Strengthening Innovation and Technology Dissemination for Sustainable Development in Cereals, Cocoa and Coffee Value Chains in Western and Eastern Africa (SATIFFS)

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Baseline Report on the Inventory of Available Technologies for Maize and Rice Value Chains in Northern Uganda

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Editorial

This report was compiled by:

Dr. Martine Nyeko, Operational Unit Coordinator, SATIFFS Project, Gulu University

Dr. Grace Okiror, Operational Unit Assistant, SATIFFS Project, Gulu University

Dr. Collins Okello, Field Technology Person, SATIFFS Project, Gulu University

Ms. Grace Lawino, Project Administrator, SATIFFS Project, Gulu University

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Table of Contents

List of Figures

List of Tables

Executive Summary

The project: Strengthening Innovation and Technology Dissemination for Sustainable Development in Cereals, Cocoa and Coffee Value Chains in Western and Eastern Africa (SATIFFS), is a European Union funded project under the African, Caribbean and Pacific Group of States Science and Technology II Programme. The technical partners are the University of Molise and ARPA Molise in Italy. The Implementing partners are BioEconomy Africa (Ethiopia), University of Energy and Natural Resources, (Ghana) and Gulu University (Uganda). The overall goal of SATIFFS is "To Contribute to the Strengthening of Science, Technology and Innovation (STI) Capacities in the Agricultural Sector of Western and Eastern African Countries to Enable Food Security and Social Economic Development". The project has the following specific objectives:

1. Establishment of working partnerships among the participating institutions.
2. Establishment of 3 Centres for Innovation and Technology dissemination (CITED) in each ACP partner Country.
3. Dissemination of successfully proven Appropriate Technologies (ATs).

As a first step toward the implementation of this project, a baseline of status of technology utilisation and adoption in the selected value chains is required. In Uganda, this project targets the maize and rice value chains in the districts of Amuru, Gulu and Nwoya in Northern Uganda. This report presents results of the baseline study conducted in these districts. The baseline involved a desk review, field study visits and a stakeholders' workshop. The findings are consolidated in the report under the various subsections, concluding with the proposal for subsequent project activities.

During the baseline study, it was noted that the production of rice and maize at household level relies heavily on manual labour, with exception of the use of oxen and tractors for land opening, whenever these are accessible. The farming operations of planting, weeding, harvesting, threshing and drying mostly rely on human labour. Critical areas for technological intervention obtained consultatively with key stakeholders were identified as shelling and drying for maize, and planting, weeding, harvesting, threshing and drying for rice. It is also important that any technological intervention should affordable, functional, simple to operate and readily available; and ensure improvement in product quality. This report proposes some appropriate technologies for addressing these issues.

Section I: Literature Survey

A literature survey was conducted to establish existing knowledge on the target enterprises of maize and rice in general, but especially aspects relevant to the project location of Northern Uganda. The report is divided into two sections: one focusing on quality characteristics, existing standards, and detection methods; and a second one explores aspects related to storage as they affect storage.

I (a): Quality, Standards and Detection

This section discusses aspects of rice and maize quality standards and attributes, methods of detection and measurement, both laboratory and field, traditional vs modern. Rice and maize form the major enterprises currently undertaken by the people of Northern Uganda, both as staple foods as well as commercial crops for income generation. On average, households cultivate between 5 – 10 acres of either of these crops each year, with a minimum of one acre and higher values around 50, for individual households. However, a few high technology and investment farms also exist in these districts with farm sizes ranging between 250 and 500 acres.

1.0 Rice quality standards and assessment

1.1 Terms and Nomenclature

The following are the terms with their definitions most commonly encountered in the rice industry.

Paddy (rough or un-milled) rice: This is rice that has been harvested from the plant with its hull (husk) intact after threshing.

Brown rice: This is rice which has passed through the first step of processing called hulling. The hull is not eaten by humans but is sometimes burned for use as an energy source. The colour may vary from light yellow to red to dark purplish black.

White or milled rice: This is rice that has passed through the second step of processing known as milling where the bran and germ have been removed. The bran has been removed to an extent dictated by the process, equipment and preferences employed. Rice bran and germ contains greater amounts of dietary fibre, vitamins, minerals and fats.

Head rice: milled rice with length greater or equal to three quarters of the average length of the whole kernel

Large brokens: milled rice with length less than three quarters but more than one quarter of the average length of the whole kernel

Small brokens or "brewers rice": milled rice with length less than one quarter of the average length of the whole kernel

Whole kernel: milled rice grain without any broken parts

1.2 General rice quality attributes

The general quality attributes of rice are categorised depending on either rough or milled rice.

1.2.1 Quality attributes of un-milled rice

A number of interrelated features determine the quality of rough rice and they include:

1. Moisture content
2. Degree of physical purity
3. Purity of variety
4. Grain dimensions
5. Percentage of cracked or damaged grains
6. Percentage of immature grains
7. Percentage of discoloured or fermented grains

These characteristics are determined by the environmental weather conditions during production, crop production practices, soil conditions, harvesting, and post-harvest practices

Moisture content: Moisture content has a marked influence on all quality aspects of both rough and milled rice and it is essential that paddy be milled at the proper moisture content to obtain the highest head rice yield. The optimum moisture content of handling and milling rough rice is 14% wet weight basis. Grain with higher moisture content becomes too soft to withstand hulling pressure which results in grain breakage and possibly pulverization of the grain. Grain that is too dry becomes brittle and has greater breakage.

Degree of physical purity: Purity is related to the presence of dockage in the grain. Dockage refers to material other than paddy and includes chaff, stones, weed seeds, soil, rice straw, stalks, etc. These impurities generally come from the field or from the drying floor. Unclean paddy increases the time taken to clean and process the grain. Foreign matter in the grain reduces milling recoveries and the quality of rice and increases the wear and tear on milling machinery.

Purity of variety: Different varieties of rice may have different sizes, shapes, and milling properties. A mixture of varieties causes difficulties at milling and usually results in reduced capacity, excessive breakage, lower milled rice recovery and reduced head rice. Different sizes and shaped grains make it more difficult to adjust hullers, whiteners and polishers to produce whole grains. This in turn results in low initial husking efficiencies, a higher percentage of re-circulated paddy, non-uniform whitening, and lower grade of milled rice.

Grain dimensions: Grain size and shape (length: width ratio) depends on the variety. Long slender grains normally have greater breakage than short, bold grains, and consequently have a lower milled rice recovery. The grain dimensions may also dictate to some degree the type of milling equipment needed. For instance, the Japanese designed milling equipment may be better suited to short bold, japonica grains whereas Thai made equipment will be more suitable for longer, slender grain types.

Percentage of cracked or damaged grains: Overexposure of mature paddy to fluctuating temperature and moisture conditions leads to development of fissures and cracks in individual kernel. Cracks in the kernel are the most important factor contributing to rice breakage during milling. Paddy also deteriorates through biochemical changes in the grain, the development of off-odours and changes in physical appearance. These types of damage are caused from water, insects, and heat exposure.

Percentage of immature grains: The amount of immature paddy grains in a sample has a major effect on head rice yield and quality. The immature rice kernels are very slender and chalky and this results in excessive production of bran, broken grains and brewer's rice. The optimal stage to harvest grain is at about 20-24% grain moisture or about 30 days after flowering. Later harvesting results in many grains lost through shattering or drying out and cracking during threshing, which in turn causes grain breakage during milling.

Percentage of discoloured or fermented grains: Yellowing is caused by over-exposure of paddy to wet environmental conditions before it is dried. This results in a combination of microbiological and chemical activity that overheats the grain. These fermented grains frequently possess partly gelatinized starch cells and generally resist the pressures applied during grain milling. While the presence of fermented grain does not affect milling yields it does downgrade the quality of the milled rice because of the unattractive appearance.

Insect- or mould-damaged grains can be distinguished by the presence of black spots around the germ end of the brown rice kernel which are caused by the microorganisms, insects, or a combination. Mould damage in particular is increased by unfavourable weather conditions. In the process of milling, these black spots are only partly removed which consequently increases the presence of damaged grains.

1.2.2 Quality attributes of milled rice

The quality attributes of milled rice are classified according to both physical and chemical characteristics.

Physical quality attributes

Milling degree: The degree of milling is a measure of the per cent bran removed from the brown rice kernel. The milling degree affects milling recovery and influences consumer acceptance.

Head rice: head rice percentage is the weight of head grain or whole kernels in the rice lot. Head rice normally includes broken kernels that are 75-80% of the whole kernel. High head rice yield is one of the most important criteria for measuring milled rice quality. Broken grain has normally only half of the value of head rice. The actual head rice percentage in a sample of milled rice will depend on both varietal characteristics (i.e. the potential head rice yield), production factors, and harvesting, drying and milling process. In general harvesting, drying, and milling can be responsible for some losses and damage to the grain.

Whiteness: whiteness is a combination of varietal physical characteristics and the degree of milling. In milling, the whitening and polishing greatly affect the whiteness of the grain. During whitening, the silver skin and the bran layer of the brown rice is removed. Polishing after whitening is carried out to improve the appearance of the white rice.

Chalkiness: If part of the milled rice kernel is opaque rather than translucent, it is often characterized as "chalky". Chalkiness disappears upon cooking and has no effect on taste or aroma, however it downgrades milled rice. Excessive chalkiness is caused by interruption during the final stages of grain filling. Though chalkiness disappears upon cooking and has no direct effect on cooking and eating qualities, excessive chalkiness downgrades the quality and reduces milling recovery.

Chemical quality attributes

Gelatinization temperature (GT): The time required for cooking milled rice is determined by gelatinization temperature or GT. Environmental conditions, such as temperature during ripening, influence GT. A high ambient temperature during development results in starch with a higher GT.

Amylose content: Starch makes up about 90% of the dry matter content of milled rice. Starch is a polymer of glucose and amylose is a linear polymer of glucose. The amylose content of starches usually ranges from 15 to 35%. High amylose content rice shows high volume expansion (not necessarily elongation) and high degree of flakiness. High amylose grains cook dry, are less tender, and become hard upon cooling. In contrast, low-amylose rice cooks moist and sticky. Intermediate amylose rice varieties are preferred in most rice-growing areas of the world, except where low-amylose japonicas are grown.

Gel consistency: Gel consistency measures the tendency of the cooked rice to harden after cooling. Within the same amylose group, varieties with a softer gel consistency are preferred, and the cooked rice has a higher degree of tenderness. Harder gel consistency is associated with harder cooked rice and this feature is particularly evident in high-amylose rice. Hard cooked rice also tends to be less sticky. Gel consistency is determined by heating a small quantity of rice in a dilute alkali.

1.3 Rice quality standards and specifications

The existing East African Standards' (EAS) specifications for rice at different stages are presented in the following tables.

Table 1. Specific requirements for un-milled rice (EAS 764:2011)

Characteristics		**Maximum limits**			**Method of test**
		Grade 1	**Grade 2**	**Grade 3**	
Foreign matter, % m/m	Organic	1.0	1.5	2.0	ISO 605
	Inorganic	0.25	0.25	0.5	
Pest damaged grains, % m/m		0.5	0.75	1.0	
Discoloured grains, % m/m		0.1	0.5	1.0	
Moisture, % m/m		13	13	13	EAS 82
Immature/Shriveled grains, % m/m		1	3	5	ISO 605
Total Aflatoxin (AFB1+AFB2+AFG1+AFG2)), ppb		10			ISO 16050
Aflatoxin B1 only, ppb		5			
Fumonisin ppm		2			

Table 2. Specific requirements for brown rice (EAS 765:2011)

Characteristics	Maximum limits			Test Method
	Grade 1	Grade 2	Grade 3	
Broken, %, max	2	5	7	ISO 605
Heat damaged rice, %, max	1.5	1.5	2.0	
Damaged rice, %, max	1.0	2	4.0	
Chalky %, max.	2	4	6	
Red or red streaked, %, max.	1,0	4	12	
immature grains, %, max	2	6	12	
Other contrasting varieties, % max	1	2	5	
Organic matters, %, max	0.1	0.5	1	
Inorganic matters, %, max	0.1	0.1	0.1	
Live weevils/kg, max	Nil	Nil	Nil	
Filth, %, max	0.1	0.1	0.1	
Paddy grains, %, max.	1	2	2.5	
Moisture contents, %, max	13	13	13	EAS 82
Total Aflatoxin (AFB1+AFB2+AFG1+AFG2)), ppb	10			ISO 16050
ISO 16050 Aflatoxin B1 only, ppb	5			
Fumonisin ppm	2			

Table 3. Specific requirements for milled rice (EAS 128:2013)

Characteristics	Maximum limits			Method of test
	Grade 1	Grade 2	Grade 3	
Broken, %	5	15	25	ISO 605
Heat damaged rice, %	1	1.5	2.0	
Damaged rice, %	1.5	2	3.0	
Chalky %	2	4	10	
Red or red streaked, %	2	6	12	
Immature grains, %	1	1.5	2	
Other contrasting varieties, %	1	2	3	
Organic matter, %	0.1	0.2	0.5	
Inorganic matter, %	0.1			
Paddy grains, %	0.3			
Live weevils in kg	Nil			
Filth, %	0.1			
Moisture content, %	14			ISO 711/ISO 712
Total aflatoxin (AFB1+AFB2+AFG1 +AFG2), ppb	10			ISO 16050
Aflatoxin B1, ppb	5			
Fumonisin, ppm	2			AOAC 2001.04
NOTE: The parameter, Total defective grains is not the sum total of the individual defects. It is limited to 70 % of the sum total of individual defects.				

Table 4. Microbiological limits for milled rice (EAS 128:2013)

S/N	Type of micro-organism	Limits	Method of test
i)	Yeasts and moulds, cfu per g, max.	104	EAS 217
ii)	*Staphylococcus.aureus*, cfu per g, max.	103	
iii)	*Escherichia coli*, per g	Absent	
iv)	*Salmonella*, per 25 g	Absent	

1.4 Rice quality assessment procedures

Grain size and shape: The length to width ratio (L/W) falling between 2.5 and 3.0 is generally considered widely acceptable as long as the length is more than 6 mm.

Size classification:

Scale	Size category	Length in mm
1	Very long	More than 7.50
3	Long	6.61 to 7.50
5	Medium or intermediate	5.51 to 6.60
7	Short	Less than or equal to 5.50

Shape classification:

Scale	Shape	Length/width ratio
1	Slender	Over 3.0
5	Medium	2.1 to 3.0
9	Bold	2.0 or less than 2.0

Chalkiness: A visual rating of the chalky proportion of the grain is used to measure chalkiness based on the Standard Evaluation System (SES) scale presented below:

Scale	% area of chalkiness
1	less than 10
5	10-20
9	more than 20

Amylose content: Select twenty grains and ground them in a Cyclone Mill. Amylose content is analyzed using the simplified iodine colorimetric procedure. Samples are categorized into low, intermediate and high based on the following grouping:

Category	%Amylose Content
Waxy	1-2
Very low amylose	2-9
Low	10-20
Intermediate	20-25
High	25-30

Gelatinization temperature (GT): GT is measured by determining the alkali-spreading value for which the alkali digestibility test is employed. Grains are soaked in 1.7% KOH and incubated in a 30˚C oven for 23 hours. Measurement ranges are based on the following: Gelatinization temperature is estimated by the extent of alkali spreading and clearing of milled rice soaked in 1.7% KOH at room temperature or at 39°C for 23 hours. The degree of spreading is measured using a seven-point scale as follows:

1. grain not affected
2. grain swollen,
3. grain swollen, collar incomplete and narrow,
4. grain swollen, collar complete and wide,
5. grain split or segmented, collar complete and wide,
6. grain dispersed, merging with collar; and
7. grain completely dispersed and intermingled.

Category	Temp ranges (˚C)	Alkali Spreading Value
Low	55-69	6-7
Intermediate	70-74	4-5
High	75-79	2-3

Gel consistency: Select from two to 10 grains and ground separately in the Wig-L Bug. Gel consistency is measured by the cold gel in a horizontally-held test tube, for one hour. Measurement ranges and category are as follows:

Category	Consistency, mm
Soft	61-100
Medium	41-60
Hard	26-40

1.5 Laboratory tools and equipment

The following is a list of tools and equipment can be used to carry out the above mentioned quality assessment procedures:

1. Laboratory oven
2. Calibrated grain moisture meter
3. Analytical balance
4. Rice crack detector
5. Digital calliper
6. Laboratory rice huller
7. Rice grain grader
8. Laboratory incubator
9. Whiteness meter
10. Satake abrasive mill
11. Engleberg rice mill
12. Plastic boxes (50 mm x 50 mm x 25 mm)
13. Spectrophotometer
14. AutoAnalyzer
15. Wig L-bug
16. Assorted laboratory ware such as beakers, test tubes, pipettes and measuring cylinders, among others

2.0 Maize quality standards and assessment

2.1 Terms and definitions

The following are terms and definitions that are commonly encountered in maize standards and industry (adopted from the East African Grain Standards).

2.1.1 Maize grain

Maize (corn): shelled grains or kernels of the species *Zea mays indentata* L, (dent maize) and/or *Zea mays indurata* L, (flint maize), or their hybrids

Blemished/damaged grains: grains which are insect or vermin damaged, stained, diseased, discoloured, germinated, frost damaged, or otherwise materially damaged.

Insect or vermin damaged grains: kernels with obvious weevil-bored holes or which have evidence of boring or tunnelling, indicating the presence of insects, insect webbing or insect refuse, or degermed grains, chewed in one or more than one part of the kernel which exhibit evident traces of an attack by vermin.

Stained kernels: kernels whose natural colour has been altered by external factors. This includes ground, soil or weather damaged kernels, which may have dark stains or discolourations with a rough external appearance.

Diseased grains: grains made unsafe for human consumption due to decay, moulding, or bacterial decomposition, or other causes that may be noticed without having to cut the grains to examine them.

Discoloured kernels: kernels materially discoloured by excessive heat, including that caused by excessive respiration (heat damage) and dried damaged kernels. Kernels may appear darkened, wrinkled, blistered, puffed or swollen, often with discoloured, damaged germs. The seed coat may be peeling or may have peeled off completely, giving kernels a checked appearance.

Germinated kernels: kernels showing visible signs of sprouting, such as cracked seed coats through which a sprout has emerged or is just beginning to merge.

Frost damaged kernels: kernels which appear bleached or blistered and the seed coat may be peeling. Germs may appear dead or discoloured.

Mouldy kernels: maize grains with visible mycelial growth on its tip or surface.

Immature/shrivelled grains: maize grains which are underdeveloped, thin and papery in appearance.

Broken kernels: pieces of maize which shall pass through a 4.50 mm metal sieve

Other grains: other grains are edible grains, whole or identifiable broken, other than maize (i.e., cereals, pulses and other edible legumes).

Foreign matter: all organic and inorganic material (such as sand, soil, glass) other than maize, broken kernels and other grains.

Filth: impurities of animal origin

Defective grains: pest damaged, discouloured, diseased, germinated, mouldy, immature and shriveled grains, or otherwise materially damaged, which specifically do not include broken grains

2.1.2 Maize flour

Whole maize meal: product obtained by grinding clean whole maize kernel by the use of mill or other grinding methods excluding roller *milling*

Granulated maize meal: the product obtained by roller milling and sifting of shelled clean maize and complying with requirements indicated in Table 1

Sifted maize meal: This is the product obtained by roller milling and sifting shelled clear maize.

Sifting: the particle size separation by sieving and aspiration of roll-milled products

Cleaned maize: the shelled maize that shall have been subjected to a cleaning process for the removal of foreign and objectionable matter originally present.

Maize flour: product obtained by removing the germ and bran followed by grinding, clean maize kernels using roller mills or other methods and sifting the resulting product to suitable degree of fineness.

2.2 General maize grain quality attributes

2.2.1 General description

I. Maize may be presented as yellow, white, or red, or a mixture of these colours.

II. Yellow maize may contain not more than 5.0 % by weight of maize of other colours. Maize grains which are yellow and/or light red in colour are considered to be yellow maize. Yellow maize also means maize grains which are yellow and dark red in colour, provided the dark red colour covers less than 50 % of the surface of the grain.

III. White maize may contain not more than 2.0 % by weight of maize of other colours. Maize grains which are white and/or light pink in colour are considered to be white maize. White maize also means maize grains which are white and pink in colour, provided the pink colour covers less than 50 % of the surface of the grain.

IV. Red maize may contain not more than 5.0 % by weight of maize of other colours. Maize grains which are pink and white, grey or dark red and yellow in colour are considered to be red maize, provided the pink or dark red or yellow colour covers 50 % or more of the surface of the grain.

V. Mixed maize includes maize not falling into the classes of white, yellow or red maize as defined in 4.1.2 to 4.1.4

VI. Maize also may be presented as flint or dent or their hybrids or mixtures thereof.

VII. Flint maize includes maize of any colour which consists of 95 % or more by weight of grains o flint maize.

VIII. Dent maize includes maize of any colour which consists of 95 % or more by weight of grains of dent maize.

IX. Flint and dent maize includes maize of any colour which consists of more than 0.5 % but less than 95.0 % of flint maize.

X. Maize shall be free from foreign odours, moulds, live pests, rat droppings, toxic or noxious weed seeds and other injurious contaminants as determined from samples representative of the lot.

XI. Maize shall be of a reasonably uniform colour according to type, be whole and clean.

2.2.2 Quality specifications

Grading: Maize grains shall be graded into three grades on the basis of the tolerable limits established in Table 1 which shall be additional to the general requirements set out in this standard.

Ungraded maize grains: Shall be maize grains which do not fall within the requirements of Grades 1, 2 and 3 of the East African Standard but are not rejected maize grains.

Reject grade maize grains: This comprises maize grains which have objectionable odour, off flavour, living insects or which do not possess the quality characteristics specified in Table 2.1. They cannot satisfy the conditions of ungraded maize grains and shall be graded as reject maize grains and shall be regarded as unfit for human consumption.

Table 5. Quality Specifications of Maize Grain (EAS 2)

Characteristics	Maximum limits			Method of test
	Grade 1	Grade 2	Grade 3	
Foreign matter, % m/m	0.5	1.0	1.5	ISO 605
Inorganic matter, % m/m	0.25	0.5	0.75	
Broken kernels, % m/m	2.0	4.0	6.0	
Pest damaged grains, % m/m	1.0	3.0	5.0	
Rotten & Diseased grains, % m/m	2.0	4.0	5.0	
Discoloured grains, % m/m	0.5	1.0	1.5	
Moisture, % m/m	13.0	13.0	13.0	EAS 285/ISO 711/712
Immature/Shriveled grains, % m/m	1.0	2.0	3.0	ISO 605
Filth, % m/m	0.1	0.1	0.1	
Total Aflatoxins, ppb	10			ISO 16050
Aflatoxin B1, ppb	5			
Fumonisin, ppm	2			
Total Defectives Grains, % m/m	4.0	5.0	7.0	ISO 605

2.3 General maize flour quality attributes

2.3.1 General description

I. Maize meal shall be of natural colour conforming to the colour of maize from which it was prepared.

II. Maize meal shall not contain any foreign matter such as insects, fungi, dirt or other contaminants above the level permitted in EAS 2.

III. Maize meal shall be free from fermented musty or other objectionable colours.

IV. Maize meal shall be free from rancidity and foreign odours.

V. Maize meal shall be wholesome and fit for human consumption in all aspects.

2.3.2 Quality specifications

Milled Maize products shall conform to the requirements given in Table 2.2.

Table 6. Quality Specification of Maize Flour (EAS 44: 2011)

S/No.	Characteristic	Type				
		Sifted maize meal	**Granulated maize meal**	**Whole maize meal**	**Maize flour**	**Test method**
i)	Fibre content, % by m/m, max.	0.7	1.0	3.0	0.7	EAS 82
ii)	Crude fat a moisture free basis, % by m/m, max.	2.25	2.25	3.1		
iii)	Moisture content, % by m/m, max.	13	13	13	13	
iv)	Total ash, % by m/m, max.	1.0	1.	3.0	1.0	
v)	Acid insoluble ash, % by m/m, max.	0.15	0.35	0.40	0.15	
vi)	Crude protein (N × 6.25) % min	7.0	7.0	8.0	7.0	
vii)	Iron mg/kg	7	7	8	8	
viii)	Fat acidity, mg KOH per 100 g of product, on dry mass basis	50	50	50	50	
ix)	Total Aflatoxin (AFB1+AFB2+AFG1 +AFG2)), ppb max	10				ISO 16050
x)	Aflatoxin B1 only, ppb max	5				
xi)	Fumonisin ppm max	2				

2.4 Microbial specification

When tested by appropriate methods of sampling and examination, the product:

- ✓ shall be free from microorganisms in amounts which may represent a hazard to health;
- ✓ shall be free from parasites which may represent a hazard to health; and
- ✓ shall not contain any substance originating from microorganisms in amounts which may represent a hazard to health.

The microbial specifications outline in table 2.3 shall apply for both maize grain and flour (EAS).

Table 7. Microbial Limits of Maize Grain and Flour (EAS 2 & 44: 2011)

S/N	Type of micro-organism	Limits	Method of test
i)	Yeasts and moulds, cfu per g, max.	10^4	EAS 217
ii)	*Staphylococcus aureus*, cfu per g, max.	10^3	
iii)	*Escherichia coli* per g	Absent	
iv)	*Salmonella* per 25 g	Absent	

2.5 Mycotoxins

Milled maize products shall comply with those maximum mycotoxin limits established by the Codex Alimentarius Commission for this commodity. The milled maize products shall not exceed total aflatoxin of 10 ppb and 5 ppb for aflatoxin B1 when tested in accordance with ISO 16050.

I (b): Storage Technology

3.1 Objectives of storage

The principal objective in any grain storage system is to maintain the stored grains in good condition so as to avoid deterioration both in quantity and quality. During storage, the grain must remain dry and clean. Grain storage can be extended for up to 2 years without any significant reduction in quantity and quality.

Storage facilities do not only offer the opportunity to provide a supply of food between staple crop harvests but farmers are able to improve farm incomes by storing crops and selling at premium prices when demand outstrips supply later in the post-harvest period (Florkowski and Xi-Ling, 1990). The most important factors that influence storage are temperature, moisture, carbon dioxide (CO_2), oxygen (O_2), grain characteristics, micro-organisms, insects, mites, rodents, birds, geographical location and storage facility structure.

Perfect storage hygiene is the basic prerequisite for successful storage. All hygiene measures are very simple, particularly effective and cheap. They can thus be perfectly performed by any farmer with little effort.

3.2 Requirement for grain storage structures

1. The store should be located on a raised site with good drainage to ensure that there is no stagnant water in its store.
2. Set up the store with the longitudinal side on an East-West axis (less radiation on the building) or exposed to the main wind direction. This creates balanced temperature conditions thereby reducing the danger of condensation.
3. Locate the store on firm soil with good road connections to enable easy transportation.

3.3 Storage and environment

To maintain high quality grain during storage, grain should be protected from weather (including extremes relative humidity and temperature), growth of microorganisms, and insects. According to Campbell et al., (2004), the current estimates of the cost of grain loss due to insect and microorganism damage of grain stored in developing countries each year ranged from $500 million to $1 billion. Tuite and Foster (1979) also reported that insects in grain enhance mould development because they increase moisture content and temperature, and open areas of the grain for attack.

It is also reported that storage fungi can grow on cereals from about 14.5% moisture content (mc) upward and can cause heating and moulding. No fungi will grow below 14.5% mc. However, fungi will continue to grow slowly even at near 0˚C, so cooling alone is not sufficient to prevent growth in damp grain. However, the lower the temperature, the slower the rate of growth.

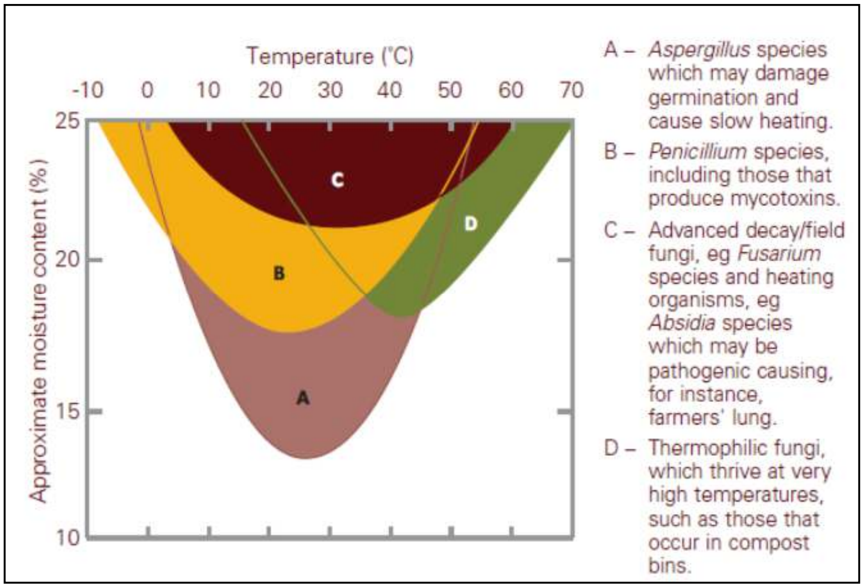

Figure 1. Effect of temperature and moisture content on fungi growth (Source: HGCA Grain storage guide for cereals and oilseeds)

Mycotoxins formed before harvest, for example by *Fusarium* Species, are stable and likely to remain during storage but not increase.

It is also noted that storage mites are very prone to water loss and die at low relative humidity. Most species of storage mites do not breed below 65% relative humidity (RH). Therefore, the numbers of storage mites may decline naturally if the surface moisture content falls below 65% RH. In addition, it is also noted that if grain is dried to 14.5% mc mites are unable to breed. Also, cooling the grain to 5˚C prevents a build-up of mites.

Temperature and moisture content management alone cannot however prevent stored product insect infestation. It is observed that stored product insects are specialised for the grain storage environment and can breed at relatively low temperatures and moisture contents. Primary control of storage pests is therefore by practicing good store hygiene. Hygienic and sanitary measures in storage are of paramount importance. Very often a thorough cleaning of a warehouse or granary prior to storage of new products is not carried out properly. As a result residues of infested products are not totally removed and these act as sources of new infestation. *The development of proper hygiene programmes for good storage practice by scientists in collaboration with storage practitioners is a task for future activities.*

Microbial infection in storage occurs due to inadequate drying of produce. The situation is made worse when there are large numbers of insects present or when the stored crop is exposed to high humidity or actual wetting due to poor storage management. Fungal infection results into rots and development of aflatoxins, which are poisonous compounds to live stock and cause cancer in human. Aflatoxin contamination is encouraged by:

1. Inadequate drying
2. Physical damage due to poor shelling/threshing methods
3. Poor storage methods (exposure to moist condition)
4. Insect infestations.

3.4 Available storage technologies for maize (*Zea Mays*)

Figure 2: Local granary

Figure 3: Improved Crib

Figure 4: On farm storage

Section II: Field Study Work

4.0 Methodology

Following the completion of the literature review, the next step was to conduct a field study. This study had the following objectives:

1. To identify existing knowledge and technologies available for the production and processing of rice and maize
2. To identify best practices in the rice production and processing as well as in the management and ownership of group resources that can be adopted and popularised in Amuru, Gulu and Nwoya districts of Northern Uganda.
3. To establish technological challenges and bottlenecks involved in rice and maize production and processing of rice, especially those faced by youths and women

The study spanned the districts of Gulu, Amuru and Nwoya which are part of the SATIFFS Project and focussed on the production, postharvest handling, value addition and marketing of rice and maize as the target commodities of the project. In Gulu District, the sub counties of Awach and Patiko were visited. In Amuru District, the sub counties of Pabbo and Amuru were visited. In Nwoya District, the sub counties of Alero and Purongo were visited. The following respondents were interviewed during this study:

1. District production officials: District Agricultural Officers, District NAADS Coordinators, etc.
2. Local leaders in the rice and maize producing sub counties.
3. Farmers groups and individual farmers
4. Women and youths groups producing rice and maize
5. Agro-processors and traders dealing in rice and maize
6. Agro-input suppliers and dealers

The team comprised of Dr. Martine Nyeko (OUC), Dr. Grace Okiror (OUA), Dr. Collins Okello (FTP) and Mr. Bernard Odoi (Driver). The study was conducted from 4th to the 11th of August 2014.

5.0 Key Findings

The following major findings were recorded.

5.1 Maize Value Chain

Maize is produced widely in the target districts. The acreage ranges from 1 to 10 acres for non-mechanized farming, with a median of about 5-6 acres per household. A few large scale commercial farms exist. A farm of 250 acres with fully mechanized operation for maize was visited. Though maize is a food crop, its production for commercial purposes varies from household to household, as well as among sub counties. It was found that farmers seem to exercise enterprise selectivity between rice and maize value chains for commercial purposes: more of one means less of the other. Several reasons were advanced for this behaviour including crop performance in the locality, availability of labour, as well as individual preferences.

The most common varieties cultivated include Longe 1,2, 5, 6, 7, 9 and 10H, with the highest preference for Longe 5. Longe 10H is hybrid. Other hybrids available in the market are FH 5160, KH50043 and YARA. Seed is mostly preserved from the previous crop, but can also be obtained from agro-input dealers. The main companies operating in the region are Victoria Seed Company and Equator Seed Company. Other companies with agents across the region are FICA seeds and NASECO. The use of fertilisers, herbicides and insecticides is limited to the few large scale produces and field trials for several research organisations. The crop yield often varies from 800 to 1200 kg per acre, depending on the production practices. Maize is produced twice a year throughout the region but time is crucial in order to ensure optimum yields during the first season. Maturity is detected in a number of ways: counting the days from planting, random checking of cobs on stalk, and observation of the colour changes of the leaves, depending on the desired end use, either for grain or fresh consumption. The crop must be planted before the first rains which occur in mid-march. Delay in planting often leads to crop failure due to dry spell that usually occurs between May and June. No irrigation is practiced in the region.

The crop is always planted in rows, by hand for ordinary most farmers. The rest of the operations of weeding, harvesting and shelling are all done by hand. A few combines exist on very large farms. The greatest technological challenges facing the maize value chain are shelling, drying and storage. Shelling is often done by hand through beating the grain in sacks, which is a single most deleterious operation to grain quality. Motorised shellers exist but are limited in access due to design (too big, expensive and fixed) or location (at or near trading centres). Drying is often done by sun on bare or paved ground, or tarpaulins. This limits the quantity that one can dry at any given time, as well as holding potential for quality deterioration in the event of sudden change in weather. Mechanical dryers are only used on commercial farms. Storage is often done in woven polypropylene sacks in private homes or community bulking centres. The bulking centres are preferable but are usually few and far between. Poor storage often leads to spoilage by pests and moisture. Storage duration ranges from two weeks to three months, depending on the farmers financial needs such as medical services and school fees. The main purpose of storage is target favourable market prices, but improper storage leads to quality and sometimes also quantity resulting in reduced income.

5.2 Rice Value Chain

Rice is also produced widely in the target districts, mostly as a cash crop. Acreages range from about 3 to up 50 acres, but the median value is about 10 acres per household in the rice producing sub counties. Rice is a high labour intensive crop for weeding, harvesting, threshing and drying. The varieties cultivated are: NERICA (The New Rice for Africa Project) 1, 2, 3, 4 and 5, SUPERICA 1, 2, 3 and 4, Sindano/Kaiso, WARP, Maji Maji, Nylon. The mostly preferred are NERICA 4 and Sindano. The NERICA varieties are short term duration varieties maturing between 90 and 120 days while Sindano/Kaiso is a long term traditional variety maturing between 150 and 180 days. Consequently, the NERICA varieties can be planted twice a year while Sindano is planted only once a year. The first season crop is usually planted between March and April, while the second season crop is planted between June and September. The second season is usually preferred for both varieties since maturation and harvesting occurs between

November and January. During these months, there is limited damage by birds, the weather is favourable with ample sunshine for maturation and drying, as well as more available labour due to reduced on-farm demand by other crops. Crop yields range between 800 -1500 kg per acre, depending on variety, management and technology.

Rice production technology is predominantly manual and labour intensive. Land opening is done either by hand hoe, draft animals, or tractor power, depending on availability and the level of investment. Planting is mostly done by broadcasting on ploughed land. If tractor power is available, sowing is done after primary cultivation then the seeds are covered with a harrowing operation. If oxen are used, seeds are often applied on an open farrow and covered with the following farrow. In a fully manual operation, seeds are broadcasted after cultivation and then covered by dragging branched across the field or other similar operation. An improved technology using welding pegs to open seed holes followed by manual covering is being promoted by some development partners in the region (Figure 5). Most of these planting methods result in random seed scattering and emergence which poses a great challenge in subsequent farm operations.

Figure 5. Demonstration of improved row planting technology under promotion

After planting, weeding is often done by manually pulling the weeds out of the field. This is done between two to four times depending on field conditions and crop variety. This is a difficult step to mechanise due to the broadcasting method of planting. Harvesting is also done manually by knife or sickle. Maturity is detected traditionally by counting days from planting and carefully following colour changes of the ears. Harvested should be done when the ears turn golden yellow, with some greenish spots. Technically, the moisture content should be between 22 – 25% wet basis in order to prevent grain fissuring. This allows farmers about one week's harvesting window before fissuring starts to occur due to over drying. Although no moisture measuring instruments are used, most farmers are very conscious of this fact and always endeavour to harvest their crop in a timely manner. However, the major drawback is availability of labour, since it takes 20 man days to harvest one acre, and it usually occurs when almost every farmer in the community is harvesting. This has often led to reduced income to farmers due to field losses arising from delayed harvesting and high labour costs. Therefore, there is a dire need to intervene with appropriate harvesting technology. Currently, there are about two combine harvesters for rice in all the target districts and are used on private farms, but when they are available for hire, they are remarkably cheaper than manual labour.

Threshing is also done by hand. The NERICA varieties can be threshed immediately after harvesting, while Sindano needs to be fermented for three days before threshing. Fermenting allows for uniform grain ripening and softening of the attachment of the grain to the ears. Fermentation is done by heaping harvested in the field and allowing the temperature to rise naturally due to respiration and environmental conditions. However, grain harvested for should not be fermented since it is known to affect seed viability. During threshing, the ears are beaten with sticks on tarpaulins and the chaff is easily separated from the grain. No winnowing is necessary. There are some portable motorised threshing machines which can be used to ease and speed up the process, but have not been widely adopted due largely to lack of access to the technology (Figure 6).

Figure 6. Portable motorised rice threshing machines

Threshed rice is transported from the field to the homestead and stored for two to three days before drying. Drying is done on paved surfaces atop some tarpaulins or bare ground (Figure 7). This is another critical step toward production of quality rice grain. Drying should be done slowly and agitated regularly for about four hours each day. It is always supervised by adults to ensure that grain is properly taken care of to avoid contamination by debris, dirt and rewetting in case of sudden rain. Rewetting during drying causes grain fissuring and cracking leading to high milling losses. Drying usually takes between two to three days depending on the weather conditions. Dried rice is stored like maize, in woven polypropylene sacks at home, communal storage facilities, or increasingly at millers' stores till the farmer is ready to sell or mill it.

Figure 7. Typical rice drying on tarpaulins

Milling is done by specialised craftsmen across the districts. The main rice mills are located at Gulu Town, but a number of small milling operations are dotted around the rest of the districts. Other large milling centres are Pabbo sub county headquarters in Amuru district and Olwiyo trading post in Nwoya District. Overall, the most common milling technology is the two way top loading rice mills. These machines do both husking or hulling and polishing at once. In the common design, it is possible to manually divert brown rice if so desired. Other models do not have this facility. All rice milled will be white rice of one grade. Adjustments and settings are made for each rice variety as they differ in size and shape, which factors affect the milling yield. No grading is currently done according to level of brokens. Separation is done only by variety, and currently all upland varieties of milled rice attract the same price in these districts. The only difference is customer preference on the basis of variety and level of brokenness. Sindano variety is often preferred because it has fewer brokens and better cooking properties compared to other varieties. The wetland rice is usually aromatic and is more expensive than upland rice. When properly adjusted, these machines give head rice of up to 70% of paddy. Furthermore, the vertical machines produce two channels of by-products: husks, which contain mostly fibre and silica as brown rice is produced, and bran which is richer in nutrients as a result of polishing/whitening (Figure 8). The husks are often burnt for fuel or disposal, while the bran is sold as feed for animals and poultry. However, horizontal mills have only one by product outlet, which combines both husks and bran and is still sold as animal feed.

Figure 8. A typical one pass vertical rice milling machine with separate outlets for husks and bran

5.3 Crosscutting issues

A number of crosscutting issues were noted during fieldwork. Foremost, it was observed and also reported by respondents that there was a lot of unutilized land. This is largely due to low investment in agricultural production. The people rely heavily on manual technologies such as the hand hoe and related tools for land cultivation. This limits the available power for agriculture. In addition, due to increased awareness of the value of education, a number of family members who traditionally joined hands in farming are now pursuing education, leaving only few members to engage in agriculture. Animal traction technology is often used to increase farm power, but it is not always available. Similarly, tractor power is not always accessible when needed. Even when these technologies are accessible and affordable, they only serve to open up the land. Other operations such as weeding, harvesting and threshing or shelling will need additional power to complete. Otherwise, farmers end up planting large tracts of land and then leave the crop in the field due to lack of labour to complete subsequent operations. There is therefore need to address the entire value in terms of technological interventions. In addition, other development partners can support the region through improved infrastructure investment and provision of credit facilities for agricultural development.

There is lack of reliable sources of agricultural inputs. Agro-input suppliers often provide uncertified seed, fertilisers and chemicals. One respondent displayed a batch of over 50 bags of NPK fertilisers which had more than 50% damaged products. The damaged fertilizer had caked due to poor production and packaging practices, extraneous materials and completely different products with the same label (Figure 9). This leads to loss of money, time, productivity and damage to equipment. Similarly, seed bags are often adulterated with poor grade or mixed varieties. In addition, the seed germination rate is usually very low, leading to poor yields. A field of mixed variety seeds is particularly dangerous for rice as it results in low milling yield due to varying grain sizes and shapes.

Figure 9 some of the damages that occur to fertiliser vs. a good batch (far right)

There are also inadequate extension services. The National Agricultural Advisory Services (NAADS) that has been in operation for a decade is now undergoing restructuring and left a number of farmer groups unattended. Even when it was operational, NAADS tended to skew service delivery towards specific target enterprises. There is need for farmer training in modern production methods such as use of fertilisers, herbicides and pesticides, as well as postharvest handling, storage and processing of rice and maize, especially milling for maize and rice. The SATIFFS project was therefore welcomed in the community as initiative by Gulu University to provide the direly needed services in the community.

There is great demand for quality maize and rice in the market. Markets exist locally as these are now staple foods all over the country. In addition to household consumption, these cereals are preferred to serve at schools, hospitals, prisons and other such like places. There is also an inexhaustible demand in neighbouring countries of South Sudan which is suffering for a civil war, and Kenya and Rwanda which have low production volumes related land forms. In addition, the country has contract with the World Food Programme of the United Nations to supply food to other regions in the world where it is needed. It is therefore important to strengthen the production of these crops.

Section III: The Stakeholders' Workshop

6.1 Background

The stakeholders' workshop was organised at Hotel Pearl Afrique in Gulu Town on 19th August 2014. A total of 28 persons attended and participated in the workshop (Figure 10). The planned program is attached in Appendix I. The objectives for the workshop were:

1. Consolidate on knowledge obtained from the field study work
2. Prioritize on the technologies for intervention
3. Identify participants for field visits and demonstrations

Presentations on SATIFFS background, objectives of the workshop and general quality requirements for rice and maize in the region were made. Members gave positive comments and reactions to these presentations.

Figure 10. Some of the workshop participants on the 19th August 2014

6.2 Presentations and discussions

Mr. Kim Johansen, a representative from AFGRI, a private company dealing in bulk storage and sale of rice and maize in the three districts provided PowerPoint presentation on Grain Quality and Storage in Northern Uganda. He gave the background to the company and general quality issues affecting the grain industry in Uganda at large. He stated that maize in the region has 40% post-harvest losses with only about 550 tonnes stored in proper facilities. The remaining ends up being sold as chicken feeds. The losses are more pronounced in first harvest season (July to August) due to difficulty in drying, while the quality of second harvest season (November to January) being better. The main maize grain quality problem is aflatoxins. He summarized by giving some of the initiatives that AFGRI has taken to improve the quality of grain in the region. This includes provision of training in the entire value chain, as well as technological infrastructure such as maize combines, transportation, drying and storage to ensure quality.

Mr. Moses Oryema, a representative of the World Food Program of United Nations (WFP), Gulu Field Officer, provided a verbal presentation on grain quality attainment at household level. He emphasized the need for quality as outlined by the previous speaker as a prerequisite for achieving good market prices. He also gave some initiatives that WFP is taking to promote production of high quality grain. These include provision of tarpaulins at household level for grain drying, as well as construction of grain Satellite Collection Points or Bulking centres at community level (sub county or parish level) to facilitate proper handling and storage. These centres are equipped with some technologies such as maize shellers, sorters and graders, moisture meters, weighing scales, and pallets; as well as some drying yards (about 10 m by 15 m concrete platforms). Both presentations were appreciated by the participants and stimulated meaningful discussions.

Dr. Grace Okiror, the Operational Unit Assistant, provided a PowerPoint presentation on the results of the field study work. He provided an overview of the quality aspects of rice and maize and existing standards. An overview of the production aspects in the project area, including acreage, use of inputs, production patterns, and technological challenges was provided. The participants provided more information that helped consolidate the report provided and accepted it to be factual and representative of the actual production situation in the project area.

6.3 Prioritisation of technological interventions

Dr. Collins Okello, the Field Technology Person of the SATIFFS Project, guided the discussion on the selection and prioritization of technologies for intervention by the project. He employed the Delphi Method (Hsu and Sandford, 2007) to complete help rank technology attributes, functions and production intervention phase. The first step was the select unique desired technology attributes and functions that each technology is expected perform. This was done during a plenary session in a participatory manner. The following technology attributes were identified by the participants:

– Adaptability
– Affordability
– Automation
– Durability
– Efficacy/efficiency
– Environmental friendliness
– Functionality
– Gender sensitivity
– Manual/power driven

– Multipurpose/multi-crop
– Portability
– Ready availability
– Safety
– Simplicity (operation/maintenance/construction)

Similarly, the following technology functions were selected:

– Bulk reduction (including sorting and grading)
– Cost saving/profitability
– Labour saving
– Product loss reduction
– Quality improvement
– Time saving

Following a consensus on technology attributes and functions, the workshop participants were randomly subdivided into four groups of at least six members each. Each group was tasked to deliberate and rank each set of the above attributes and functions. In the event that the group decided that certain attributes or functions were equally important, then an "average rank", derived from the current and the next rank, was used. For example, if group members agreed that adaptability and affordability were equally ranking No. 1, then the rank assigned would be 1.5. Figure 11 describes results obtained by averaging the ranks for each attribute as assigned by all the four groups.

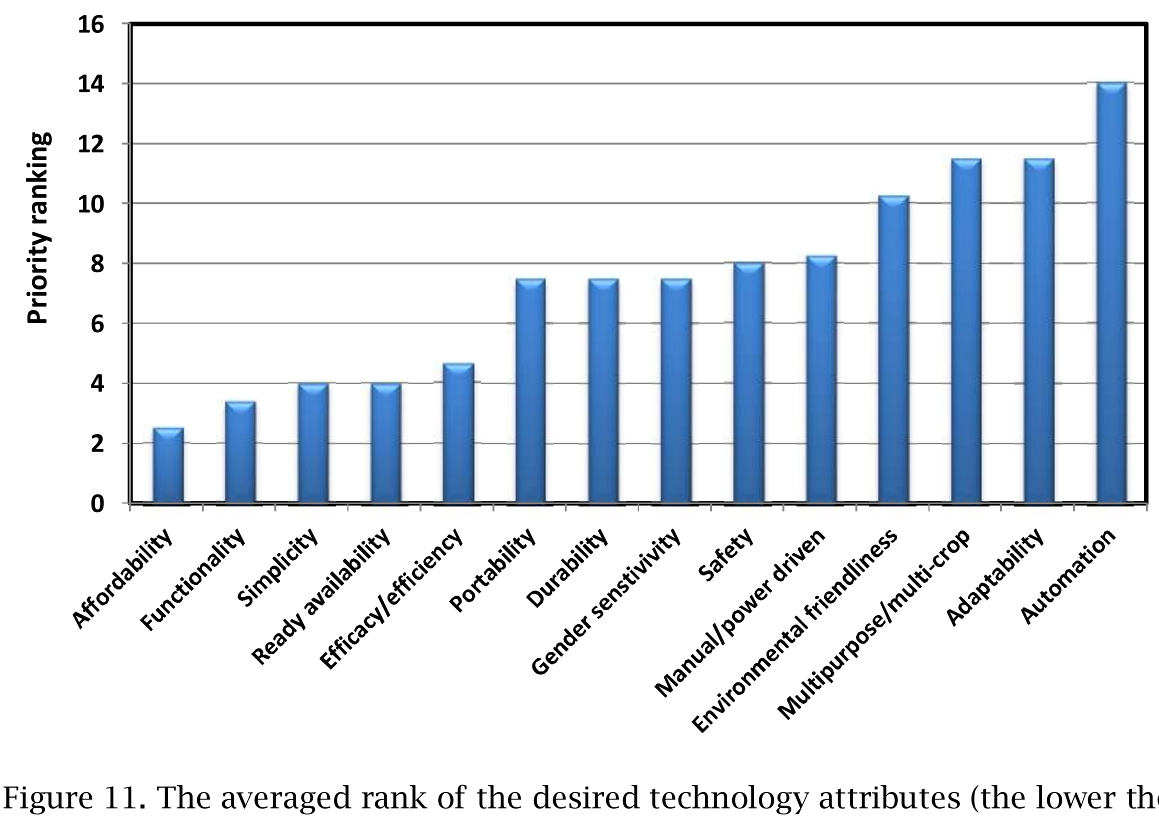

Figure 11. The averaged rank of the desired technology attributes (the lower the rank, the higher the priority to the stakeholders)

It is observed that affordability or the cost implication was the foremost attribute of importance selected by the stakeholders, while automation was of least significance. Nevertheless, Figure 8 shows that the attributes can be clustered into three major groups of importance: 1) affordability, functionality, simplicity, availability and efficacy would form a "technology design" category, which is of primary importance; 2) portability, durability, gender sensitivity, safety and manual operation would fall under the "performance attributes" category; 3) while environmental friendliness, adaptability, multipurpose usage and automation would be classified as "other attributes". It is therefore important that the designs selected for dissemination should be optimised to suit the desires of the stakeholders in order to ensure quick adoption and multiplication by the community. Similarly, the functional requirements for the technology to be promoted were ranked as shown in the Figure 12.

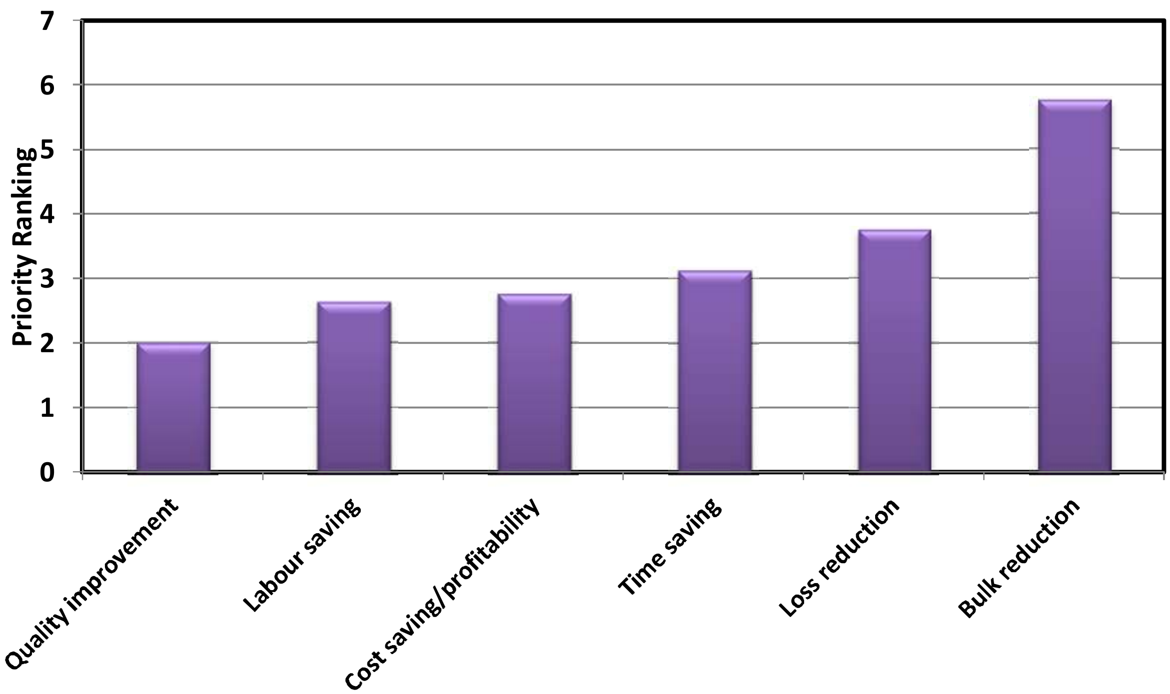

Figure 12. The averaged rank of the desired technology functions (the lower the rank, the higher the priority to the stakeholders)

It is also observed here that improvement in the quality of agricultural products was ranked highest by the stakeholders. This shows that farmers greatly understand the relationship between quality and price and so would like to have quality maintained or improved from their current practices.

After completing to rank technology attributes and functions, the stakeholders focussed on ranking the priority operations for technological intervention for rice and maize separately. Results of the rankings are given in Figure 13.

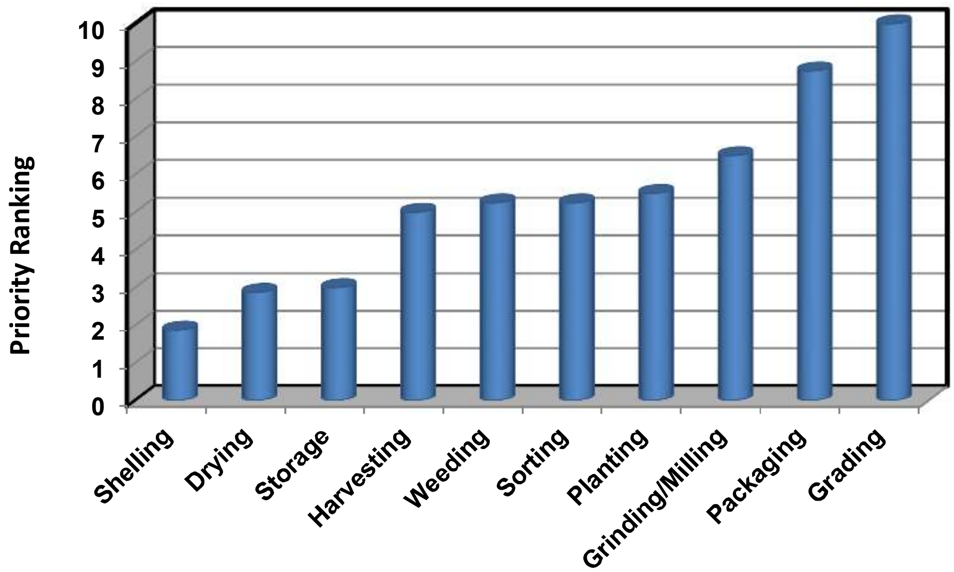

Figure 13. Ranking of priority operations for technological intervention for maize (the lower the rank, the higher the priority to the stakeholders)

It was observed that shelling is seen as the most important operation that should be improved in order to achieve desired quality. This is well in agreement with the findings of the field study, since most respondents reported that shelling is still done manually by most smallholder farmers. Drying and grading followed closely while packaging and grading ranked last. A similar plot for rice is shown in Figure 14.

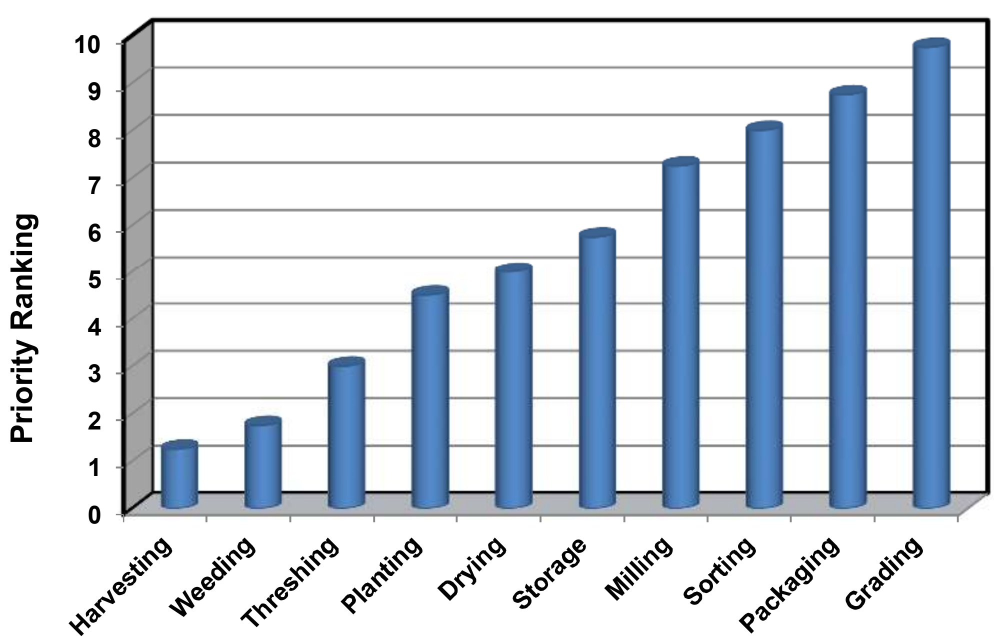

Figure 14. Ranking of priority operations for technological intervention for rice (the lower the rank, the higher the priority to the stakeholders)

For the rice value chain, it is observed that harvesting is the most urgent operation for technological intervention, closely followed by weeding and threshing. Though planting is ranked fourth overall due to its low labour requirement and availability of rudimentary methods of accomplishing the task as described previously, it is important to note that row planting is essential if weeding is to be mechanised. Therefore, appropriate planting technology automatically takes on the same rank as weeding technology. The next operation of importance to the stakeholders is drying, which is also a big challenge as described earlier. The operations of storage, milling, sorting, packaging and grading currently have some level of mechanisation at rice processing facilities and deemed adequate by the community.

6.4 Conclusion

In summary, the stakeholders' workshop provided great insight into the technological needs of the maize and rice value chains in Northern Uganda, as well as the order of priority with which any interventions should be implemented. A quality assessment centre is crucial for monitoring the products available, both for public health and safety, as well as for appropriate commodity pricing. Specifically, technology for moisture content measurement, chemical and biological content determination, and laboratory grading is essential. For maize, it was concluded that shelling and drying emerged as the main operations for urgent technological intervention. For the rice value chain, key priorities are planting, weeding, harvesting and drying. It is also important that any technological intervention should be affordable, functional, simple to operate and readily available; and ensure improvement in product quality.

SECTION IV: WAY FORWARD

In order to establish a centre for innovation and technology dissemination (CITED) for rice and maize value chains in Northern Uganda under the objectives of this project, the following activities are envisioned.

7.1 Establishment of a quality assessment laboratory for cereals

The following equipment and tools will be required to facilitate quality assessment and monitoring.

1) Moisture meter - Measurement of moisture in the site or in the field for cereals, crop, cocoa, coffee. Automatic temperature compensation.
2) pH-meter - Measurement of pH in the site or in the field for cereals and crop Features:
   - Measures pH value from 0 to 14 pH
   - Measuring resolution 0.01 pH
   - Portable and battery operated
   - Standardization Facility
   - Anti-Corrosive powder coated body
   - Easy plug in detachable sensor socket
3) Technical Balance: Weight:2200 g - Div.: 0,1 g - Reproducibility: <=+-0,1 g - Linearity: <=+-0,1 g
4) Laboratory Oven - From 5˚ over room temperature until 300˚C. Vol. 50 Litres. PID digital control. Stainless steel chamber with supports for the shelves completely removable
5) Kit ELISA (48 test for aflatoxyns) No. 1 plate or strip colorimeter equipped with a 450 nm filter and related kits for testing the performance of the reader at 450 nm;
6) N. 1 Personal Computer with office software, for data processing;
7) Laboratory mill for cereals - for preparing samples to be analysed
8) Laboratory reagents and consumables - to perform the analysis outlined above
9) IRRI Rice Quality Assessment Kit

Figure 15 The IRRI Rice quality assessment kit

(Available from: http://www.knowledgebank.irri.org/step-by-step-production/ postharvest / milling/irri-rice-quality-assessment-kit)

7.2 Appropriate technologies for testing and dissemination

Considering the stakeholders' needs and priorities, the following technologies are recommended for immediate testing and dissemination for both rice and maize value chains

Table 8. Recommended technologies for testing and dissemination

Technology	Dissemination plan	After Sale Service	Accessories	Testing and Optimization
Manual rice planter(up to 70 cm width, 4 row planter, 8 kg seed hopper capacity, variable seed rate)	Field demonstrations, operations and maintenance manuals	Training of FTPs in operation and maintenance, Provision of service and parts limited warranty	Conventional tillage tools for seedbed preparation	Effect of operation speed on seed rate, Labour requirements, field efficiency, effect of soil pulverization on seed germination
Rice harvester (reaper: 1m working width, binder, 10-12 hp diesel, self-propelled, walk behind operation)	Field demonstrations, operations and maintenance manuals	Training of FTPs in operation and maintenance, Provision of service and parts limited warranty	Harvest storage bags if mini combine, windrow rakes and threshers/winnowers if basic reaper	Effective working width, effect of different raw spacing, effect of forward speeds, throughput, reliability, damages, and fuel consumption
Portable motorized Rice Threshers	1. Training of TFP on use and maintenance 2. Train Artisans to use machines 3. Warranty on machines 4. Offering Technical advice	1. Complete toolkits with spanners 2. Welding plant 3. Welding rods 4. Measuring instruments	1. Manual translation into local languages 2. Training of FTP/Artisans/users of the machines 3. Field demonstration and optimization	The efficiency of the thresher (mechanical and output
Motorised Maize shellers	1. Training of TFP on use and maintenance 2. Train Artisans to use machines 3. Warranty on machines 4. Offering Technical advice	1. Complete toolkits with spanners 2. Welding plant 3. Welding rods 4. Measuring instruments	1. Manual translation into local languages 2. Training of FTP/Artisans/users of the machines 3. Field demonstration and optimization	The efficiency of the thresher (mechanical and output
Mechanical Dryer (Using rice husks, maize cobs, and other biomass. motorised blower and portable)	Training FTP on Monitoring performance and maintenance of technology	Standard toolbox from manufacturer, Instruments e.g. moisture meter and temperature probes	Train farmers on how to install, operate and maintain	Monitoring the effect of temperature, humidity and moisture content on drying process

These technologies need to sourced and obtained for dissemination.

References

Campbell, J. F., Arthur F. H., & Mullen. M. A. (2004). "Insect management in food processing facilities". Advances in Food and Nutrition Research 48: 239-295.

EAS 128:2013, Milled rice specifications, East African Standard

EAS 2:2005, Maize (grains) — Specification, East African Standard

EAS 217, Methods for the microbiological examination of foods

EAS 44:2000, Milled whole maize-meal and maize products — Specification, East African Standard

EAS 764 (2011) (English): Rough (Paddy) rice – Specifications, East African Standard

EAS 765:2011, Brown rice specifications, East African Standard

EAS 82:2000, Milled cereal products — Methods of test, East African Standard

Florkowski, J. and Xi-Lling, J. (1990), "Simulating the impact of pecan storage technology on farm price and grower's income", Southern Journal of Agricultural Economics, Vol. 22, No. 2, pp. 217-222.

Hsu, Chia-Chien, and Sandford, Brian A. (2007). The Delphi Technique: Making Sense of Consensus. *Journal of Practical Assessment, Research & Evaluation, Vol 12, No 10.*

ISO 16050, Foodstuffs — Determination of aflatoxin B_1, and the total content of aflatoxin B_1, B_2, G_1 and G_2 in cereals, nuts and derived products — High performance liquid chromatographic method, International Standards Organisation

ISO 605, Pulses — Determination of impurities, size, foreign odours, insects, and species and variety — Test methods, International Standards Organisation

ISO 711, Cereals and cereal products — Determination of moisture content (Basic reference method), International Standards Organisation

ISO 712, Cereals and cereal products — Determination of moisture content — Routine reference method, International Standards Organisation

Tuite, J., Foster, G. H. 1979. Control of storage diseases of grain. Annual review of Phytopathol 17:343

APPENDIX I: PROGRAMME FOR STAKEHOLDER WORKSHOP

19th AUGUST 2014, HOTEL PEARL AFRIQUE- GULU

19th August 2014			
TIME	**ACTIVITY**	**METHOD**	**RESOURCE PERSONS**
08.30 - 09.00AM	Registration	Self	Secretariat
09.00 - 09.15AM	Opening remarks	speech	Dean
9:15 – 9: 45 AM	Introduction	Self	Eng. Ebangu
09:45 -10:15 AM	Introduction of the workshop (objectives, program, logistics etc.)	PPT	Grace
10.15 - 10.45AM	Coffee break	self	
10:45 -11:30AM	Presentation from WFP on grain quality attainment	PPT + Q&A	WFP
11:30 – 2.15PM	Presentation from AFGRI on grain storage	PPT+ Q&A	AFGRI
12:15 –01:00PM	Presentation of the baseline report	PPT + Q&A	Grace
01.00 –02.00PM	Lunch break	self	
02.00-03.00PM	Appropriate technology for Maize & Rice	Working groups	Collins
03:00 -03.15 P.M	Tea break	self	Stephen
03:15 -04.15 P.M	Prioritization of the technologies	Plenary presentation	Collins
4.30 P.M	Closing of the day	All	All