs' activities was the main dis-incentive for them to fully participate in the approaches.

5.3 Policy recommendations

This study has drawn attention to the information that can guide policy towards boosting adoption of integrated agricultural innovations through the use of participatory research approaches. The participatory research approaches play an important role in dissemination of agricultural technologies such as integrated innovations. Based on the findings of this study, the following recommendations can be made to policy-makers and program coordinators to improve the efficiency and effectiveness of PRAs in reaching farmers and making them to become adopters of the agricultural integrated innovations:

Farmer research groups approach was seen as both an effective and efficient model in reaching the target farmers and making them adopters of the agricultural integrated innovations. Therefore, Tanzania government, donors and other stakeholders should employ the model in transferring agricultural technologies. In addition, the model could be useful for starting collegial research to improve management of a target crop or problem developing key extension messages with farmers' involvement and understanding how to communicate these messages most appropriately. This could be followed up with use of mobile demonstration plots approach to disseminate key extension messages more widely since the model seems to reach many farmers at very short period of time and attract more youth in disseminating agricultural integrated innovations.

The approaches had very few female participants. This implies that the approaches involved more male than women yet women are the ones doing most of the farm operations. Therefore, the PRAs should be geared towards increasing the participation of more women so that to have more adoption rates of agricultural integrated innovations. This could be achieved through allowing extension work becoming more field based with mobile training unit who can go out to more remote area and provide door to door services so as to reach more female farmers. In addition, the time spent during the PRAs' activities per training should be reduced so that more female can be able to fully engaged in the activities.

5.4 Further research

The main aim of the study was to establish the efficiency and effectiveness of popular participatory research approaches in the study area. Thus to this end the study suggests further studies to assess the efficiency of participating farmers in the use of inputs as a results of their involvement in PRAs' activities.

7.0 REFERENCES

Abdullahi, N. and Abdullahi, I. (2012). Cowpea Marketing in Isa Local Government Area of Sokoto State, Nigeria, *Farm Manag* (Formerly FAMAN Journal), 13(1): 80

Abdoulaye, T., Amaza, P. S., Olanrewaju, A. S. and Ellis-Jones, J. (2012). Promoting adoption of innovations through participatory approaches: Example from northern Nigeria. *Tropicultura, 30 (3)* 155-160.

Adger, W.N. K., Faribrass, J. and Jordan, A. (2003). Governance for sustainability: towards a thick understanding of environmental decision making. *Environment and Planning*, 35(6): 1095-1110.

Aigner, D. J, Lovell, C. A. K, Schmidt P. (1977). Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics*; 6: 21-37.

Amudavi, D. M., Chianu, J. and Khan, Z. R. (2012). The Effectiveness of Dissemination Pathways on Adoption of "Push-Pull" Technology in Western Kenya. *Quarterly Journal of International Agriculture*, 1: 51-71.

Ango, A.K., Illo, A.I and Abdullahi, A.N. (2013). Role of Farm Radio Agricultural Programmes in Disseminating Agricultural Technology to Rural Famers for Agricultural Development in Zaria, Kaduna State, Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology*, 2(1), 54-68.

Ani, A.O., Ogunnika, O. and Ifah, S.S. (2004). Relationship between Socio-Economic Characteristics of Rural Women Farmers and Their Adoption of Farm Technologies in Southern Ebonyi State, Nigeria. *International Journal of Agriculture & Biology*, 6(5), 802-805.

Ashby, J. A. (1990). *Evaluating the technologies with farmers, a handbook*. CIAT Publication No. 187 Cali, Colombia: Centro Internacional de Agricultural Tropical (CIAT): 95.

Battese, G.E., Rao, D.S.P. and O'Donnell, C.J. (2004). A meta-frontier Production Function for Estimation of Technical Efficiencies and Technology Gaps for Firms Operating under Different Technologies. *Journal of Productivity Analysis*, 21(1):91-103.

Bello, M., Salau, E.S. and Ezra, L. (2012). Analysis of factors influencing continuance of technology adoption: The situation with some Nigerian farmers. *Journal of Sustainable Agricultural, Resource*, 1: 292-300.

Bellon, M.R. and Reeves, J. (2002). *Quantitative Analysis of Data from Participatory Methods in Plant Breedin*g. Mexico, DF: CIMMYT.

Biggs, S. (1990). A multiple source of innovation model of agricultural research and technology promotion. *World Development*, 18(11): 1481–1499.

Biggs, S. D. (1989). *Resource-poor farmer participation in research: A synthesis of experiences from nine national agricultural research systems.* The Hague: International Service for National Agricultural Research.

Braun, A.R., Thiele, G. and Fernandez, M. (2000). Farmer Field Schools and local agricultural research committees: complementary platform for integrated decision-making in sustainable agriculture. Agricultural Research and Extension Network paper 105.

Cater, M. R., Laajaj, R., and Dean, Y. D. (2013). The Impact of Voucher Coupons on the Uptake of Fertilizer and Improved Seeds: Evidence from a Randomized Trial in Mozambique: Forthcoming, *American Journal of Agricultural Economics*, 95(5): 1345-1351.

Campbell, B. (2003). Assessing the Performance of Natural Resource Systems: *Integrated Natural Resource Management (CABI Publishing, Oxford, UK)*:267–292.

Charnes, A., Cooper, W.W., Lewin, A.Y., Seiford, L.M. (1995). *Data Envelopment Analysis, Theory, Methodology and Application,* Kluwern Academic Publishers London.

Charnes, A., Cooper, W. and Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 120: 429–444.

Chavula, H. (2013). The role of ICTs in agricultural production in Africa. *Journal of Development and Agricultural Economics*, 6(7):279-289.

Conroy, C. and Sutherland, A. (2004). Participatory technology development with poor farmers: Maximizing impact through the use of recommendation domains. *Agricultural research and extension network* paper No.133.

Djokoto, J.G. (2012). Technical Efficiency of Agriculture in Ghana: A Time Series Stochastic Frontier Estimation Approach. *Journal of Agricultural Science*, 4(1): 154-163.

Doss, C. R. and Morris, M. L. (2001). "How Does Gender Affect the Adoption of Agricultural Innovations? The Case of Improved Maize Technology in Ghana. *Agricultural Economics*, 25: 27-39.

Farm-Africa. (2015). Testing the use of Mobile Technology to Improve Smallholder Sesame cultivation in Tanzania, Working paper.

Farrell, M.J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society* 120: 253–281.

Friis, H.E., and Sthapit, B. (2000*). Participatory approaches to the conservation and use of plant Genetics Resource*. International Plant Genetics Resource Institute: Rome.

Gabriel, J., Torrez, R. and Thiele, G. (1990). Participatory approaches in potato improvement. Experience from Bolivia. *Selection Methods*: 194-199.

Garcia-Torres L., Benites J., Martinez-Vilela, A. and Holgado-Cabrera, A. (2003). Preface *In*: Conservation Agriculture – Environment, Farmers Experiences, Innovations, Socio-economy, Policy. Kluwer Academic Publishers. Netherlands

Girei, A.A., Dire, B., Iliya, M.M. and Salihu, M. (2013). Stochastic Frontier Production Function on the Resource use Efficiency of Fadama II Crop Farmers in Adamawa State, Nigeria. *European Journal of Agricultural and Forestry Research*, .2:1-15.

Gonsalves, J., Braun, A. and Campilan, D. (2005). *Participatory Research and Development for Sustainable Agriculture and Natural Resource Management*: A source book, IDRC, Ottawa.

Haider, M.Z., Ahmed, S. and Mallick, A. (2011). Technical Efficiency of Agricultural Farms in Khulna, Bangladesh: Stochastic Frontier Approach. *International Journal of Economics and Finance*,3:3.

Hailu, D. (2007). Experiences of a JICA research project in Ethiopia: Enhancing technology development and dissemination through Farmers Research Group Laboratory of Animal Genetics and Breeding. A PhD dissertation submitted to Tokyo University of Agriculture.

Heidari, M. D., Omid, M. and Akram, A. (2011). Using non-parametric analysis (DEA) for measuring technical efficiency in poultry farms. *Brazilian Journal of Poultry Science* 3(4): 271-277.

Harris, L.M. (2011). Modeling a Cost-Effective IPM Dissemination Strategy for Vegetables and Rice: An Example in South Asia. Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of Masters in Science in Agricultural and Applied economics.

IICD. (2013). Youth, ICTs and Agriculture: Exploring how digital tools and skills influence the motivation of young farmers in Eldoret, Kenya. A Research Report on the ICT for Development. Retrieved fromhttp://www.iicd.org/about/publications/the-iicd-approach-from-need-tosustainability (2015-07-200

Ismail, M.M, Idris, N. and Hassanpour, B. (2013). Technical efficiency estimates of paddy farming in peninsular Malaysia: A comparative analysis. *Annals of Biological Research,*4(5):114-118.

Itam, K.O., Etuk, E.A., and Ukpong, I.G. (2014). Analysis of resource use efficiency among small scale fish farms in Cross River State, Nigeria. *International Journal of Fishiries and Aquaculture*, 6(7):80-86.

Jamsari, H. Jasmine, A. M. and Norhamidah, J. (2012). Factors associated with the continuality of agricultural innovation adoption in Sabah, Malaysia. *Journal of Sustainable Development*, 5: 47-54.

Kasterine, A. and Vanzetti, D. (2005). Effectiveness, Efficiency and Equity of Market-based and Voluntary Measures to Mitigate Greenhouse Gas Emissions from the Agri-food Sector. Trade and Environment Review: Geneva.

Kelly, E. Shalloo, L. and Gearyl, U. (2012). Application of data envelopment analysis to measure technical efficiency on a sample of Irish dairy farms*; Irish Journal of Agricultural and Food Research*, 51:63–77.

Khan, Z.R., Midega, C.A.O. and Nyangau, I.M. (2009). Assessment of Technical Efficiency of Farmer Teacher in the Uptake and dissemination of Push-Pull Technology in Western Kenya. *Proceedings of the 25th Annual Meeting, Intercontinental San Juan Resort, Puert Rico*.

Kindie, G. and Charlotte, M. (2012). Integrated innovations and recommendation domains: paradigm for developing, scaling-out, and targeting rainwater management innovations. *Journal of Ecological Economics*, 76:34-41.

Krueger, R. A. and Casey, M. A.(2000).*Focus groups: A practical guide for applied research*. Thousand Oaks, CA: Sage.

Lin, J.Y. (1991). ‘Education and Innovations adoption: evidence from hybrid rice in China’ *American Journal of Agricultural Economics*, 73:713-723.

Lindberg, C. (1996). Society and Environment Eroded - a study of household poverty and natural resource use in two Tanzanian villages, Geografiska Regionstudier Nr.29, Kulturgeografiska instutitionen Uppsala universitet, Stockholm, Sweden.

Löfstrand, F. (2005). Conservation agriculture in Babati District, Tanzania, Impacts of conservation agriculture for small scale farmers and methods for increasing soil fertility, Master of Science thesis no. 45, Swedish University of Agricultural Science Department of Soil Science.

Maina, W. S., Mwangi, J. G., Boselie, D., Onduru, D. and Buses, B. C. (2012a). Up-scaling Farmer Field Schools and Rainforest Alliance certification among smallholder tea producers in Kenya: Options, opportunities and emerging lessons, PEC 2012; 43(43):141-158, ICID.

Maina, W.S., Buses, B. C., Mwangi, J. G., Boselie, D., Onduru, D. and Waarts, Y. (2012b). System Design and Scalability of Farmer Field Schools and Rainforest Alliance Certification of Smallholder Tea Producers East and West of Rift Valley – A Research Report on the Scalability of Sustainable Tea Value Chain project in Kenya.

Maina, S.W. and Mwangi, G. J. (2011). The effectiveness of agro-dealers in enhancing dissemination and adoption of the push pull technology among smallholder farmers in western Kenya. *Journal of problems of education in the 21st century*, 33:118.

Maina, S.M., Mwangi, J.G. and Boseline, D. (2012). Cost and benefits of running a tea based farmer field school in Kenya. *Journal of problems of education in the 21st Century*, 47:165.

Martin, A., Gross-Camp, N., Kebede, B. and McGuire, S. (2014). Measuring effectiveness, efficiency and equity in the Payments for Ecosystem Services trial in Norwich. *Journal of Global Environmental Change*, 28: 216–226.

Masuki, F. G. K., Khamaldin, D. M. and Siza, D. T. (2003). Smallholder System Innovations Programme, Soil-Water Management Research Group, *Sokoine University of Agriculture*, Retrieved from http://www.swmrg.suanet.ac.tz

Max, N. A. (2015). Effect of Farmers' socio-economics Toward Adoption Level of Agricultural Technology in Sigi Regency Indonesia. *Journal of Applied Sciences*, 15: 826-830.

Maytak, S., Boselie, D., Mbadi, P., Fraats, J. and Mitei, Z. (2013). Cost-Benefit Analysis of Farmer Field Schools and Certification for Smallholder Tea Farmers in Kenya .An IDH learning study executed in close collaboration with KTDA, Unilever and Rainforest Alliance IDH – The Sustainable Trade Initiative.

Meeusen, W. and Van Den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic* Review, 18: 435-444.

Meera, S. N., Jhamtani, A. and Rao, D.U.M. (2004). Information and communication technology in agricultural development: a comparative analysis of three projects from India. *Agricultural Research and Extension Network*, Paper No.135.

Melkassa, M. and Zerfu, E. (2004). Participatory research concept and practices, *Farmer Research Group*: Concept and Practices. Proceedings of workshop 20-21 October 2004: 2-3.

Mevlut, G., Besir, K. and Erdal, D. M. (2009). Determination of technical efficiency in cotton growing farms in Turkey: A case study of Cukurova region. *African Journal of Agricultural Research*, 4 (10):944 – 949.

Mvena, Z.S.K., Mattee, A.Z. and Wambura, R.M. (2013). Farmer Field schools as a Springboard for Enhanced Uptake of New agricultural technologies: Lessons for Tanzania. *Tanzania Journal of Agricultural Sciences*, 12:43-51.

Murage, A.W., Obare, G., Amudavi, D. and Khan, Z., (2012). Efficiency of Push-pull Technology Dissemination Pathways for Stemborer and Striga Control in Western Kenya: Data Envelopment Analysis Approach Paper presented on "Resilience of agricultural systems against crises" Tropentag, Gottingen - Kassel/Witzenhausen Sept 19th-21st 2012.

Mustapha, S.B., Gwary, M.M, Nuhu, H.S. and Samaila, P.A. (2012).Assessment of the Effectiveness of Lake Chad Research Institute Adopted Villages Scheme in the Dissemination of Improved Farm Technologies in Borno State Nigeria, *International Journal of Science and Technology*,2:2224-357.

O'Donnell, C. and Nguyen, K. (2011). Review of efficiency measurement methodologies to inform hospital resource allocation decisions in NSW: Evidence check rapid review brokered by the Sax Institute. Retrieved from http://www.saxinstitute.org.au.

Ogunniyi, L.T. (2012). Fertilizer Use Efficiency of Maize Producers in Ogun State of Nigeria. *The Pacific Journal of Science and Technology*, 13 (2): 370-376

Ojo, M.A. and Jibowa, A.A. (2008). Socio-economic Characteristics Influencing Role Performance of Rural Community Power Actors in Agricultural Extension Delivery System in Osun State, Nigeria. *Journal of Agriculture and Rural Development*, 2: 27-40.

Okwu, O.J. and Umoru, B.I. (2009). Study of women farmers' agricultural information needs and accessibility: A case study of Apa Local Government Area of Benue State, Nigeria. *African Journal of Agricultural Research*, 4 (12):1404-1409.

Ortiz, O., Garrett, K. A., Health, J.J. Orrego, R.J. and Nelson R.J. (2004). Management of potato late blight in the Peruvian Highlands: Evaluating the benefits of farmer field schools and participatory research. *Journal of Plant Disease*, 88(5): 565-571.

Pedzisa, T., Minde, I. and Twomlow, S. (2008). The use of participatory processes in a wide-scale dissemination of micro dosing and conservation agriculture in Zimbabwe. *International Crops Research Institute for the Semi-Arid Tropics*, Bulawayo, Zimbabwe.

Phalan, B., Onial, M. and Balmford, A. (2011). Reconciling food production and biodiversity conservation: land sharing and land sparing compared. 333 (6047): 1289– 1291.

Premlata, S. and Singh, D. K. (2014). The effectiveness of training programmes under Agricultural Technology Management Agency in Bihar India. *Indian journal of Extensional Education, 5*: 120-130.

Probst, K.J., Hagmann, T. and Fernandez, M. (2000). Developing a framework for participatory research approaches in risk-prone environments. *Paper presented at Eutscher Tropentag, University of Hohenheim, and Stuttgart, Germany*.

Rehman, F., Muhammad, S. and Ashraf, I. (2013). Effect of farmers' socioeconomic characteristics on access to Agricultural information: empirical evidence from Pakistan. *The Journal of Animal and Plant Sciences*, 23(1):324-329.

Ren, M.N. and Alemdar, T. (2006). Technical Efficiency Analysis of Tobacco Farming in Southeastern Anatolia-Turkey. *Journal of agriculture*,30:165-172.

Richard, E., Kasindei, A., Kimaro, F. and Slaa, S. (2007). Farmer participatory research in northern Tanzania: *Farm-Africa working papers.*

Ricker-Gilbert, J. (2005). Cost-Effectiveness Evaluation of Integrated Pest Management (IPM) Extension Methods and Programs: The Case of Bangladesh. Thesis Submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of Masters in Science In Agricultural and Applied Economics.

Rhoades, R.E. and Nazarea, V. (2006). Reconciling local and global agendas in sustainable development: Participatory research with indigenous Andean communities. *Journal of Mountain Science*,3(4): 334–346.

Rossi, P.H. and Freeman, H. E. (1993). Evaluation: A systematic approach (5thed.). Newbury Park: Sage Publications: 363-401.

Rusike, J., Twomlow, S., Freeman, H.A. and Heinrich, G.M. (2006). Does farmer participatory research matter for improved soil fertility technology development and dissemination in Southern Africa? *International Journal of Agricultural sustainability*, 4 (3):176–192.

Snapp, S., Kanyama, P.G., Kamanga, B., Gilbert, R. and Wellard, K. (2002). Farmer and Researcher Partnership in Malawi: Developing Soil fertility Technology for the near-terms and far terms. *ICRISAT-Malawi.*

Selener, D. (1997). Participatory action research and social change a source book. Ithaca, New York: Cornell University.

Shiferaw, B., Obare, G. and Muricho, G. (2006). Rural Institutions and Producers Organizations in Imperfect Markets: Experiences from Producer Marketing Groups in Semi-Arid Eastern Kenya. *CAPRI Working Paper 60*.Also jointly released as *ICRISAT Socioeconomics and Policy Working Paper Series No.23.Patancheru, Andhra Pradesh.*

Sanders, J., Shapiro, B. and Ramaswamy, S. (1995). The Economics of Agricultural Technology in Semi-Arid Sub- Saharan Africa. Baltimore, Maryland. USA, Johns Hopkins University Press: 27-36.

Scoones, I. and Thompson, J. (2009).*Beyond farmer first: Rural people's knowledge, agricultural research, and extension practice*. Intermediate Technology Publications: London.

Tilman, D., Balzer, C. and Hill, J. (2012). One Billion Hungry: Can We Feed the World? *Cornell University Press*: New York.

Vanlauwe, B., Bationo, A. and Chianu. J. N. (2010). Integrated soil fertility management: Operational definition and consequences for implementation and dissemination. *Journal of outlook in agriculture*, 39:17-24.

Xiaolan, F. and Shaheen, A.(2012). Impact of Mobile Telephone on the Quality and Speed of Agricultural Extension Services Delivery: Evidence from the Rural e-services Project in India. *International Association of Agricultural Economists (IAAE) 2012 Triennial Conference, Foz do Iguaçu, Brazil*.

Yusuf, O., Sani I., Usman, S. and Dawang, C. N. (2013). Factors determining farmers' participation in *Striga*resistant maize variety production in Ushongo Local Government area of Benue State. *Journal of Agricultural Biotechnology and Sustainable Development*, 5(3):48-53.

8.0 APPENDICES

QUESTIONNAIRE FOR FARMERS

My name is Semeni Ngozi, a student at Egerton University. This questionnaire has been developed to gather data for the purpose of evaluating efficiency and effectiveness of participatory research approaches among smallholder farmers in your area. You are among the farmers who have been selected for the study. The data collected will be used only for the purpose of this study and will be highly appreciated and treated with utmost confidentiality**.**

MODULE1; HOUSEHOLD COMPOSITION AND STRUCTURE

1a) Name of the respondent

1b) Sex of respondent

1c**)** Name of Farmer (household head) ………………………………………………

1d) Phone Number……………………………………….

1e). Gender of (household head) Male [0] Female [1]

1f). Age of Household head (years)…………………...

1g). Marital status: (1).Married (2).Single (3).Divorced/Separated (4).widowed

1h). Education level of the household head:

None (1)……years Primary incomplete (2) ……years

Primary complete (3)……years Secondary incomplete (4)….…years

Secondary complete (5) ….. years Middle level college (6) ……years

University (7) …..years

1i). Occupation of the household head:

(1)Unemployed (2) Self employment

(3)Salaried and self employment (4) Salaried employment

1j). Family Size (Number of dependents living with you)………………………………..

MODULE 2; FARM CHARACTERISTICS

2a).What is the size of your farm in acres? ………………………………

2b).Under what type of ownership is your farm?

(1)Owned (with title) specify acres……………………

(2)Owned (without title specify acres…………………….

2c). Do you carry out farming activities?

(0)Yes (1) No

2d).If yes how much of your farm (in acres) do you use for farming activities? ....

2e).What farming activities do you carry out in your farm?

(1) Crop farming (4) Fish farming

(2) Livestock farming (5) Poultry farming

(3) Others (specify)………………….

MODULE3;CHARACTERISTICS OF PARTICIPATORY RESEARCH APPROACHES

(3a)Have you participated in any of the PRAs?

1)Yes 2) No

3b)Which PRAs did you participate?

(3c)Farmer field schools (2) Farmer research group (3) Mother-baby trials

(3d) On-farm demonstrations 5) other (specify)...........................

3e) Why did you decide to participate in the above PRAs?

3f) Give reason for [6Ce] above

1)…………………………………………………

2)…………………………………………………………

3)……………………………………………………

4)……………………………………………………..

5)………………………………………………………….

3g) What is the average distance to where the PRAs is held (s)………………………Km

MODULE 4; FINANCIAL CAPITAL

4a).What is the income status of the household per month?

Tick where applicable.

(1) <100,000 (2) 110,000-200,000 (3)210,000-500,000 (4) 510,000-1,000,000(5) >1,000,000

4b) What was the use of the money?

(1) Maize legume farming (2) Other farming activities

(3) Off-farm activities (4) other (specify)…………

4c) Have you applied for a loan from any financial institution in the past one year?

(0)Yes (1) No

4d) If yes, indicate source and use.

Source	Use
1)Bank…………………………………..	
2) Cooperative……………………………	
3) Merry go round……………………….	
4)Micro finance…………………………	
5) Informal lender ……………………….	
6) Employer ……………………………..	
7)Other (specify)…………………………	

MODULE5; SOCIAL CAPITAL

5a). Are you or any of household a members of an organization, group or association?

(0)Yes (1) No.

5b). If yes which one? (1) Youth group (2) Women group

(3) Saving & credit society (4) other (specify)………………

5c).For how long has he/she been a member of that group? ....

5d).What benefits or service does the group/association offer?

(1) Education/training (2) Credit (3) Farming

(4) Irrigation (5) Farming information (6) Marketing produce

(7) Tree planting (7) other (specify)………………………….

MODULE 6; HOUSEHOLD ASSETS

6a) Indicate the assets currently owned by the household

Item		Current number	Unit Value	Total value	Item	Current Number		Unit Value	Total Value
Item					**Item**				
Cow shed (s)	1				Spade/shovel	15			
Ox plough	2				Farm house(s)	16			
Food store	3				Furniture	17			
Water pump	4				Panga	18			
Milking shed	5				Jembe	19			
Fenced farm	6				Vehicle(s)	20			
Chuff cutter	7				Tractor	21			
Wheelbarrow	8				Tractor trailer	22			
Spray pump	9				Water tank	23			
Bicycle	10				Posho mill	24			
Feed troughs	11				Well water	25			
Milk Buckets	12				Power saw	26			
Motorcycle	13				Mobile phone	27			
Television	14				Radio	28			

MODULE7; IMPROVED TECHNOLOGY KNOWLEDGE

7a). what aspect of technology was trained? ………………………………

7b). Do you access extension services? (0) Yes (1) No

7c). Number extension contacts in the last year: ……………………………….

7d). Do you feel that you get adequate services from extension officers?

(0)Yes (1) No

7e).Who provides the extension services?

(1) Government officers (2) NGOs (3) Private institutions

(4) Social groups (5) others (specify) ……………………

MODULE8; CROP PRODUCTION

(8) In the table below indicate major crops that the household produced in the past one year quantity produced, expenses, selling price and profit

Crop	Quantity produced	Land prep & weeding cost	Man hour cost	Seed &Fertilizer cost	Harvesting cost	Other expenses	Pric	Total expenses	Profit

Crop code
1= Maize2= Bean 3= Vegetables 4= Sorghum 5= Millet 6= Fruits 7= Groundnut 8= others

MODULE9; LIVESTOCK PRODUCTION

9a).Did you own any livestock in your farm in the last one year? Yes [ ] No [ ]

9b) If yes, complete the table below:

Livestock	No. owned by household	No sold	Unit selling price (Tshs)	No. purchased	Purchase price	No. consumed	No. died
Goats							
Donkeys							
Sheep							
Indigenous chicken							
Broilers							
Layers							
Ducks							
Pigs							
Beehives							
Local cows							
Dairy(exotic)							
Local bulls							
Calves							

9c). Outline the livestock products income sources in Tshs.

Livestock Product	Average production/month	Unit of Production	Amount Sold /month	Price/Unit (Tshs)
Cow milk				
Goat milk				
Eggs				
Honey				
Hides and Skin				
Fish				
Manure				
Others(specify)				

Thank you

CHECKLIST FOR KEY INFORMANTS

My name is Semeni Ngozi, a student at Egerton University. This questionnaire/Checklist has been developed to gather data for the purpose of evaluating Efficiency and Effectiveness of Participatory Research Approaches among smallholder farmers in Babati. You are among the organizations that have been selected for the study. The data collected will be used only for the purpose of this study and will be highly appreciated and treated with utmost confidentiality.

Instructions for the enumerators

1. *Introduce yourself and tell the purpose of the study before starting the interview*
2. *Tick the box on the closed questions as indicted*
3. *Ask interview questions clearly*

Module 1: **Effectiveness of the popular participatory research approaches**

PRAs	Effectiveness of PRAs measured in number of AIIS adopters)	
	Expected adopter	Actual adopters
MBTs		
FRGs		
OFDs		
FFS		

Module 2: Costs associated with a participatory research approach

Participatory research approaches	**Input X_1 Labor cost (Tshs)**	**Input X_2 Fertilizer cost (Tshs)**	**Input X_3 Seeds cost (Tshs)**	**Input X_4 Researcher's allowance(Tshs)**	**Input X_5 Monitoring costs (Tshs)**	**Output Y Number of AIIS adopters**
FFS						
MBTs						
FRGs						
OFDs						

Module 3: Characteristics of participatory research approaches

a) Farmer field schools

(1) ....

(2) ....

(3) ....

(4) ....

(5) ....

b) Mother baby trials

(1)..

(2)..

(3) ....

(4)..

(5)..

c) Farmer research groups

(1)..

(2)...

(3)...

(4)...

(5)..

d) On-farm demonstrations

(1)..

(2)...

(3)..

(4)...

(5)..

Thank you

CHECKLIST FOR FOCUS GROUP DISCUSSION

Hi every one, welcome to our session. Thanks for taking the time to join us to talk about Efficiency and effectiveness of Participatory research approaches in your village. My name is Semeni Ngozi assisting me is Elia Mbazi and Cleopa Charles. You were invited because you have participated in some of the PRAs so you're familiar with the PRAs' activities. There are no wrong answers but rather differing points of view. Please feel free to share your point of view even if it differs from what others have said. Keep in mind that we're just as interested in negative comments as positive comments, and at times the negative comments are the most helpful. You've probably noticed the microphone. We're tape recording the session because we don't want to miss any of your comments. People often say very helpful things in these discussions and we can't write fast enough to get them all down. We will be on a first name basis tonight, and we won't use any names in our reports. You may be assured of complete confidentiality. The reports will go back to the district agriculture office to help them plan future programs.

Q1. Tell us your name and how long you have been participated in the PRAs activities.

Q2. When did your group started?

Q3. How were you selected to participate in the PRAs?

Q4. Why did you decide to participate in the PRAs?/ Who did influence your participation in the PRAs activities?

Q5. What factors might discourage your decision to continue participating in the PRAs' activities?

Q6.How many farmers did you manage to train/ share with them the technology you got from these trainings?

Q7. What challenges associated with the PRAs' activities that you participated?

Thank you