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RESEARCH ARTICLE

UPTAKE AND USE OF CLIMATE INFORMATION SERVICES TO ENHANCE AGRICULTURE AND FOOD PRODUCTION AMONG SMALLHOLDER FARMERS IN EASTERN AND SOUTHERN AFRICA REGION.

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Abstract

This study evaluates the contribution of climate information services (CIS) to agriculture and food production, and rural household incomes in selected Climate Change Adaptation in Africa projects in Eastern and Southern Africa region. It establishes the resilience of projects after completion; factors influencing the sustainable use of CIS in the project area and beyond; and the benefits of institutionalization of climate information services through organized groups and extension services. Existing project documents were reviewed; questionnaires and interviews conducted with farmers, field project officers and key informants to achieve the study objectives. The results showed that institutionalization of climate information services through organized groups such as farmer groups and extension services enhance climate resilient agriculture. Access, consistency, reliability and relevance of the climate information to farmers' needs were fundamental in integration of climate information into household decision making. Thus translation and communication of the seasonal forecasts in local languages empowers farmers to make informed farm management decisions. Use of CIS increases agricultural yields by between 5% to more than 75% and gender, age, education levels and household sizes influence the use of CIS in farm decisions. Therefore, investment in adult literacy and women involvement are key to use of CIS for increased productivity in Africa.

Introduction:-

Climate variability and change pose significant challenges not only to Sub-Saharan Africa but to societies worldwide. The impacts of climate change and variability on agriculture are large particularly in sub-Sahara Africa where rainfall is the main source of water for farming (Forch et al., 2011; Kristjanson et al., 2012). The Kenyan Government recognizes that arid and semi-arid areas are the most vulnerable to climate-related risks with huge impacts on livestock and smallholder farming, which are the dominant sources of livelihoods in these areas (Jarvis et al., 2011). The potential impacts of changes in climate and climate variability on these mixed systems are not that

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well understood, particularly as regards to how the food security of vulnerable households may be affected (Kristjanson et al., 2012; Thornton and Herrero, 2014).

Studies have indicated that fluctuations and variations in climate, particularly rainfall and temperature, adversely affect the physical, biological and socio-economic systems leading to household exposure to risks, disasters and calamities (Tasokwa, 2011; IPCC, 2013; Amwata, 2013). Extreme climate events (IPCC, 2013; Omondi et al., 2013) such as floods and drought continue to increase vulnerability of rural livelihoods to food risks. One of the contributing factors is inadequate knowledge and information on role of climate on livelihoods (Wood et al., 2010; Ericksen et al., 2011; Rosenzweig and Udry, 2013). Studies have shown that CIS have great potentials in increasing resilience in agriculture and reducing the vulnerability of households through proactiveness and to maximisation of opportunities through planning of the type of crops and livestock species that are resilience to weather extreme events (Ziervogel and Downing, 2004; Jarvis et al., 2011). According to Wood et al. (2013), access to weather information, assets, and participation in social institutions have aided households in making informed farming decisions, thus enhancing agricultural productivity and food security across the SSA countries.

Studies show that households face considerable challenges in adapting to climate change (Bryana et al., 2013; Below et al., 2012; Panda et al., 2013). While many households have made remarkable adjustments to their farming practices in response to climate variability and change such as changing planting decisions, few households are able to make more costly investments, for example in agroforestry and or irrigation (Bryana et al., 2013). One of the challenges that smallholder farmers in sub Saharan Africa face is the growing risk from increasingly variable rainfall in terms of start and end of season; and amount and distribution of rainfall within growing seasons (Camberlin and Okoola 2003; Wood et al., 2010; Pohl and Camberlin 2014).

Research on climate effects on agriculture using statistical methods (Gourdji et al., 2013; Lobell et al., 2011a, b) has provided insight into impacts, but has been unable to address household-level adaptations since these changes were implicit in aggregated data. Some studies have identified long and or short-run adaptation measures among farmers (Schlenker and Roberts, 2009; Guiteras, 2009; Schlenker and Lobell, 2010), but have been unable to discuss the role of CIS in informing specific adaptation strategies for enhancing agricultural production. Research at the community and household levels has provided insight into particular adaptation strategies and impacts (Below et al., 2012; Vermeulen et al., 2011), but it remains unclear to what extent these strategies and impacts are generalizable.

Seasonal forecasts remains one of the ‘low hanging fruits’ that remains underutilised yet it offers and enormous potential for improving agricultural production, food security and livelihoods particularly in areas where changes in precipitation and intensification of extreme weather events are a routine (Martin et al., 2000; Murphy et al., 2001; Ziervogel and Downing, 2004). Skills in climate forecasting allow for the prediction of future anticipated climate-related events, thus offering considerable opportunities to the managers of agricultural systems and farmers and livestock keepers to realise the systems’ potential through increased productivity and profitability, reduced risks, and better policies for improved food security (Rosenzweig and Udry, 2013; Amwata, 2013). One of the likely explanations why seasonal forecasts have not been fully tapped is attributed to a limited understanding of probabilistic information, difficulty in communicating risk and probability especially to rural farmers (Ziervogel, 2004). These have further been exacerbated by poor packaging of the information without due consideration of the needs and priorities of end-users under different climate regimes and agroecological zones. Other factors include illiteracy (Tarhule and Lamb, 2003), inter-village complexity, lack of communication infrastructure (Ziervogel et al., 2005; Mokssit, 2007; Wood et al., 2013), misunderstanding of forecast information (Roncoli et al., 2003; WMO, 2007; Mokssit, 2007). Limited trust in source and inadequate resources to sustain the programmes (Roncoli et al., 2000), geographic isolation (Tarakidzwa, 2007) have further undermined the role of SCF in several sectors of development, in particular agriculture. Overcoming some of these barriers can help to improve aggregate decision-making and, in turn, minimise poverty and aid in sustianbale development. Accurate information therefore assists farmers in deciding which agricultural technologies and adaptation mechanisms may be most useful in responding to weather variability and climate change (Hansen et al., 2007; Ziervogel and Ericksen, 2010).

Some studies have documented the economic benefits of SCF (Ziervogel and Calder, 2003; Ziervogel, 2004). However, very few studies in Africa have estimated their money worth. For instance, in Kenya, Christian Aid reported that SCF had improved the yields of farmers by more than 15% (Ewbank, 2012). In Queensland the reported benefits of SFC and climate risk assessment to grazing industries from 1991/92 to 2002/03 was estimated at the range of $600M-1200M (Collins, 2002). Similarly, in the United States of America, by incorporating National Oceanic and Atmospheric Administration's (NOAA's) El Niño Southern Oscillation (ENSO) forecasts into planting decisions, farmers in the US were able to increase agricultural outputs and produce benefits to US economy of up to USD 300 million/year depending on accuracy of the forecasts (Rodney, ND).

This study therefore evaluates the contribution of the CCAA/IDRC weather and climate agro-advisories projects in supporting livelihoods, improved farmers, crop and livestock planning and output in some selected sites in Kenya, Tanzania and Zimbabwe. It further assessed the continued use of the climate advisories in meeting land-use planning objectives in the most effective way, and the probability of the longer term maintenance of sustainable results. The study further attempted to understand factors that motivate sustained production and dissemination of weather and climate information, establish the opportunities and challenges for actors on climate information value chain in order to provide guidance on how to increase acceptance and use of climate seasonal advisories.

Methodology:-

Pre-reconnaissance survey:-

A pre-reconnaissance survey visit was arranged within the study area with selected government officials, project management team and Field Farmers Training Centres (FFTCs) officials of each site. This was to conduct an inception meeting to introduce: the project objectives and the benefits to various stakeholders, meet the survey team and the project group members and to seek permission to be able to interview farmers in each of the communities; and also meet agricultural and other officials involved directly with the community (e.g. extension officers) in the various project areas.

A total of 109 respondents were interviewed, 45 males and 64 females in all the study sites. These respondents were small-holder farming communities in five selected districts in eastern and southern Africa who had previous training experience in the use of seasonal climate forecast in agricultural practices through FFTCs.

Most farmers who are members of the FFTCs were interviewed since they were part of the CCAA projects. All the respondents interviewed had access to CIS. A majority (79%) of the respondents were using a mix of conventional and indigenous knowledge CIS while the remaining 21% of the respondents used singly indigenous knowledge CIS to plan their farming practices. However, none of the respondents interviewed reported to use conventional knowledge as a single method.

Of the respondents interviewed, all were users of SCFs in planning their farming practices. As a result of several trainings by the Meteorological Services, all the farmers were familiar with the way SCFs products are disseminated (e.g. 'the probability of above-, near- and below- normal rainfall in the next 3 months') in their regions. The farmers' background, social and economic conditions, the process of decision-making among others were recorded for the analysis. The project management staff and government officials who were directly involved in these projects were also interviewed to double check or authenticate views expressed by the Farmer Focus Group Discussions (FFGDs).

Data:-

This study used both quantitative and qualitative designed questionnaire in order to understand how participants viewed and used CIS for their agriculture based planning. Participatory Rural Appraisal (PRA) were conducted with the farmers, stakeholders and key informants. Nine Farmers' Field Schools in five IDRC projects sites were selected (**Figure 1**) for this study. This was because the activities in these projects were focused on institutionalizing weather and climate information services through farmer groups and extension workers to enhance climate resilient agriculture among smallholders. They also represent areas with high degree of economic vulnerability to climate, together with a range of social, political, and climatic contexts. Three areas are located within Kitui County in eastern Kenya, one in Vihiga County in Western Kenya, two sites in Kisumu County, Same District in Tanzania and two sites in Lupane District in South Western Zimbabwe. Another criteria considered in the selection of these project sites was based on activities focusing on knowledge and applications of SCFs by small-holder farmers and extension officers in farm management decision making. The survey was carried out in two phases in this research study i.e. the pre-survey conducted through project leaders and the actual survey with government officials, project management teams and farmers from the FFTCs.

Figure 1:-
Descriptive statistics such as graphs, charts and tables were used to summarize the data. In addition, frequencies, percentages, means and associations between farmer responses and demographic data were also derived using Statistical Package for Social Science (SPSS). The information gathered from the pre-survey, guided a detailed questionnaire that was designed for phase 2 of the survey.

Phase 2 was dedicated to actual data collection for the study from the smallholder farming communities within the respective study sites. The data was obtained using two different approaches. First was administration of household questionnaires in the nine different project sites. The second approach an inclusive Focused Groups Discussion (FGD), taking into consideration gender and age groups. The FGD process was made possible with the help of respective chairpersons of the FFTCs and the Agriculture Extension Officers. A set of interview questions were asked to guide the group discussions and the respondents (Archer (2000). Other than the characteristics of the respondents, the questionnaire administered inquired on the process of decision-making commonly practised in the field, dissemination, adoption, capacity and habit on climate forecast related to farming activities. The questionnaire was administered through face-to-face interview (Nazir, 1988) with the farmers in the field. By using face-to-face interviews, the aim was to minimise the possible misunderstanding by the respondents of any ambiguous questions.

Table 1:-Distribution of respondents in based on the project sites

County/District	Farmers Group	No of Male respondents	No. of female respondents	No of Respondents
Kitui	Kyeni	4	8	12
	Kaveta	5	6	11
	Unikoo	7	2	9
Kisumu	Nyahera	10	7	17
	Reru	2	7	9
Vihiga	Nganyi	8	13	21
Same	Mwembe	4	12	16
Lupane	Menyezwa	2	5	7
	Damka	3	4	7
Total		**45**	**64**	**109**

Table 2:-Household demographics and the use of CIS

Household demographic characteristics	Categories/ groups	Climate Information services		Total %)
		Conventional & Indigenous (%)	Indigenous (%)	
Family sizes (person/s)	1	0	3	3
	2–3	14	15	51
	4–6	36	3	39
	7–9	7	0	7
	Total	**79**	**21**	**100**
Age (years)	≤ 30	10	0	10
	31–40	24	4	28
	41–50	36	5	41
	51–60	9	8	17
	≥60	0	3	3
	Total	**79**	**21**	**100**
Level of education	None formal schooling	18	9	27
	Primary	43	10	53
	Junior High School	8	1	9
	Senior High School	8	0	8
	College/University	3	0	3
	Total	**79**	**21**	**100**
Gender of the household head	Male	28	13	41
	Female	51	8	59

	Total	**79**	**21**	**100**

Table 3:-Agricultural productivity (90kg bag/acre) in relation use of CIS (%)

Agricultural productivity/acre	Respondents' use of CIS (%)		
	Conventional & Indigenous	Indigenous	Total
Less than 5 bags	17	10	27
>5 to≤10 bags	43	10	53
10 to ≤ 15 bags	8	1	9
≥15 bags	10	0	10
Total	79	21	100

Table 4:-Farmer's response to adaptation to below and above normal rainfall as established by the Nganyi farming communities in Western Kenya

Adaptation option by farmers on different rainfall levels	
Predictions for below normal rainfall	Predictions for above normal rainfall
i. Plant drought resistant crops	i. Grow more vegetables besides other food crops
ii. Sow less maize but more millet and sorghum	ii. Plant earlier
iii. Reduce density of field crops	iii. Increase crop densities
iv. Dig furrows next to fields to stop wilting	iv. Increase sharecropping: where one party supplies the land and the other the inputs
v. Collect water and pour over plants	v. Plant different crops to my neighbour so that there is a market to all
vi. Plant cassava since they survive harsh conditions	vi. Be aware of diseases and pests for crop

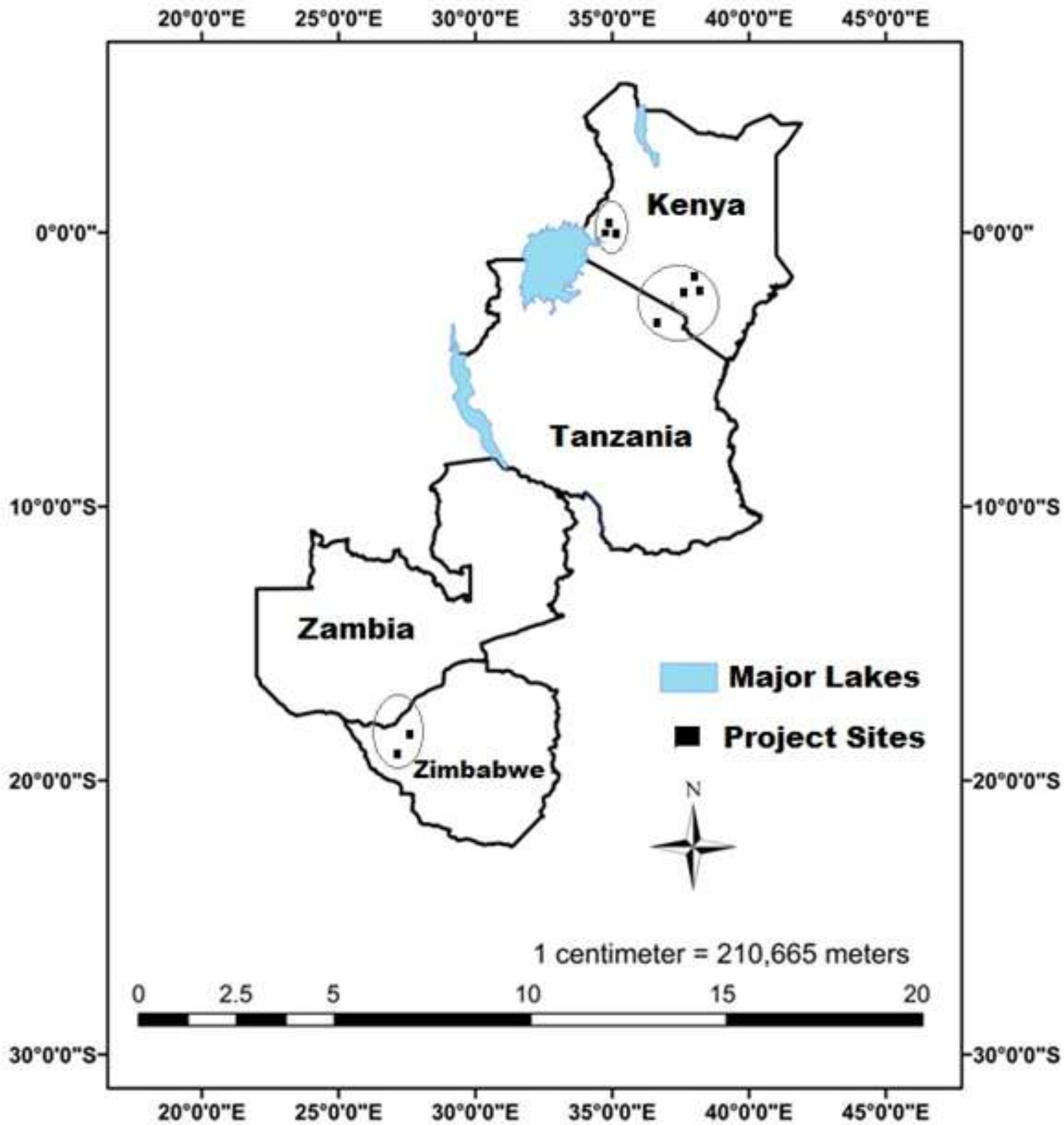

Figure 1: Map of study locations. Individual study sites are encircled. Specific site details are available at: http://.http://www.idrc.ca/EN/Programs/ last accessed on 25-2-2016.

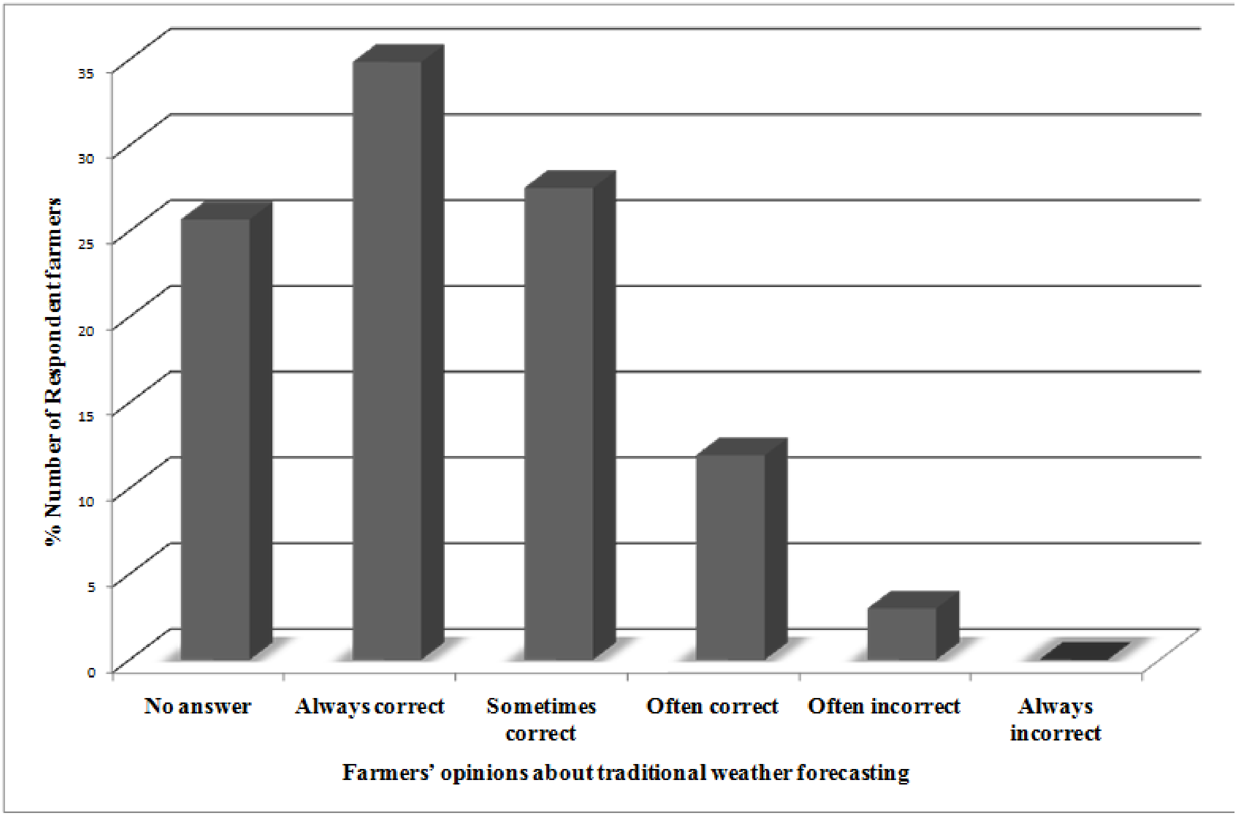

Figure 2: Farmers response on accuracy of rainfall forecast provided

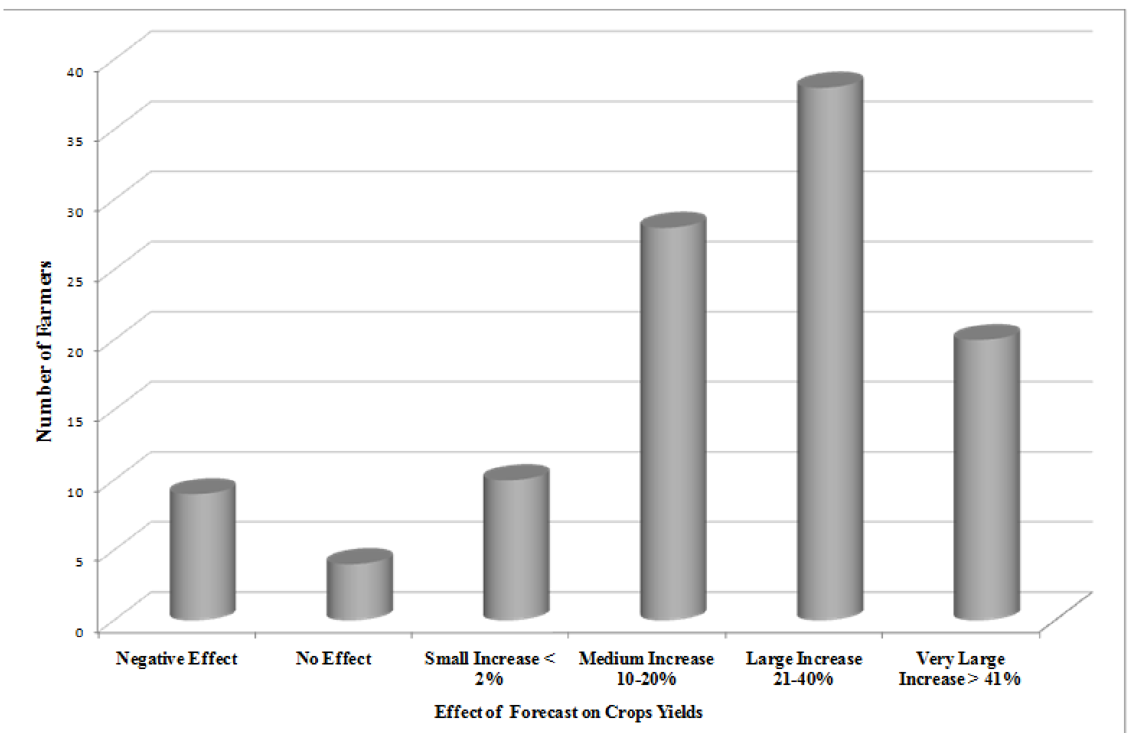

Figure 3: Farmers' attribution of yield increase to climate information in enhanced agricultural decision-making

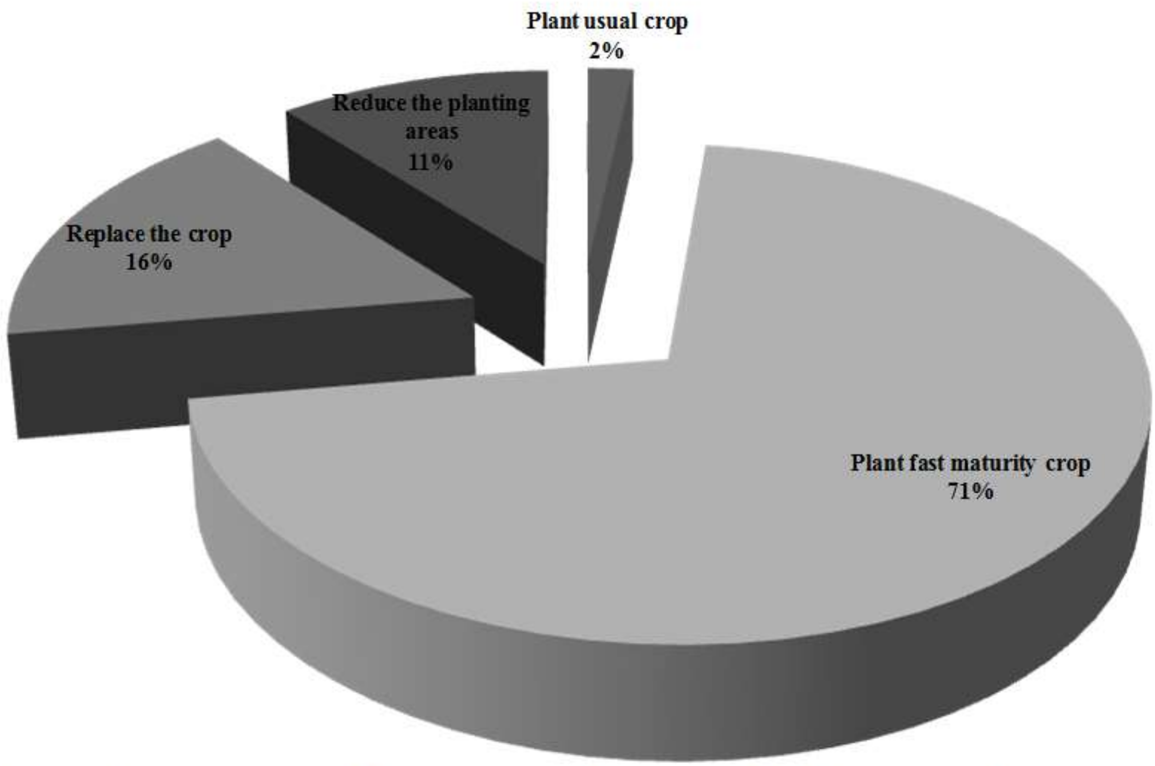

Figure 4: Farmers planting decision when below normal rainfall is forecasted

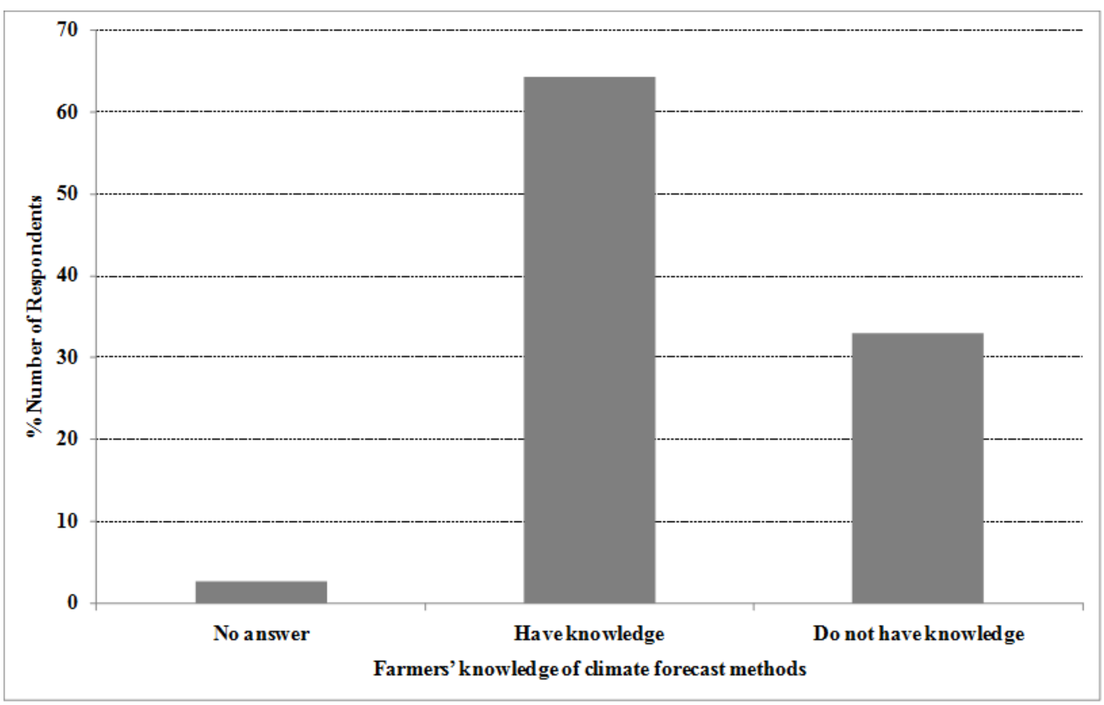

Figure 5: Farmers' knowledge of seasonal forecast preparation and dissemination

Results and Discussion:-

Valuable information was obtained during both questionnaire administration and PRA process, especially on use of seasonal climate forecast, the dissemination of the forecasting information previously (during project phase) and currently (2 years after the project) conditions. To simplify the naming of the research areas, the names of FFTCs were used and the number of respondents from each project sites as shown in (**Table 1)**. In total, 109 respondents were interviewed across the five sites, of which 59% were female while the remaining 41% were male.

Table 1

Table 2 shows the distribution of respondents based on household demographic characteristics (family size, gender, level of education and age) and use of CIS. The results show that greater percentage (86%) of the females was using CIS compared to 69% of the males. On the same note, more males (13%) were using indigenous CIS than the females (8%). The reverse was true and more females (51%) were using a combination of conventional and indigenous CIS as compared to 21% in males.

Table 2

In terms of the level of education and use of CIS, most respondents (about 80%) had a maximum of elementary education with only 20% attaining junior school and above levels of education. This implies that the educational levels of respondents were still relatively low. In terms of education levels and use of CIS, the highly educated with senior high school and above levels of education were unlikely to use indigenous CIS as a single method while the majority who used indigenous CIS a single method had lower levels of education ranging between no formal education and Junior High School. The likely explanation is that with more education, the more the ability to adopt the mix of conventional and indigenous CIS. This finding supports Rogers (1983) and Mutavi et al. (2006) who noted that higher literacy levels influence the ability of people in the adoption of innovation processes. However, they noted that the challenge was how to take advantage of those farmers with high education to influence those who had low levels of education to adopt new innovations. Similarly, designing an extension program based on climate forecast that could be understood and used by most farmers was cited as one of the major setbacks.

Age showed some relations with use of CIS. From **Table 2** respondents who were less than 30 years were unlikely to use indigenous CIS and a reverse was noted among those aged more than 60 years who preferred indigenous CIS. The likely explanation is that those who are young are educated and more dynamic to embrace new innovations including a mix of conventional and indigenous CIS compared to older counterparts, who majority still use the indigenous CIS. In support, Asambu (1993) found that young were more willing adopt new agricultural innovations. The relation between household size and use of CIS showed that most respondents had a family size of between two and six persons. About 50% of respondents had two to three members, while about 40% had 4 - 6 members; only 8% had more than seven members. In terms of use of CIS, households with one member relied wholly on indigenous CIS, while large households with more than seven members never used indigenous CIS**.**

Accuracy of weather forecasts:-

Seasonal forecast accuracy in this context refers to the percentage of time that the predicted and actual rainfall is in agreement (Ziervogel et al., 2004). On the farmers' perception about forecast accuracy, about 35% said that the forecast is always correct, while another about 27% said that the forecasts are sometimes correct. It was noteworthy that 25% had no answer to this question (**Figure 2**). The results show that the level of forecast accuracy determines the level of trust and that there is a threshold of below which trust will be lost significantly.

Figure 2

When the farmers were asked about the possibility of transfer of technology, especially on weather forecast in agriculture, 80% welcomed the idea and were willing to adopt the innovations if it would improve agricultural yields by at least 20%. About 18% said that they would blend it with traditional ways while 3% preferred traditional weather forecasting to be good enough.

Influence of CIS to agricultural yield:-

There are several factors that influence farmers in using CIS in farm activities. When farmers were asked how they attributed their agricultural performance on the decisions they took on use of CIS, the majority 88% noted an increase of yield with use of CIS. About 53% of the respondent reported an increase in yield of above 20%; 23% reported an increase of 10-20%; while only 12% of the respondents reported a no change or a reduction in yield. Farmers from Kieni in Kitui, for instance, felt that without using seasonal forecast, they would harvest 8 instead of

17 bags (90kg) of maize per acre. (**Figure3**). In terms of agricultural yield and CIS, respondents obtaining ≥15 bags/ acre of maize were using both conventional and indigenous CIS. However, 37% of those who received less than 5 bags/ acre of maize were using only indigenous knowledge compared to 63% of those using both (Table 3).

Figure 3

The interview with farmers, project management and government officers responsible for these projects showed that neighbouring farmers who were not using good adoption of seasonal forecasts and related agronomic practises had poor yields and majority resorted for advice from the FFTCs.

It should be noted that other factors such as soil fertility, crop varieties, and farm inputs among others were not taken into consideration in this survey. They were taken to remain constant while considering the yields increase.

Decision-making process on-farm;-

Decision-making process on-farm is another aspect that influences the use of climate forecast in agriculture processes. This aspect is also important when dealing with the process of adoption of innovation (Rogers, 1983). In dealing with weather or climate forecast, there are several factors affecting farmers in making decisions. For instance, if drought/enhanced rainfall occurs, what decision will the farmers make?

Farmers were asked what they would do in their farms (in relation to crop variety) if below normal rainfall information was disseminated. Most farmers (71%) said that they would plant fast maturing crops with different cropping patterns while about 16% would replace the crop with other crops that need less water; 11% said they would reduce the planting areas and only 2% would plant normal crops (**Figure 4**). These answers indicate that some farmers still adopt traditional methods of forecasting without modern knowledge of how to maintain the level of production, especially in drought years.

Some of the factors that have influenced farmers' decision include sustained use of climate information, full involvement and participation in use of weather advisories in planning of agricultural activities. Enhanced training, sharing of knowledge and information among stakeholders through meetings, workshops, and conferences facilitated the flow of climate advisories from meteorological services to extension officers and eventually to the farmers hence the decision taken. Embrace of farmers' traditional forecast practices, providing space to share the different types of knowledge increased everyone's ability to make informed choices and good decisions. This was noted to motivate most farmers to own the idea behind use of seasonal forecast. As a matter of fact, accurate and useful forecasts are produced where traditional and conventional forecasts are blended.

Figure 4

The type of decisions that farmers opted to undertake in response to the forecast were mostly short-term tactical decisions such as sowing of a particular maize variety and planting earlier, rather than long-term strategic decisions. These decisions are part of agricultural risk management strategy. The focus on short-term decisions is expected when using new information. When these decisions seem to be appropriate way of responding to the forecast, then more long-term decisions can be made in response to the forecast, depending on the risk preference of the decision maker (Carberry et al., 2000). The decisions chosen for use in the model, in response to the forecast, are the adjustment of cropping densities and the ratio of maize to sorghum planted. These decisions are generally available to a wide range of farmers, including those with few resources.

Table 4

Table4 shows examples of adaptation options used by farmers to adapt to below and above normal rainfall forecast. The options show that abundant resources are not required for all responses. Some responses were more prevalent than others and some more appropriate for a wide range of users. Options such as changing cropping densities can be pursued by all households and many can change crop type by bartering with their neighbours, as is a common practice. Changing to drought tolerant varieties might only be an option for households who can afford to buy new seed variety, unlike most households that keep their seed from the harvest to plant the following year.

Knowledge about weather forecasts:-

Knowledge about weather forecast methods is another factor that influences farmers' use of climate information in agricultural activities. This factor is related to the idea of sharing information and using modern techniques of forecasting weather for the purpose of agricultural activities.

Figure 5 gives the summary of farmers' response when their knowledge on how seasonal forecast is prepared and disseminated. Based on this outcome, it was noted that farmers, to some extent, have adequate knowledge on seasonal forecasts methodology. According to the survey, more than 65% of farmers had knowledge; about 33% of the respondents had no idea on how seasonal forecasts were prepared while 2% did not respond to the question.

Figure 5

This high number, bearing in mind their educational level, could be attributed to several trainings and drills they underwent during the CCAA/IDRC project phase. This study, therefore, showed that sustained effective use of accurate seasonal forecasts with appropriate agriculture related weather advisories results into increased food production among the smallholder farmers studied. Use of seasonal forecast has been one of the major concerns to all the farming communities studied. The majority of the farmers indicated that climate forecast information should be disseminated at least one month before the beginning of the season, either through the local vernacular FM radio stations or directly to their cell phones as Short Message Services (SMSs). The majority of the smallholder farmers in the nine villages surveyed had no Internet facilities to download climate forecast information yet this is the most timely and cost effective way to disseminate climate information.

The effectiveness of seasonal forecasts as a supportive decision-making tool for smallholder farmers remains subject to debate given the fact that deterministic forecasts are still not available for farmers several months in advance as ideally required. The research should therefore respond to needs expressed by farmers related to forecasts generated with the current tools (Huda and Packham, 2004; GFCS, 2009). The challenge becomes how to ensure the concomitant development of appropriate products, with dissemination strategies that highlight the nature of the given information, as well as taking advantage of and /or establishing effective distribution channels. Indeed, efficient dissemination of seasonal forecasts requires in-depth understanding of the networks of stakeholders concerned with the transmission of information to end-users (Ziervogel and Downing, 2004) while adoption requires both repeated exposure to products generated by seasonal forecasts and feedback mechanisms to inform the development of appropriate products to cater for the needs expressed by users (Ziervogel, 2004).

Key findings of the study:-

Survey conducted two years after the expiry of the projects showed that CIS has enabled farmers to improve on agriculture activities in the following areas

1. Planning of agricultural activities especially land preparation, planting dates, animals to be kept and harvesting time.
2. Improvement in agriculture production record keeping
3. Increased understating of climate and environmental factors/issues
4. Improvement in agronomic practices
5. Good adoption of use of climate forecasts
6. Improvement in yields in most places due to seasonal forecast adoption

Conclusion and recommendations:-

This study has explored the extent to which the completed CCAA/IDRC supported projects had remained climate resilient, two years after completion and also establish the factors responsible for the observed climate resilient or under performance of the projects.

Based on this study, it is concluded that institutionalizing climate services through farmer groups and extension workers contributes to and sustains climate resilient agriculture among the small-holder farmers studied. Thus translation and communication of the seasonal forecast in easily understandable language, that give farmers the capacity to make informed farm management decisions, is a critical factor in efficient flow and uptake of climate information.

Some of the factors that have contributed to the sustained use of climate information are the community ownership of the activities, full involvement and participation in these projects. This was manifested in continuous taking of readings and keeping of the rainfall records before sending to their respective meteorological services. Increased understating of climate and environmental factors/issues influencing crop production, improved agronomic practices, good adoption and use of climate forecasts has also resulted in the improvement of yields and thus resiliency. It shows that farmers still use and have improved in planning of agricultural activities using weather forecasts.

It is, therefore, suggested that more in-depth information and longer data of analysis is important to concretely come up with clear study on use of seasonal forecast for yields improvement. More studies need to be conducted, as well as in-depth survey to extend the results of such study and to get farmers well informed about such technology that is appropriate in order for them to increase their productivity.

The forecast products require refinement with users needs prioritized while strengthening extension services for timely and effective dissemination. If national level forecast dissemination strategies are prioritized, the blanket targeting of rural groups will address user needs. Further investigation into the impact of the forecast on community members who are not members of the FFTCs at the village level is encouraged before dissemination is actively pursued without appreciating potential impacts.

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