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# Assessment of Knowledge Co-production in Adaptation to Rainfall Variability in Kitui South Sub-county, Kenya

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author MMM designed the study and carried out data collection and analysis. Authors CWR and KNO supervised the entire research process. All the authors read, edited and approved the manuscript.*

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## ABSTRACT

**Aims:** This study tried to investigate the extent of knowledge co-production between indigenous farmers and agricultural extension in dry lands.
**Study Design:** The study adopted survey research design where both qualitative and quantitative approaches were used.
**Place and Duration of Study:** The study was carried out in Kitui South sub-County in the semi-arid Southeastern Kenya. Data was collected between June 2019 and August 2019.
**Methodology:** An enumerator-administered questionnaire was used to collect data from 311 household heads. Purposive and proportional sampling techniques were used to select households which participated in the study. Data was analyzed with the aid of SPSS Version 20. Percentages and proportions were used to establish instances of knowledge co-production between indigenous and modern scientific methods of farming.
**Results:** The study established that all households used both indigenous and scientific methods of farming except in irrigation and crop harvesting methods. The highest co-production was between use of locally preserved seeds and use of modern seasonal climate forecast (71.4%), use of traditional seasonal climate forecasts and use of modern seasonal climate (64.6%) as well as use of

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traditional crop storage and use modern seasonal climate forecast (59.2%). Seasonal climate forecasting was the leading corresponding method of knowledge co-production in the study area.
**Conclusion:** The study concludes that use of both indigenous and modern methods of farming can improve adaptation to rainfall variability. The study recommends access to adequate water to promote knowledge co-production on irrigation which was lacking yet very critical in dealing with rainfall variability in the study area.

*Keywords: Knowledge co-production; indigenous method; scientific method; adaptation.*

## 1. INTRODUCTION

Knowledge co-production is a wider societal involvement in research which brings contributors together in the knowledge production process [1]. It may also be used to refer to the collaboration between indigenous knowledge and modern scientific knowledge in explaining and solving situations affecting mankind [2]. Generally, in knowledge co-production aspects of indigenous knowledge are incorporated in scientific inquiry to fill in the gaps which may inadequately be addressed by science. However, in strict terms, knowledge co-production means the use of both indigenous and scientific modern methods on a 50-50 basis [3].

There has been a growing awareness in the recent years that scientific knowledge alone is not sufficient in coming up with solutions to climate change and variability [4] and that knowledge of local communities is pivotal in providing climate knowledge and appropriate adaptation strategies [5]. Knowledge co-production is, therefore, one of the innovations important in dealing with the complexities and challenges of climate change and variability [6]. Knowledge co-production has been viewed as a solution to disconnect between scientific information on climate change and the implementation of appropriate responsive management strategies [7]. This is important as indigenous farmers have diverse and complex locally adaptive agricultural systems managed through traditional institutions to ensure food security for the community. However, this approach of co-production of knowledge between scientific and indigenous practitioners is faced with many challenges as the heterogeneous groups involved have diverse worldview, interests, objectives and cultural backgrounds [8]. To bring these diversities to harmonious co-existence for adaptation purposes, consultations and collaboration as well as yielding substantial grounds by the two sides of the divide is of great importance.

Exchange of knowledge between indigenous people and scientists, which is the foundation of knowledge co-production, is as old as the origin of science [2]. No scientific inquiry that grew from a vacuum void of indigenous knowledge and therefore it is worth noting that origin of science is rooted on traditional knowledge [8]. Collaboration research involving observation and assessment of indigenous communities offer valuable information necessary for validation of global scientific models and ensures adaptation strategies are in line with local needs and priorities [9]. Collaboration between holders of indigenous knowledge and the mainstream modern scientific research is, therefore, key in coming up with new co-produced knowledge appropriate for adaptation [2]. Non-scientific actors are crucial in helping researchers understand reasons behind failure of adaptation planning and decision-making in matters related to climate change and variability [10]. Despite knowledge co-production between modern science and traditional knowledge growing in its importance, indigenous knowledge systems are under-represented in adaptation policies and are often less understood by the scientific communities. This is mainly due to the fact that indigenous knowledge systems are usually un-codified and are oral in character [2]. Scientists also point out many shortcomings in knowledge co-production by arguing that indigenous knowledge is unsystematic, inaccurate and lacking quantitative aspects.

Throughout the world, use of indigenous knowledge to co-produce appropriate scientific strategies of adaptation to climate change and variability is growing in its popularity. Australia has come up with a National Climate Change Adaptation Research Plan targeting indigenous people [11]. This research plan looks at the best practices used by the indigenous people in dealing with adaptation to climate change and variability with the aim of incorporating best scientific practices in order to bring out some aspects of knowledge co-production. Canada has also established numerous projects funded by the government through the Climate Change Adaptation Programme to promote knowledge co-production between indigenous people and climate scientists [12]. This was achieved upon the realization that modern scientific adaptation strategies were insufficient and required complementation from indigenous knowledge. In the Arctic region, some communities have deployed co-management strategies by combining traditional and modern methods in adaptation to climate change [10]. This has been preferred by many as either of the two methods seems not to yield reliable results when used on their own. Likewise, in most of small islands of the world, community-based adaptation which combines indigenous knowledge and modern scientific methods has been observed to be popular. A form of hybrid knowledge in climate change adaptation has also been witnessed to have emerged in Asia where local and scientific knowledge are used together in adaptation to climate change and variability [13]. This has yielded better results than using either scientific or indigenous adaptation strategies independently.

Despite knowledge co-production being regarded to be beneficial, sometimes studies on joint knowledge production for adaptation to climate change in Africa have provided arguments in favour of indigenous societal merit over scientific merit [14]. Web-based initiatives such as Africa Adapt and we Adapt share climate change adaptation knowledge with much emphasis on indigenous approach. Donors such as UK's Department for International Development (DFID) and Canada's International Development Research Centre (IDRC) are now keen in funding research relating to indigenous knowledge and climate change in the region [10]. Over time, indigenous knowledge has guided many seasonal activities such as farming among local communities by providing finer spacio-temporal practices unmatched by climate scientists. This is because indigenous knowledge focuses on issues relevant to local livelihood well-being and sustainability thus relevant to climate change adaptation [3]. Incorporating indigenous knowledge in scientific research is, therefore, crucial in disaster preparedness due to its near accurate observation system.

In Kenya, there has been use of indigenous knowledge on adaptation to rainfall variability alongside scientific methods although this has not been widely recognized among scholars [15]. This trend is, however, slowly changing due to the recognition of the important role played by indigenous knowledge in adaptation to rainfall variability. A collaboration between the 'rain makers' of Nganyi community of Banyore people in Western Kenya and Kenya Meteorological Department (KMD), for instance, has been aimed at producing locally acceptable seasonal climate forecasts as they are disseminated through both conventional and indigenous methods [15]. The KMD and the 'rain makers' of this community have created a mutual understanding whereby the meteorological department consults the community on their opinion about seasonal climate outlook, an aspect considered in preparation of forecasts for the region. To underscore the importance of this collaboration among academicians, the Great Lakes University of Kenya has developed local knowledge curricula among its academic programmes. Although these are broad curricula, aspects of adaptation to seasonal rainfall variability can be understood in this context.

Kitui South sub-County is located in the semi-arid Southeastern Kenya. Rainfall variability has negatively impacted on rain-fed crop farming in the sub-County leading to households' livelihood vulnerability due to prolonged famine [16]. These shifting rainfall patterns have negatively affected traditional growing seasons and crop yield in most cases crops drying up just before reaching maturity. The adaptation strategies to rainfall variability suggested and even implemented by different stakeholders in the study area have not reduced vulnerability [16]. This requires knowledge co-production between scientific and indigenous knowledge as the later has been in existence and in use over years with success. This paper therefore investigates the extent of knowledge co-production between indigenous farmers and agricultural extension in the study area, relevant in promoting adaptation to rainfall variability.

## 2. METHODOLOGY

### 2.1 Study Site

Kitui South sub-County (Fig. 1) is located in the semi-arid Southeastern Kenya. The area is generally lowland and experiences unreliable bimodal rainfall regime with an average annual amount of about 600 mm [16]. The long rains are received between March and May while the short rains are received from October to December. The short rains are more reliable for rain-fed farming in the study area. Temperature is

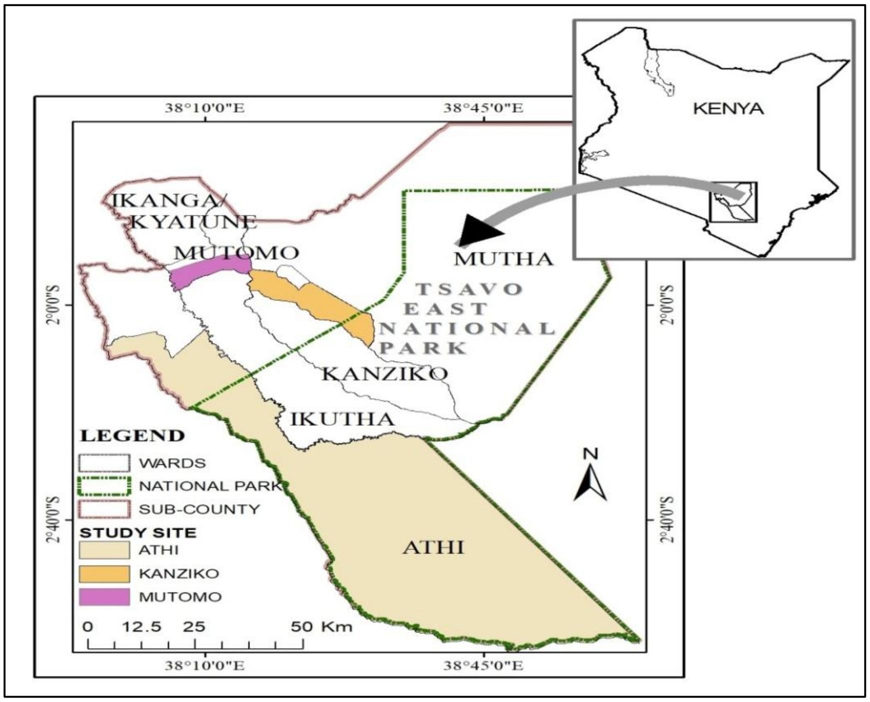


**Fig. 1. Map of the Study Area**
*Source, [17]*

generally high ranging between 18°C and 34°C [16]. The sub-County has four main agro-ecological zones (AEZ's) namely: Lower Midland 4 (LM4), Lower Midland 5 (LM5), Inner Lowland 5 (IL5) and Inner Lowland 6 (IL6). Crop farming is mainly practiced in three AEZs of LM4, LM5 and IL5 as agro-ecological zone IL6 receives very little or no rainfall in most of the years [16].

Over 87% of the residents in the study area derive their livelihoods from agriculture with main crops grown being maize, beans, sorghum, millet, green grams, cow peas and pigeon peas. Most of the households practice subsistence crop farming with few large-scale farms of sorghum and green grams of not more than 60 acres [16]. The adaptation strategies to rainfall variability suggested and even implemented by various stakeholders in the proposed study area have not reduced vulnerability [16].

## 2.2 Research Design

The study adopted survey research design where both quantitative and qualitative approaches were used to achieve its objectives. In qualitative approach, Key Informant Interviews was used while in quantitative approach, cross-sectional household survey was used.

## 2.3 Sample and Sampling Procedure

Kitui South sub-County was purposively picked due to its dominance in rain-fed agricultural activity, nearness to a meteorological station and proneness to drought events. Multi-stage sampling design was used to obtain the administrative divisions and households to be used in the study. In stage one, all the six administrative divisions in the sub-County were listed and clustered based on various agro-ecological zones (AEZs), land-use system activities and the extent to which they are perceived to be prone to extreme rainfall events. There are six AEZs in the sub-County namely Low Midland 4 (LM4), Low Midland 5 (LM5), Inner Lowland 5 (IL5), Inner Lowland 6 (IL6), Upper Midland 3-4 (UM3-4) and Upper Midland 4 (UM4) [18].

In stage two, purposive sampling was used to select the study sites. Out of the six administrative divisions in the sub-County, three (Athi, Mutomo and Kanziko) were purposively sampled to represent the three main agro-ecological zones, LM5, LM4 and IL5, where crop farming is dominant and highly affected by rainfall variability. Three administrative locations, one from each division, were also purposively sampled. This was based on proximity to administrative centre of the divisions for institutional support and access to key informants. These were Mutomo location (in Mutomo division), Athi location (in Athi division) and Kanziko location (in Kanziko division).

In stage three, proportional sampling technique was used to obtain the number of households' heads to be interviewed per location. According to 2009 Kenya's population and housing census, the study area (the three locations) has 3,409 households [19]. A list of all heads of households engaged in crop farming was obtained from the Chief's office of each location to form the sample frame. The study was guided by Krejcie and Morgan formula [20] to determine the number of households to be involved during questionnaire interview. This gave a sample of 345 households.

The number of respondents to be interviewed during the household survey in each location was established. This was guided by the formula shown in Equation 1.

$$n = p/\mu \times 345 \quad (1)$$

Where;

n is the sample size for the location
p is the population of households in the location
μ is the total households in the three locations

The sample size for each administrative location is shown in Table 1.

**Table 1. Sample population for households**

| Location | Total households | Sampled households |
|---|---|---|
| Mutomo | 1,132 | 114 |
| Athi | 1,251 | 127 |
| Kanziko | 1,026 | 104 |
| Total | 3,409 | 345 |

*Source: Field data 2019*

## 2.4 Data Collection and Analysis

Questionnaire was used to collect data from all the sampled households' heads in the study area. To avoid misinterpretation of the questions, the household questionnaire interview was conducted in the local language by local field assistants. The questions were semi-structured with dichotomous responses, multiple responses and open ended questions.

Frequencies and percentages were used to establish the relationships between indigenous and scientific methods of farming. This was between corresponding indigenous and modern scientific methods of farming. This was done to establish instances of knowledge co-production in adaptation to rainfall variability.

# 3. RESULTS AND DISCUSSION

All respondents reported to have generally used both indigenous and modern methods in adaptation to rainfall variability in the previous three years. Table 2 and Table 3 show results on use of specific indigenous and scientific/modern farming methods respectively.

Results in Table 2 shows that none of the households used furrow irrigation and that all the households used hands in crop harvesting. Majority of the households used locally preserved seeds (92.0%), traditional seasonal climate forecast (74.9%), traditional crop storage methods (70.7%), oxen in land preparation (68.8%), farm yard manure (64.6%) and traditional pest control (63.0%).

Results in Table 3 shows that none of the households used modern irrigation methods and machinery in crop harvesting. Majority (79.4%) of the households used modern SCF, certified seeds (65.6%), pesticides (55.9%) and modern methods of crop storage (53.7%).

**Table 2. Usage of indigenous farming practices**

| Indigenous practice | Usage |
|---|---|
| Use of locally preserved seeds (eg. *kikamba, kinyanya*) | 286 (92.0%) |
| Use of farm yard manure | 201 (64.6%) |
| Use of oxen in land preparation | 214 (68.8%) |
| Use of furrow irrigation method | 0 (0.00%) |
| Traditional seasonal climate forecast (weather lores) | 233 (74.9%) |
| Use of traditional pest control (eg. ash, cow dung) | 196 (63.0%) |
| Use of hands in harvesting | 311 (100.0%) |
| Traditional methods of crop storage (eg. use of ash, smoking) | 220 (70.7%) |

*Source: Field data 2019*

**Table 3. Usage of scientific methods of farming**

| Modern practice | Usage |
|---|---|
| Use of certified seeds | 204 (65.6%) |
| Use of fertilizer | 6 (1.9%) |
| Use of machinery in land preparation eg. tractors | 49 (15.8%) |
| Use of modern irrigation method eg. drip, solar/petrol pump | 0 (0.00%) |
| Use scientific seasonal climate forecast (SCF) from KMD | 247 (79.4%) |
| Use of pesticides | 174 (55.9%) |
| Use of machinery in harvesting eg. combined harvester | 0 (0.00%) |
| Modern methods of crop storage eg. pest-proof bags, portable silos | 167 (53.7%) |

*Source: Field data 2019*

**Table 4. Cross-tabulation between indigenous and scientific farming methods**

| Traditional methods | Modern methods | | | | | |
|---|---|---|---|---|---|---|
| | Certified seeds | Use of fertilizer | Use of machinery | Scientific SCF | Modern pest control | Modern storage |
| Use of local seeds | 179 (57.6%) | 6 (1.9%) | 47 (15.1%) | 222 (71.4%) | 149 (47.9%) | 159 (51.1%) |
| Farmyard manure | 145 (46.6%) | 0 (0.0%) | 22 (7.1%) | 161 (51.8%) | 107 (34.4%) | 142 (45.7%) |
| Use of oxen to cultivate | 136 (43.7%) | 6 (1.9%) | 47 (15.1%) | 154 (49.5%) | 130 (41.8%) | 95 (30.5%) |
| Traditional forecast | 147 (47.3%) | 0 (0.0%) | 30 (9.6%) | 201 (64.6%) | 118 (37.9%) | 143 (46.0%) |
| Traditional pest control | 121 (38.9%) | 0 (0.0%) | 9 (2.9%) | 163 (52.4%) | 85 (27.3%) | 131 (42.1%) |
| Traditional crop storage | 131 (42.1%) | 0 (0.0%) | 13 (4.2%) | 184 (59.2%) | 104 (33.4%) | 142 (45.7%) |

*Source: Field Data 2019*

Cross-tabulation between the six widely used indigenous and scientific/modern farming methods was done. These were the type of cultivar planted, use of manure and fertilizer, land preparation methods, seasonal climate forecast, pest control methods and crop storage methods. This was aimed at showing areas of knowledge co-production between any of the farmers' indigenous knowledge and scientific/extension knowledge. However, cross-tabulation was not done for irrigation and methods of harvesting as these methods were not used concurrently by households in the study area. The results are shown from Table 4.

Table 4 shows that there was a high use of both locally preserved seeds and modern seasonal climate forecast (71.4%), use of traditional seasonal climate forecasts and use of modern seasonal climate (64.6%) as well as use of traditional crop storage and use modern seasonal climate forecast (59.2%). This may be attributed to the high use of modern seasonal climate forecast information among smallholder farmers in the area. There was low knowledge co-production in the use of oxen in land preparation and use of fertilizer (1.9%), use of locally preserved seeds and fertilizer (1.9%) as well as use of traditional methods of pest control and use of machinery in land preparation (2.9%). Use fertilizer and machinery in land preparation may have been low due to financial constraints in acquiring these inputs. There was no household which used farm yard manure and fertilizer, traditional seasonal climate forecast and fertilizer, traditional methods of pest control and fertilizer as well as traditional methods of crop storage and fertilizer. This could be due to the low rate of use of fertilizer by the households caused by financial constraints in acquiring it.

A comparison in use of corresponding indigenous and scientific/modern methods was done. The results are shown in Fig. 2.

Use of both modern and traditional seasonal climate forecast was the leading (64.6%) aspect of knowledge co-production among the corresponding methods. This is important since use of either of the two methods may have their

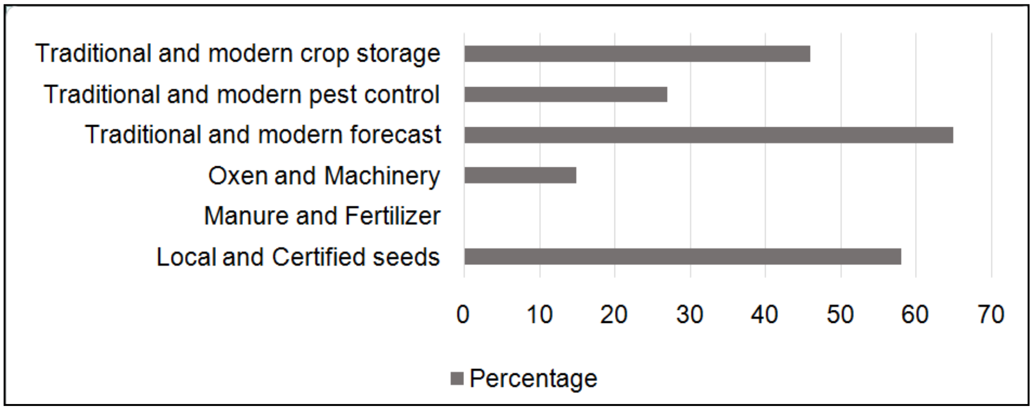


**Fig. 2. Knowledge co-production levels**
*Source: Field data 2019*

weaknesses. In their study on use of indigenous weather forecasting among the Shona community of Zimbabwe, [21] noted that blending of indigenous methods of seasonal climate forecast with modern scientific techniques was important as it gives some degree of reliability. Use of both locally preserved and certified seeds was at 57.6%. This may be attributed to the support of households in the study area by NGOs and CBOs to access modern seed varieties scientifically developed to adapt to specific environment as well as use of traditional seeds. Smallholder farmers in rural areas generally have low ability to access scientific modified seeds [22]. Although farm yard manure and fertilizer were used in the study area, no household used both inputs. This may be attributed to inability of most households to acquire fertilizer, opting for cheaper farm yard manure. In addition, households without livestock (the main source of farm yard manure) and income enough to afford fertilizer are not likely to use both inputs. Use of either farm yard manure or fertilizer also depends on the crop grown, soil type and climatic conditions of an area [23]. This is, therefore, an indication that there is no knowledge co-production between use of farm yard manure and fertilizer in the study area. More than 15% of the households used both oxen and machinery in land preparation. This finding corresponds to that of Babu [24] who found that both draught animals and power machinery used in Mbarali District in Tanzania, an aspect of knowledge co-production.

Over 27% of the households reported to have used both traditional methods and scientific methods in pest control for the previous three years, an indication of knowledge co-production between these two methods. The greater use of traditional methods of pest control may be due to the fact that traditional methods of pest control are cheap and sometimes absolutely freely and readily available as compared to modern scientific pesticides. It can also be noted that 45.7% of the households used both traditional and modern methods of storing crop produce indicating knowledge co-production in use of the two methods. In a similar study on traditional science of seed and crop yield among indigenous women farmers of Matabeleland South Province in Zimbabwe, it was also established that smoke coating and ash mixtures were commonly used alongside modern methods of storage of crop harvest as this was economical in terms of time and labour [25].

## 4. CONCLUSION AND RECOMMENDATION

The study established that there were instances of knowledge co-production in the study area. However, this was limited to seeds for planting, land preparation methods, seasonal climate forecasting, pest control methods and crop storage methods. Use of both indigenous and modern methods of seasonal climate forecasting was the leading instance of knowledge co-production in the study area. Since crop production in dryland is mainly affected by insufficient moisture due to unreliable rainfall, it is recommended that knowledge co-production should be promoted in irrigation as this is key in improving crop farming in the study area.

## CONSENT

Informed consent form was prepared and provided to all sampled household heads. It provided all information about the research and voluntary consent of their participation. The respondents were assured of confidentiality of the information obtained during the study, risks and benefits of the study as well as their rights as participants.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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## APPENDIX: QUESTIONNAIRE FOR FARMERS

### Please tick the appropriate response or give a brief comment where applicable

**Part A: Personal details**

1. Gender of the household head:

[ 1 ] Male  [ 2 ] Female

2. Education level of household head:

[ 1 ] Non formal education [ 2 ] Primary [ 3 ] Secondary  [4] Tertiary

3. Age bracket of household head (in years)

[ 1 ] Below 35  [ 2 ] 36-50  [ 3 ] 51-65  [ 4 ] Above 65

4. Household size (members):

[ 1 ] Below 5  [ 2 ] 5-10  [ 3 ] 11-15  [ 4 ] Above 15

**Part B: Socio-economic Factors**

5. Where does your household get its food from?

[ 1 ] Family farm only  [ 2 ] Family and rented farm [ 3 ] Family farm and buying  [ 4 ] Buying only  [ 5 ] Other sources (specify)……………………………………………

6. What is the source of income for your household?

[ 1 ] Crop farming only [ 2 ] Crop and livestock farming [ 3 ] Non- agricultural sources

7. What is the total land size owned your household (in acres)? ………………………….
8. What is the size of land leased/rented (in acres)? ………………………………………..
9. What is the size of land currently under farming (in acres)? ……………………………

**Part C: Knowledge co-production**

10. Have you received any training on adaptation to rainfall variability in the last three years?

[ 1 ] Yes    [ 2 ] No

*NB: If 'No' proceed to question 15*

11. If yes (in 10 above), by which organization(s)?

[ 1 ] Government extension    [ 2 ] NGOs    [ 3 ] CBOs    [ 4 ] Others (specify)……………….

12. Which specific areas have you been trained on?

[ 1 ] Early warning    [ 2 ] Soil management    [ 3 ] Crop breeding/selection    [4] Farming methods    [ 5 ] Any other (specify)……………………………………

13. How often do you interact with the agricultural extension officers during training?

[ 1 ] Always    [ 2 ] Very often    [ 3 ] Often    [ 4 ] Not often    [ 5 ] Not at all

14. Has the training helped you to adapt to rainfall variability?

[ 1 ] Yes    [ 2 ] No

15. Indicate the indigenous farming practices you have been using for the last three years:

[1] Use of locally preserved seeds (eg. *kikamba, kinyanya*) ☐
[2] Use of farm yard manure ☐
[3] Use of oxen in land preparation ☐
[4] Use of furrow irrigation method ☐
[5] Traditional seasonal climate forecast (weather lores) ☐
[6] Use of traditional pest control (eg. ash, cow dung) ☐
[7] Use of hands in harvesting ☐
[8] Traditional methods of crop storage (eg. ash, smoke) ☐

16. Indicate the scientific/modern methods of farming you have been using for the last three years:

[1] Use of certified seeds ☐
[2] Use of fertilizer ☐
[3] Use of machinery in land preparation eg. tractors ☐
[4] Use of modern irrigation method eg. drip, solar/petrol pump ☐
[5] Use scientific seasonal climate forecast from KMD ☐
[6] Use of pesticides ☐
[7] Use of machinery in harvesting eg. combined harvester ☐
[8] Modern methods of crop storage eg. pest-proof bags, portable silos ☐

17. What do you think should be done to develop effective and sustainable adaptation strategies to rainfall variability?

[1] Increased training by agricultural extension officers on scientific methods of adaptation
[2] Financial support from the government on adaptation
[3] Use of both indigenous and scientific methods in adaptation
[4] Engaging more on non-agricultural economic activities
[5] Any other (specify) ………………………………………………………
………………………………………………………………………………

**THANK YOU FOR YOUR PARTICIPATION**



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