An assessment of factors affecting adoption of maize production technologies in Iganga District, Uganda

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NARO/CIMMYT

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NATIONAL AGRICULTURAL RESEARCH ORGANISATION

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Sustainable Maize and Wheat Systems for the Poor

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An Assessment of Factors Affecting Adoption of Maize Production Technologies in Iganga District, Uganda

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Abstract: Data from formal and informal farmer surveys in Iganga District, Uganda, as well as secondary data, were analysed to describe maize farmers' circumstances and practices, identify socioeconomic and technical factors affecting the adoption of improved maize variety Longe 1 and related practices, and develop recommendations for research, extension, and policy. The study area and its technology generation and transfer systems are described. The methodology used to collect and analyse the data is reviewed, along with details on the technology package promoted to farmers. Farmers' most important criteria for adopting Longe 1 technology were (in descending order of importance) early maturity, high yield, large grains, and sweetness. Nonadopters preferred the older maize technology, Kawanda Composite A, because of its large kernels, high yield, and sweetness. Results of the logistic regression model showed that the use of hired labour, level of education, membership in farmers' groups, and land tenure had a statistically significant effect on the probability of adopting Longe 1 technology. The findings from this study point to several recommendations for research, extension, and policy makers. First, revised fertiliser and herbicide recommendations could help improve the profitability of Longe 1. Second, farmers' use of the older maize technology indicates that farmers should have access to more alternative maize seed types. Third, the extension service should strengthen contact with farmer groups. Fourth, labour-saving technologies such as herbicide and draft animals should be incorporated into the maize husbandry and post-harvest technology package. Fifth, a group revolving-fund loan scheme should be explored by formal and informal credit institutions as well as farmers' groups. Finally, universal primary education should be upheld so the economy can benefit from improved farm management skills acquired by literate farmers.

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Acronyms

AEP	Agricultural Extension Programme
BIFA	Bulamagi Integrated Farmers' Association
CARD	Community Association for Rural Development
CIMMYT	International Maize and Wheat Improvement Centre
DEC	District Extension Coordinator
DFI	District Farm Institute
FAO	Food and Agricultural Organisation of the UN
IGADD	Intergovernmental Authority on Drought and Development
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
MEPU	Monitoring Evaluation and Planning Unit
NAARI	Namulonge Agricultural and Animal Production Research Institute
NARO	National Agricultural Research Organisation
NAROSEC	NARO Secretariat
NARSs	National agricultural research systems
NGOs	Nongovernmental organisations
OFPEP	On-Farm Production Enhancement Programme
OPV	Open pollinated varieties
T&V	Training and Visit
UNBP	Uganda National Bean Programme
UNFA	Uganda National Farmers' Association

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Executive Summary

The study whose results are presented here set out to establish the key technical and socioeconomic factors that affect adoption of Longe 1 improved maize production technology in Uganda. Informal and formal survey techniques, such as exploratory client consultations and diagnostic procedures, elicited primary data, which were supplemented by secondary sources. Iganga District was selected to be the focus for this study because maize is a major subsistence and commercial crop serving the fresh and dry grain markets in the urban centers at Iganga, Jinja, and Kampala. In addition, on-farm maize technology verification and demonstration trials were conducted widely in the district by the national Maize Research Programme and Agricultural Extension Programme (AEP). A multistage purposive sampling procedure was used to obtain respondents consisting of extension contact group members (43) and nongroup members (56) from Kigulu, Bunya, and Luuka Counties. Descriptive statistics and logistic regression using the SPSS Version 4.0 computer package were used to analyse the data.

The results of the analysis indicate that, compared to nonadopters, farmers who adopted the Longe 1 technology were slightly older, owned larger farms, were more educated, used more hired labour, participated more in farmers' groups/associations, had nonfarm employment opportunities, had greater access to extension services, sold larger quantities of maize, and were predominantly males. Adopters and nonadopters did not differ in access to credit, household size, farming experience, maize area, and ownership of livestock. Virtually no farmer used the recommended fertilisers and herbicides. Similarly, a very small proportion of the farmers had access to farm credit. Farmers cited lack of awareness of fertiliser and herbicide technologies as their major reasons for not using them. The most important criteria for adopting Longe 1 were (in descending order of importance): early maturity, high yield, large grains, and sweetness. Nonadopters of Longe 1 preferred to continue growing the other, older, maize technology, Kawanda Composite A, because of its large kernels, high yield, and sweetness.

Results of the logistic regression model showed that the use of hired labour, level of education, membership in farmers' groups, and land tenure had a statistically significant effect on adoption of the Longe 1 technology.

Several recommendations were made for research, extension, and policy:

1. The national maize research programme should address the deficiencies in profitability of Longe 1 by updating fertiliser and herbicide technology packages.

2. The research programme and the Uganda Seed Project should provide farmers with more alternative maize seed types and possibly renew supplies of Kawanda Composite A.
3. The extension service should encourage/strengthen contact group activity to enhance interventions for maize production constraints.
4. Labour-saving technologies such as herbicide and draft animals should be incorporated into the maize husbandry and post-harvest technology package.
5. The advantages of a group revolving-fund loan scheme should be explored by formal and informal credit institutions as well as farmers' groups.
6. The government policy of universal primary education (UPE) should be upheld so the economy can benefit from improved farm management skills acquired by literate farmers.

An Assessment of Factors Affecting Adoption of Maize Production Technologies in Iganga District, Uganda

William Ntege Nanyeenya, Mary Mugisa Mutetikka, Wilfred Mwangi, and Hugo Verkuijl

1.0 Introduction

1.1 The Ugandan Maize Sector

Maize is produced throughout Uganda, but the main production zones are in the West, East, North, and Southeast. Until 1930, the government promoted maize production, but this policy was later reversed owing to the maize crop's heavy uptake of soil nutrients, vulnerability to sheet erosion under poor management, and competition with cotton, the major export crop at the time (Jameson 1970). In 1949, the Cotton Research Corporation opened a regional research station at Namulonge, but until the early 1970s most research focussed on Uganda's principal cash crops, coffee and cotton (Laker-Ojok 1994). Maize became an important subsistence and nontraditional cash crop in the 1970s and 1980s as marketing systems for cotton collapsed. Although USAID sponsored a programme to strengthen research in food crop production in 1983, the programme lasted only until the late 1980s, before much actual research could be undertaken.

Currently maize is a major staple, giving variety to household diets in the form of roasted or steamed green cobs, maize flour, and porridge. Maize stover and bran also constitute major ingredients in livestock feeds. Maize is thus a strategic crop in Ugandan food security, largely as a result of increasing urbanisation, and has the potential to become a nontraditional agricultural export. Uganda's aggregate maize supply is about 900,000 metric tonnes (t) from an area of about 563,000 hectares (ha). Maize exports for the financial year 1993/94 were 88,263 t, equivalent to 27,551 million Ugandan shillings (USh).[1] Per capita consumption of maize is 23 kilograms (kg) per capita per year (MFEP1995). Based on seed requirements, animal feed, industrial use, and human consumption, total demand for maize is estimated at 391,300 t.

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[1] 1,020 USh = 1 US$.

1.2 *Rationale and Objectives for the Study*

Multilocational research and demonstration trials by the Maize Research Programme of the National Agricultural Research Organisation (NARO), along with the Agricultural Extension Programme (AEP), Directorate of Agricultural Extension (DAE), Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF), have made farmers aware of the increased yield and income benefits of the improved maize varieties Kawanda Composite A and Longe 1. Despite these efforts, farmers' average yields range from 0.8 to 1.5 t/ha, compared to 3.5 and 4.3 t/ha obtained under farmers' conditions for Kawanda Composite A and Longe 1, respectively. Either Ugandan farmers are growing predominantly local varieties, or they are using traditional production practices to grow improved varieties, which prevent those varieties from expressing their potential yield. Even though it is understood that adoption is a stepwise process for a given package of maize production technology, the gap between farmers' yields and yields obtained by researchers on experiment stations or by researchers and farmers in on-farm verification trials calls for further investigation.

The study described in this report was undertaken to discover which technical and socioeconomic factors affect the adoption of improved maize in Uganda. The results should be useful to farmers, researchers, extensionists, and policy makers. Researchers can use results of the study to understand the reasons for the disparity between farmers' actual yields and the yields they could obtain with improved technology. For Maize Programme scientists, especially maize breeders, the empirical evidence on key technical and socioeconomic issues that farmers consider important in adopting maize technologies will be particularly useful in developing improved maize varieties. This study is also timely, given that a stated objective of the Maize Programme is to develop hybrid maize. For agricultural extension programmes, the findings of the study should provide opportunities for improving upon maize productivity at the farm level as well as for improving the compatibility of integrated crop-livestock and intercropping systems. The key findings from this study could help revise extension messages so that the technical and socioeconomic constraints on maize production can be addressed more effectively. Finally, the recommendations derived from the study are expected to form the basis for policy initiatives, especially in institutions dealing with inputs, credit, storage, and marketing. It is hoped that the subsequent research, extension, and policy interventions will lead to improved maize productivity, better household food security, and higher incomes for primary producers and secondary beneficiaries.

The specific objectives of the study were to:

1. identify socioeconomic and technical factors that affect adoption of improved maize technologies in Uganda;
2. describe maize farmers' current circumstances and practices; and
3. use this information to develop policy recommendations.

The remainder of this report is organised as follows. Before presenting the results of the study, we provide a brief description of the study area in Iganga District and discuss the technology generation and transfer systems that serve the area. We also detail the methodology used to collect and analyse the data and describe the technology package that was promoted to farmers. Next, we summarise survey results, including socioeconomic and demographic information, characteristics of the maize varieties grown by farmers, and farmers' agronomic practices. This information is followed by an analysis of factors influencing farmers' adoption of improved maize, based on a logistic model. We conclude by drawing the implications of the survey findings and the logistic analysis for research, extension, and policy.

1.3 The Study Area

Iganga District[2] (longitudes 33°22'E to 33°97'E, latitudes 0°17S'to 0°75'N) borders the Tororo District in the East, Jinja District in the West, Kamuli District in the North, and Lake Victoria in the South (Figure 1). The district has an area of 13,114 square kilometers (km^2) of which 4,823 is land area (Mugisa 1992). The population is 945,800, with a sex ratio of 95 males to 100 females and a population density of 196 persons/km^2.

Elevation in the district ranges from 1,070 to 1166 meters above sea level (masl). The average annual mean temperature is 21°C. Rainfall is bimodal (February-July and August- December), with an annual total ranging between 1,250 and 2,200 millimeters (mm). Two agroecological zones cut across the district: 1) the southern and western tall grasslands, where perennial and annual crops are produced, mainly in mixed farming systems, and 2) the northern and eastern short grasslands, where annual crops are produced, mainly in mixed farming systems (Figures 2 and 3). Sandy loams and sand clay loams falling on red ultisols/alfisols (ferrallitic soils) are dominant.

[2] Formerly part of the old Busoga District.

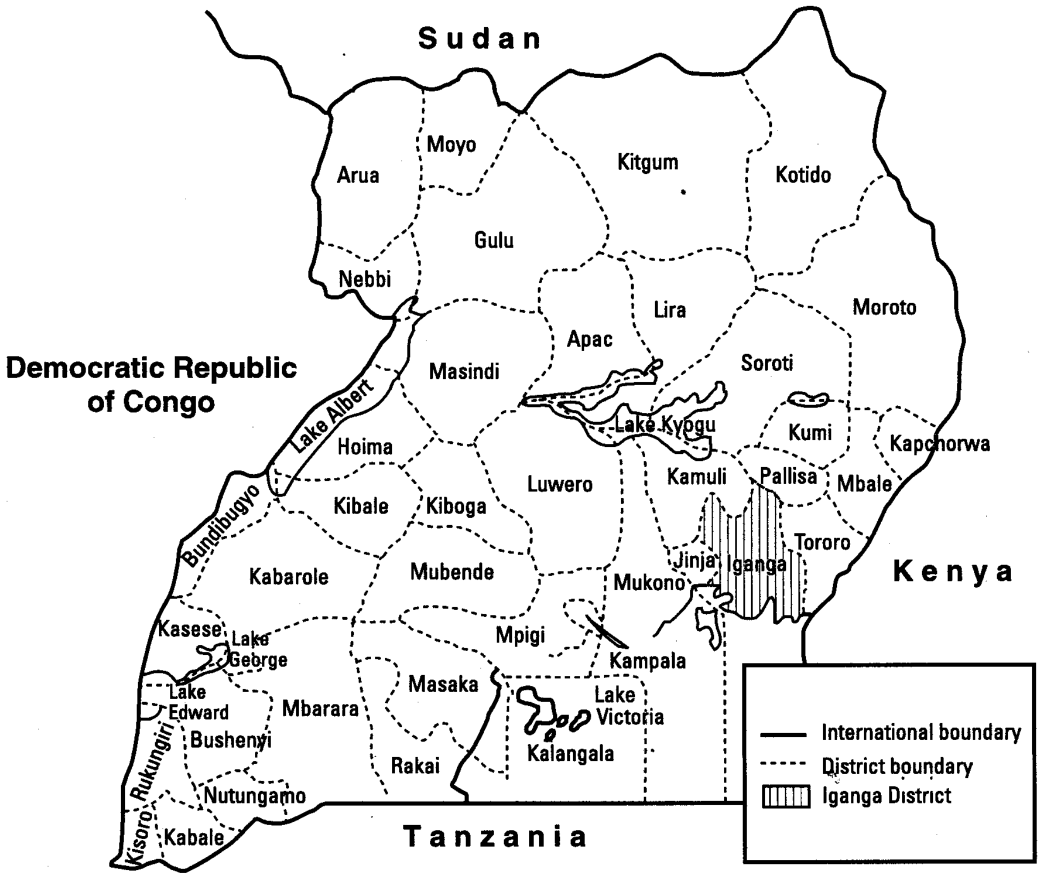

Figure 1. Location of Iganga District in Uganda
Source: Census Office, Entebbe, Uganda (1991).

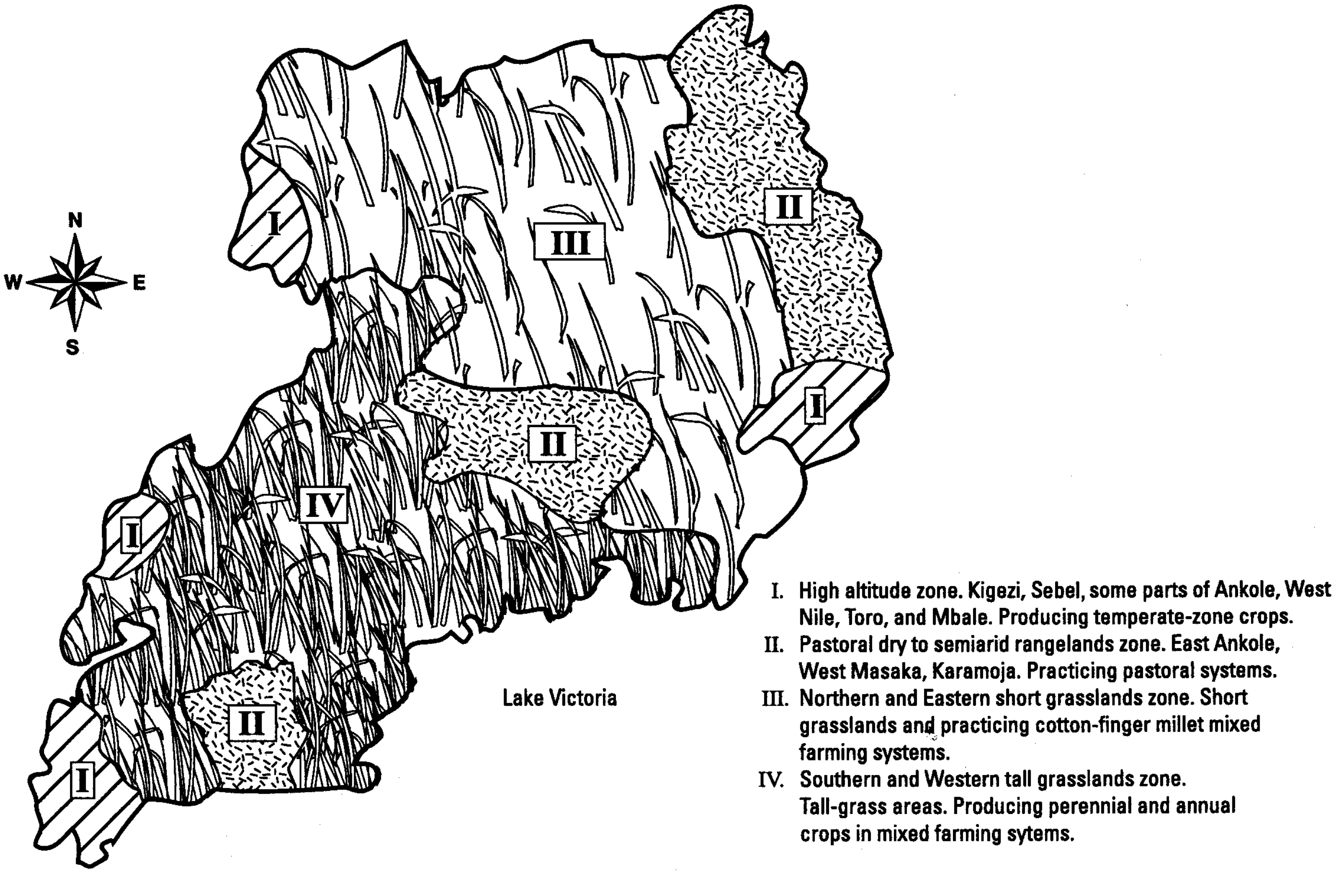

Figure 2. Distribution of the four major agroecological zones in Uganda

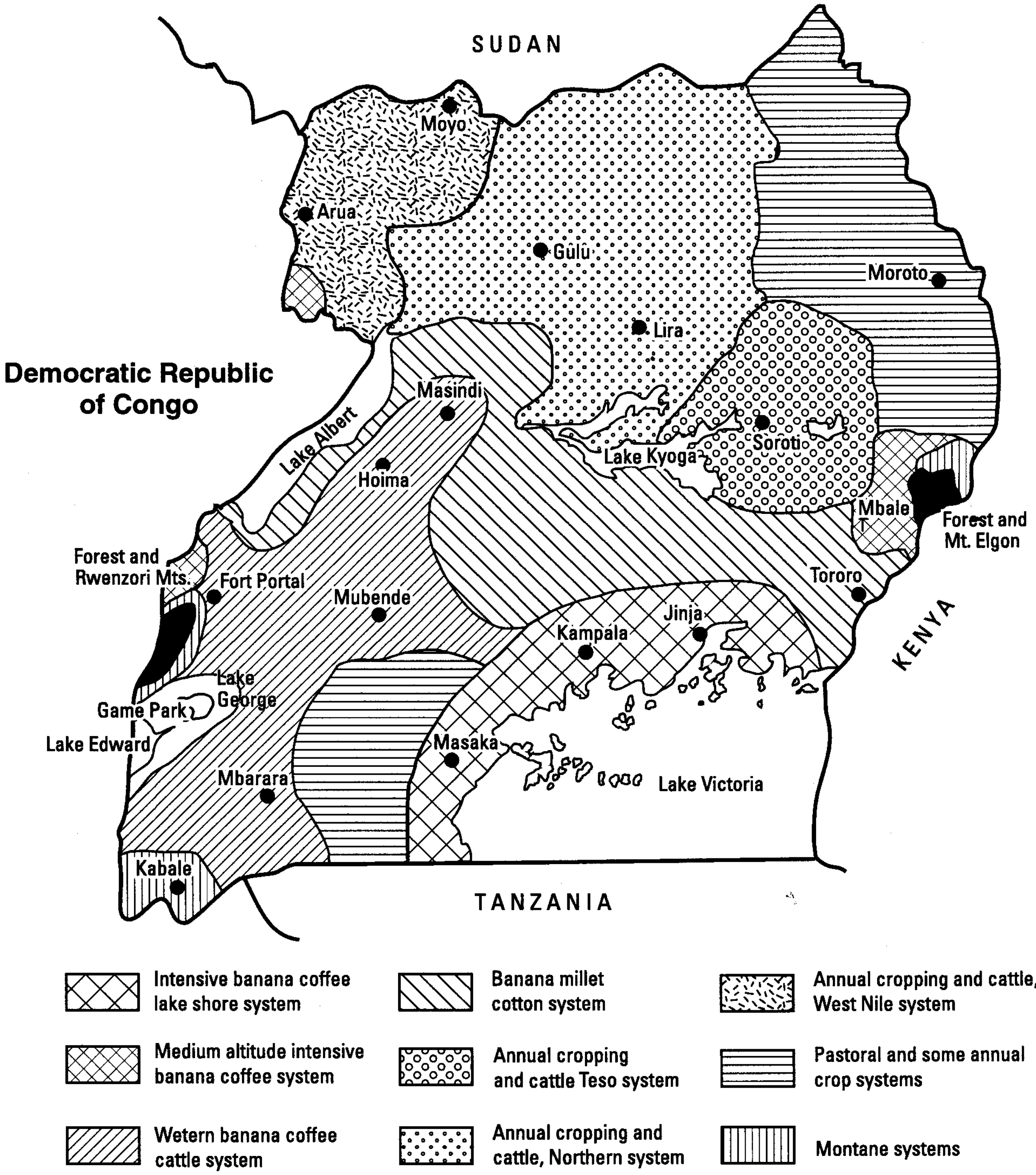

Figure 3. Farming systems in Uganda

Iganga District is basically rural: only 4.7% of the population lives in urban areas, and agriculture is the main economic activity. The main food crops are finger millet, maize, sorghum, rice, bananas, sweet potatoes, cassava, beans, *simsim*, and field peas. The major farming systems are banana-coffee-maize and finger millet-cassava-maize (IGADD/FAO 1994). Cattle, goats, sheep, and poultry are the main domestic livestock. Fishing in Lake Victoria and brickmaking are other important economic activities.

Iganga District comes under the aegis of the Agricultural Extension Programme (AEP), a government extension service which follows the Training and Visit (T&V) System. In addition, nongovernmental organisations (NGOs) such as the On-Farm Production Enhancement Programme (OFPEP) conduct agricultural extension in the area.

The district is served by several formal financial institutions, including the Cooperative Bank, Uganda Commercial Bank, Bank of Baroda, Uganda Womens' Finance and Credit Trust, Entandikwa,[3] Uganda National Farmers' Association (UNFA), and local farmers' organisations, such as the Bulamagi Integrated Farmers' Association (BIFA) and the Community Association for Rural Development (CARD). Informal money lenders, such as input suppliers and agricultural produce buyers, play an important though not easily observable role in the area.

Iganga District was selected for this study for several reasons. First, maize is a major subsistence and commercial crop. The district accounts for about 10% of the maize produced in Uganda. District farmers serve both the fresh and dry grain markets in the urban centers of Iganga, Jinja, and Kampala. Second, since the late 1980s, maize technology verification and demonstration trials have been widely conducted by the Maize Programme, both at Ikulwe District Farm Institute in Iganga and on farmers' fields throughout the district. Third, farmers in the district have received extension support from the AEP. It was considered that farmers' wide exposure to improved maize technology packages, along with the importance of maize as a source of food and income, should have favoured the adoption of recommended maize technologies in the study area and would provide ample data for an analysis of the determinants of technology adoption.

1.4 The Technology Generation and Transfer Systems

The National Agricultural Research Organisation (NARO) uses several criteria for ranking the importance of research on different crops: the value of aggregate

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[3] Seed money financing small entrepreneurs in agriculture and other production and service businesses offered by the Ministry of Economic Development.

production of a commodity, expected increase in yields as a result of research intervention, probability of research success, potential for adoption of associated technologies, future demand for the commodity, and the nature of the existing research agenda. According to these criteria, maize is the highest priority commodity and maize varietal improvement the highest priority research activity (Uganda Government 1991a, 1991b). The research agenda for maize is executed by the National Maize Programme, located at the Namulonge Agricultural and Animal Production Research Institute (NAARI).

The primary objective of the Ugandan Maize Programme is to develop high yielding varieties with resistance/tolerance to major pests and diseases, as well as to provide appropriate maize production technology packages to farmers so that the productivity of maize farming can increase.

The Maize Programme's primary client is the Uganda Seed Project of MAAIF, which multiplies breeder seed, certifies seed, and markets seed to farmers, mainly through private entrepreneurs and DECs. A very small proportion of seed is sold directly to farmers. The extension service of MAAIF as well as nongovernmental extension systems provide technical guidance to maize growers. Associated agricultural inputs recommended in the technology package are provided by private suppliers who operate wholesale and retail shops located mainly in urban centres.

The stages of technology development and transfer, which include quality breeder seed development, seed bulking/processing, and provision of farmer extension education, are the responsibility of NARO, the Uganda Seed Project, and MAAIF, respectively. This arrangement could offer the advantages of specialisation, but faulty feedback on performance of the technologies under farmers' conditions could cause inefficiencies in any one of the three component operational units. In the absence of input on farmers' actual needs, continuous varietal improvement could lead to the generation of inappropriate and unacceptable technology – especially considering that researchers' interface with farmers usually stops at the on-farm trial stage.

2.0 Methodology

2.1 Literature Review

Agricultural projects have a measurable impact when the beneficiaries gain from the outputs generated through project resources. It is important to recognise that beneficiaries (farmers) will adopt only technologies that suit their needs and circumstances, be they technical, social, economic, and agroecological. Earlier research on adoption has given considerable importance to these factors, which are outlined in greater detail below. These factors have been crucial to the development of analytical techniques for studying adoption at the farm level, particularly logistic regression, which is used in this study.

Information and incentives to adopt – Awareness of the profitability or potential preferential benefits of new technologies is necessary to trigger the diffusion of an agricultural innovation. However, for the adoption process to be sustained, the new technology must be compatible with farmers' economic resources and supported by institutions responsible for providing inputs and technical advice (see below). Extension visits, attendance at on-farm demonstrations, exposure to mass media, literacy, level of education, and time spent outside one's village are some proxies for awareness of new innovations. Innovations that are perceived to be economically compatible with farmers' values and resources are often readily adopted (CIMMYT 1993).

Institutions, resource availability, and adoption – Manfield (1963, 1968) argued that the time taken before a firm starts using a new technique is inversely related to its size. The relationship of farm size and adoption is conditioned by such factors as fixed adoption costs, risk preferences, human capital, credit constraints, labour requirements, and land tenure arrangements (Feder, Just, and Zilberman 1985). It is commonly hypothesised that greater exposure to appropriate information through various communication channels reduces subjective uncertainty and encourages adoption. However, Rogers (1964) observed that wide availability of mass media (television, radio, magazines) is often limited by cost and literacy. He noted that localised sources of information, such as neighbours and friends, could play a greater role in the diffusion of technology than formal extension services. Profitability, experience, education, and credit were the major factors affecting adoption of new hybrid rice technologies in Thailand (Ruttan and Thirtle 1987). Binswanger (1978) observed that adopters of ox-cultivation in Africa cropped larger areas and the adopters of tractors in Southeast Asia operated larger farms.

The human factor and adoption – Hicks and Johnson (1974) reported that a higher rural labour requirement explained nonadoption of intensive rice varieties in Taiwan and that shortages of family labour explained nonadoption of high yielding varieties in India. The contribution of the human factor to adoption depends on both worker and allocative ability. Formal schooling is hypothesised to play a more important role in determining allocative ability than worker ability. CIMMYT (1993), however, has stated that the focus on the various socioeconomic, technical, and agroclimatic factors depends on the intended audience or beneficiaries of the findings of the study.

2.2 *Sampling Procedures*

A multistage purposive sampling procedure with simple random sampling selection was used to identify farmers to be included in the sample. Farmers from the counties in Iganga where maize is a priority crop, namely Kigulu, Bunya, and Luuka, constituted the population (Figure 4). The major maize-producing subcounties were identified, and the parishes that were sampled within those counties were selected based on the importance of maize in the farming system (Table 1). Extension contact groups were purposively selected as pivotal centres from which lists of members producing maize were obtained. Lists of maize producers in each parish who participated and did not participate in those groups were developed by local leaders and contact group members.

The "fishbowl" method was used to obtained samples of farmer respondents: contact group members and nonparticipating farmers were assigned numbers on small pieces of paper, which were folded, put in a basket, and shuffled. A piece of paper was randomly picked, opened, recorded, folded again, and returned. This was repeated until the desired sample size was obtained. A sample of 99 farmers was obtained, consisting of 35 farmers from Kigulu, 31 from Bunya, and 33 from Luuka. Given resource and time constraints, a sample size of at least 30 respondents per county was targeted. The number of farmers belonging to extension contact groups was 43, while 56 were not group members.

For this study, we defined an adopter as a farmer growing Longe-1 maize variety on his or her own initiative. This excluded farmers whose fields may have been planted with on-farm trials by research or extension personnel. Longe 1 is the improved variety being promoted by both the Maize Research Programme and Uganda Seed Project.

Table 1. Counties, subcounties, and parishes covered by the study

Counties	**Bunya**	**Kigulu**	**Luuka**
Subcounties	Waitambogwe	Bulamagi	Waibuga, Busalamu
Parishes	Butte, Lugolole, Mulingirire, Katonte	Bulamagi, Nawanyingi, Bunyiro, Bulowoza	Itakaibulu, Walibo, Nabubya, Busalamu

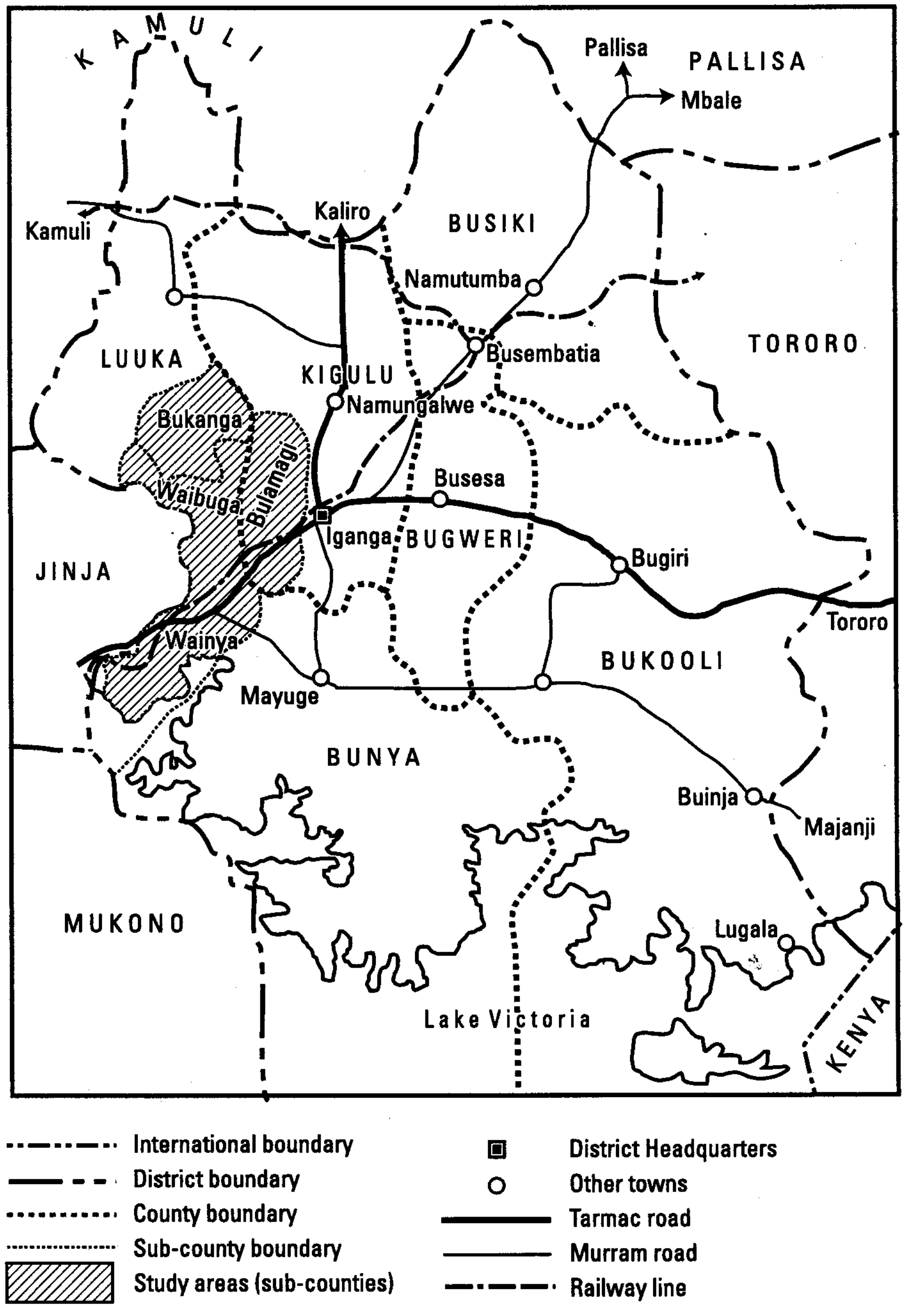

Figure 4. Study areas in Iganga District
Source: Population and Housing Census (1991).

2.3 Data Collection

Primary data formed the core of the data used in this study. These data were obtained from farmer-respondents by direct interviews using structured questionnaires. The formal survey was preceded by an informal survey to obtain qualitative data on farmers' practices and circumstances for developing the questionnaire. This information was supplemented by informal interactions with extension staff at Iganga District Administration and the maize research team at NAARI. Secondary data on social, economic, and agroecological characteristics of the district were obtained from the Agricultural Research Information Service (ARIS) and statistics from Planning Department/MAAIF and Ministry of Economic Planning.

2.4 Survey Procedure

The preparatory phases of the study involved introductory visits to the district agricultural offices, where discussions were held between the researchers and the DEC as well as the subject matter specialists on crop production and plant protection. Through this consultation, major maize-producing counties were selected and county extension coordinators identified, with whom the researchers worked during sample selection and data collection.

At the same time, the draft questionnaire was discussed and refined. The questionnaire was pretested on some farms in Bunya County, which resulted in the inclusion of Kawanda Composite A as one of the maize varieties being grown by farmers. Originally this variety had been excluded because the Seed Project stopped marketing it in 1990, and it had been assumed that farmers no longer grew it. The questionnaire's coverage of fertiliser use was also scaled down to reflect the fact that inorganic fertiliser is virtually never used in Iganga District. Storage, marketing, and utilisation of harvested maize were given more prominence in the questionnaire after their prominence in farmers' decisions about which varieties to adopt became apparent.

Three enumerators (one per county) and an overall field supervisor were selected and trained prior to implementing the survey. Interviews were conducted during the maize season at the very time when the major field and post-harvest management operations for maize were taking place. The survey started in November 1995 and was finalised in August 1996.

2.5 *Analytical Model*

Feder, Just, and Zilberman (1985) showed that many models used in adoption studies fail to meet the statistical assumptions necessary to validate the conclusions based on the hypothesis tested, and they advocated the use of qualitative response models. The two models used in adoption studies are the logit and probit. The advantage of these models is that the probabilities are bounded between 0 and 1. Moreover, they compel the disturbance terms to be homoscedastic because the forms of probability functions depend on the distribution of the difference between the error terms associated with one particular choice and another. Usually a choice has to be made between logit and probit, but as Amemiya (1981) has observed, the statistical similarities between the logit and probit models make such a choice difficult. Choice of any model is therefore not dominant and may be evaluated *a posteriori* on statistical grounds, although in practice even here there are no strong reasons for choosing one model over the other. For this study we used a logit model, because the dependent variable is dichotomous and the model is computationally simpler. This study focuses on farmers' decision to use an improved maize variety, Longe 1. Furthermore, the study quantifies the probabilities of significant factors influencing the decision to adopt Longe 1.

Following Gujarati (1988), the model is specified as:

[1] $\ln\{P(X)/(1-(P(X))\} = B_o + B_1X_1 + B_2X_2 + ... + B_{14}X_{14} + e$,

where:

X_1 = AGEHH (age of household head in years);

X_2 = HHSIZE (number of people in household);

X_3 = EDUC (literacy of the farmer);

X_4 = FAMSIZE (farm size, in acres);

X_5 = CREDIT (access to credit by the farmer);

X_6 = LSTOC (the value of livestock kept, in USh);

X_7 = LABOUR (use of hired labour by the farmer);

X_8 = NFINCOME (availability of nonfarm income to the household);

X_9 = RADIO (whether farmer has a radio or not);

X_{10} = EXTENSN (access to extension services by the farmer);

X_{11} = DEMTRIAL (whether farmer participated in demonstration trial);

X_{12} = GROUP (membership in an extension contact group);

X_{13} = SEX (gender of farmer);

X_{14} = TENURE (land tenure); and

e = error term.

The dependent variable is the natural log of the probability of adopting Longe 1 (*P*), divided by the probability of not adopting it (1-*P*). The model was estimated using the maximum likelihood method of SPSS Version 6.1 software.

Formation of the model was influenced by a number of working hypotheses. It is hypothesized that a farmer's decision to adopt or reject new technologies at any time is influenced by combined (simultaneous) effect of a number of factors related to the farmer's objectives and constraints. The variables described next were hypothesised to influence the adoption of Longe 1.

Farmer's age (AGEHH) – The age of a farmer can generate or erode confidence; in others words, with age, a farmer can become more or less risk-averse to new technology. It is hypothesised that a farmer's age can increase or decrease the probability of adopting Longe 1.

Household size (HHSIZE) – Large households will be able to provide the labour that might be required by improved maize technologies. Thus, household size would be expected to increase the probability of adopting Longe 1.

Household head received education (EDUC) – Exposure to education will increase the farmer's ability to obtain, process, and use information relevant to the adoption of an improved maize variety. Education thus is thought to increase the probability that a farmer will adopt improved maize technology packages. This is a dichotomous variable (0 = illiterate, 1 = literate).

Farm size (FAMSIZE) – Farm size is an indicator of wealth and perhaps a proxy for social status and influence within a community. It is expected to be positively associated with the decision to adopt improved maize technology.

Credit (CREDIT) – Farmers who have access to credit can relax their financial constraints, and in some cases, access to credit is tied to a particular technological package. It is expected that access to credit will increase the probability of adoption. This is a dichotomous variable (0 = no use of credit, 1 = use of credit).

Livestock ownership (LSTOC) – Ownership of livestock is hypothesised to be positively related to the adoption of improved maize technologies.

Hired labour (LABOUR) – Hiring labour is hypothesised to be positively related to the adoption of improved maize technologies. This is a dichotomous variable (0 = no use of hired labour, 1 = use of hired labour).

Nonfarm employment (NFINCOME) – Nonfarm employment generates nonfarm income that gives farmers access to new technologies. It is therefore hypothesised that nonfarm employment is positively related to the adoption of improved maize technologies. This is a dichotomous variable (0 = no nonfarm income, 1 = nonfarm income).

Farmer owns a radio (RADIO) – Radio can diffuse extension messages to farmers. Radio owners have the advantage of this access to technical information, and thus radio ownership is hypothesised to increase the probability that a farmer will adopt improved maize technologies. This is a dichotomous variable (0 = farmer does not own a radio, 1 = farmer owns a radio).

Contact with extension (EXTENSN) – Agricultural extension services provided by MAAIF are the major source of agricultural information in the study area. It is hypothesised that contact with extension workers will increase a farmer's likelihood of adopting improved maize technologies. This is a dichotomous variable (0 = farmer had no extension contact, 1 = farmer had extension contact).

Participate in demonstration trial (DEMTRIAL) – Farmers participating in demonstration trials are expected to recognise the benefits of adopting the technologies demonstrated and hence to be more likely to adopt them. This is a dichotomous variable (0 = the farmer did not particate in a demonstration trial, 1 = the farmer participated in a demonstration trial).

Membership in extension contact group (GROUP) – Being a member of an extension contact group puts a farmer in a privileged position in relation to other farmers. Because group members have better access to technical information and receive preferential treatment from extension workers, membership is hypothesised to be positively associated with the adoption of improved maize technologies. This is a dichotomous variable (0 = farmer is not a member of an extension contact group, 1 = farmer is a member of an extension contact group).

Gender of farmer (SEX) – Female- or male-headed households can have different adoption rates. This variable can be both positive or negative. It is dichotomous (0 = male farmer, 1 = female farmer).

Land tenure (TENURE) – Land tenure is hypothesised to have either a positive or negative effect on the adoption of maize technologies, depending on the opportunities that farmers perceive in a given tenurial arrangement. This is a dichotomous variable (0 = farmer rents the land, 1 = farmer/family owns the land).

3.0 Maize Production Technology Recommendations

The components of maize production technology packages are outlined in NARO (1994) and MAAIF (1991) and summarised briefly here.

3.1 Maize Varieties and Plant Populations

Two varieties are recommended for the four agroecological zones in Uganda: Kawanda Composite A and Longe 1. Both varieties are open pollinated varieties (OPVs).

The recommended plant populations are as follows:

- **Longe 1 (released in 1991):** The seed rate is 25 kg/ha at a spacing of 75 x 50 cm with two plants per hill, for a density of 53,000 plants/ha.
- **Kawanda Composite A (released in 1971):** The seed rate is 28 kg/ha at a spacing of 90 x 60 cm with two plants per hill, for a density of 37,000 plants/ha. The inter-row spacing of 75 cm for Longe 1 and 90 cm for Kawanda Composite A is sufficient for intercropping one row of beans spaced at 15 cm within rows.

3.2 Management of Weeds, Other Pests, and Diseases

Maize should be thinned in the first 21 days; thinning should be timed to coincide with the first weeding to reduce labour requirements. The first weeding should be done within the first four weeks after germination. A second or third weeding could follow, depending on the emergence of weeds. The recommended herbicides are Stomp 500E pre-emergence (3 l/ha) and Laddock early post-emergence (4 l/ha).

Control of major insect pests such as stalk borers, termites, and cutworms can be effected culturally by enforcing a closed season for at least two months following a maize crop. Sevin 5% (Carbarlyl) is the chemical recommended for stem borers. It is applied once per season, two to three weeks after crop emergence. Maize streak virus is the major disease affecting maize. Early planting and use of resistant varieties like Longe 1 reduce its severity.

3.3 *Fertiliser Recommendations*

The nutrient endowment of Ugandan soils varies widely. However, it is advisable to apply phosphatic fertilisers basally at planting and to top-dress with nitrogenous fertilisers when the crop is knee high. Recommended rates are 30 kg P_2O_5/ha (70 kg of triple super phosphate) and 45 kg N/ha, respectively.

3.4 *Harvesting and Storage*

Dry maize should be harvested when cobs collapse and face downwards. Farmers are advised to strip the husks from maize cobs stored in cribs. Shelled maize should be treated with 100 g of Actellic 1% for a 90 kg bag.

4.0 Socioeconomic and Demographic Characteristics

Socioeconomic and demographic characteristics of the sampled households are shown in Table 2 for adopters and nonadopters. Most adopters (74%) were male. Most adopters (44%) were from Kigulu, 33% were from Bunya, and 23% were from Luuka. On average, adopters were slightly older (36.3 years) than nonadopters (35.7 years). The average household size was nearly eight members for nonadopters versus nine for adopters. The average farm size of 5.9 acres was higher for adopters than for nonadopters (5.5 acres). Correspondingly, adopters had larger areas under cultivation (3.3 acres) than nonadopters (2.7 acres), and adopters sold more maize per harvest (5.9 bags) than nonadopters (5.5 bags). Adopters and nonadopters did not differ appreciably with respect to age, household size, farming experience, farm size, maize area, and amount of dry maize grain sold.

Ninety-one percent of the adopters were literate compared to 64% of nonadopters. The χ^2-test showed a significant difference ($\chi^2=9.2$, df=1, $p<0.01$) between education and use of Longe 1. More adopters had access to extension services (51%), measured in extension worker visits, than nonadopters (35%), but this difference was not statistically significant. However, the χ^2-test did show a significant difference ($\chi^2=3.1$, df=1, $p<0.1$) for contact group membership: more adopters were members of extension contact groups (54%) than nonadopters (36%). Sixty-five percent of adopters used hired labour, whereas only 36% of nonadopters did so, and the χ^2-test showed a significant difference ($\chi^2=8.4$, df=1, $p<0.01$). Similarly, more adopters engaged in nonfarm work (32.6%) than nonadopters (16.4%)($\chi^2=3.5$, df=1, $p<0.1$).

The average number of major farm implements was four hand hoes, one *panga* (machete), and one axe. There was no significant difference between adopters and nonadopters. For both groups the average number of cows was two, while the mean number of chickens averaged seven for nonadopters and eight for adopters. The number of goats averaged three for adopters and two for nonadopters.

Table 2. Distribution of socioeconomic characteristics of nonadopters and adopters in Iganga District

Characteristic	Nonadopters (N=56)		Adopters (N=43)		t-statistic
	Mean	Standard deviation	Mean	Standard deviation	
Age of household head (yr)	35.7	11.3	36.3	13.7	0.25 (NS)
Farm size (acres)	5.5	13.8	5.9	6.1	0.15 (NS)
Household size (number persons)	7.8	5.1	8.9	4.4	1.1 (NS)
Farming experience (yr)	14.7	11.4	14.6	12.8	0.04 (NS)
Area under maize (acres)	1.1	1.0	1.05	0.7	0.2 (NS)
Cultivated area (acres)	2.7	3.9	3.3	2.7	0.8 (NS)
Dry maize grain sales (bags)	5.5	7.9	5.9	7.7	0.03 (NS)
	Number of farmers	**Percent of farmers**	**Number of farmers**	**Percent of farmers**	χ^2
Gender of farmer					1.4 (NS)
Male	35	62.5	31	73.8	
Female	21	37.5	11	26.2	
Farmer's location, by county					4.0 (NS)
Kigulu	16	28.6	19	44.2	
Luuka	23	41.1	10	23.3	
Bunya	17	30.4	14	32.6	
Farmer's education					9.2**
Illiterate	20	35.7	4	9.3	
Literate	36	64.3	39	90.7	
Farmer's access to extension					2.5 (NS)
No	35	64.8	21	48.8	
Yes	19	35.2	22	51.2	
Member of contact group					3.1*
No	36	64.3	20	46.5	
Yes	20	35.7	23	53.5	
Use hired labour					8.4**
No	36	64.3	15	34.9	
Yes	20	35.7	28	65.1	
Availability of nonfarm income					
No	46	83.6	29	67.4	3.5*
Yes	9	16.4	14	32.6	

Note: NS = not significant; * = significant at $P<0.1$; ** = significant at $P<0.01$. For numbers not adding up to 56 or 43, values are missing.

5.0 Maize Production Practices and Adoption of Recommendations

5.1 Maize Varieties Grown by Adopters and Nonadopters

Survey findings for major varieties grown, farmers' varietal preferences, and farmers' sources of seed are shown in Table 3. In 1996 the major varieties cultivated by adopters were Kawanda Composite A (14%), Longe 1 (74%), and a combination of the two (12%). All nonadopters grew Kawanda Composite A. About 81% of adopters responded that Longe 1 was their preferred variety, whereas 98% of nonadopters preferred Kawanda Composite A. Regarding sources of Kawanda Composite A seed, it was found that 96% of farmers who did not adopt Longe 1 obtained their planting seed from previous harvests and purchased only about 2%. Among the adopters, 51% responded that they purchased their Longe 1 seed, while 46% obtained it from previous harvests and 3% obtained it from MAAIF.

Farmers' reasons for preferring the maize variety they grew are shown in Table 4. Among adopters of Longe 1, the most important criteria for selecting a variety were early maturity (61%) and high yield (26%). For nonadopters, the most important criteria were large kernels (67%) and high yield (11%). The majority of the farmers interviewed indicated that they knew the recommended variety. About 95% of adopters knew Longe 1 was the recommended variety, while 63% of nonadopters knew the recommended variety.

Table 3. Maize varieties grown by nonadopters and adopters and their sources of seed

	Nonadopters		Adopters	
	Number of farmers	**Percent of farmers**	**Number of farmers**	**Percent of farmers**
Maize variety planted in 1996				
Kawanda Composite A	56	100	6	14.3
Longe 1	0	0	31	73.8
Both	0	0	5	11.9
Preferred maize variety				
Kawanda Composite A	55	98.2	8	18.6
Longe 1	1	1.8	35	81.4
Source of Longe 1 seed				
MAAIF	na	na	1	2.9
Purchased	na	na	18	51.4
Retained from previous harvest	na	na	16	45.7
Source of Kawanda Composite A seed				
Purchased	1	1.8	1	5.9
Retained from previous harvest	53	96.4	15	88.2
Other	1	1.8	1	5.9

Note: na = not applicable.

About 90% of adopters indicated that they had discontinued growing some varieties, while 57% of nonadopters had discontinued growing some varieties. Among adopters, 62% had stopped growing the local variety and 5% had disadopted Longe 1 (Table 5). The major reasons given by the adopters for disadoption of varieties were poor yield (42 %) and late maturity (45%). Among nonadopters, 81% had stopped growing the local variety and 13% had disadopted Longe 1. The major reasons given by nonadopters for disadopting varieties were poor yield (45%), lack of a market (26%), and late maturity (16%).

Table 4. Farmers' reasons for preferring maize variety grown

Reason for preference	Nonadopters		Adopters	
	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers
High yield	6	10.9	11	25.6
Disease resistance	1	1.8	..	..
Early maturity	..	..	26	60.5
Large kernels	37	67.3	3	7.0
Grain color	1	1.8	..	..
Weed competition	1	1.8	..	..
Taste	2	3.6	..	..
Sweetness	4	7.3	3	7.0
Filled cobs	1	1.8	..	..
Drought resistance	2	3.6	..	..

Table 5. Varieties discontinued and reasons for discontinuing

Variety and reason	Nonadopters		Adopters	
	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers
Discontinued variety				
Local variety	25	80.6	24	61.5
Longe 1	4	12.9	2	5.1
Popcorn	1	3.2	12	30.8
Other	1	3.2	1	2.6
Reasons for discontinuing				
Poor yield	14	45.2	16	42.1
Late maturity	5	16.1	17	44.7
No market	8	25.8	3	7.9
Poor storability	1	3.2	1	2.6
Other	3	9.7	1	2.6

The major reasons given by adopters for not growing the improved variety during the first rains of 1996 were the price of the seed (43%), unavailability of seed (14%), and the belief that the improved variety was no better than the local one (43%). For nonadopters, the major reasons for not growing the improved variety were that the farmer had not heard of it (28%), the seed price (9%), unavailability of seed (47%), and the belief that the improved variety was not better than the local one (11%).

It is important to note that Kawanda Composite A, the improved maize variety that has dominated the seed multiplication effort, was released more than 20 years ago. Despite the lack of maintenance breeding and the collapse of the seed multiplication system from the early to mid-1980s, it is estimated that 43% of all maize producers grow this variety. Longe 1, released in late 1991, has been available mainly to farmers participating in on-farm trials (Laker-Ojok 1994).

5.2 *Planting Method and Cropping Pattern*

Both the adopters as well as nonadopters row planted their maize (100%). For Kawanda Composite A, 21% of nonadopters of Longe 1 had a crop stand of two plants per hill, 66% had three plants per hill, and 13% had four plants per hill. Fifty-five percent of nonadopters of Longe 1 intercropped Kawanda Composite A, while 41% grew it as a monocrop. Among Longe 1 adopters, 56% monocropped Longe 1, while 38% grew it as an intercrop. Thirty percent of the adopters followed the recommended spacing of 75 x 50 cm, and 71% of the adopters had the recommended crop stand of two plants per hill. Beans were the most common maize intercrop: 88% of the sample farmers intercropped maize with beans. Soybeans and groundnuts were the next most common intercrops (each intercropped by about 4% of the sample).

5.3 *Management of Weeds and Other Pests*

All farmers sampled controlled weeds manually using hand hoes. The most serious weed was couch grass, for adopters (63%) as well as nonadopters (57%). *Euphobia* spp. and black jack were next in importance, reported by about 17% and 14% of adopters and nonadopters, respectively. Other minor weeds were Galinsoga and commelina. In 1996, 56% of nonadopters weeded Kawanda Composite A twice, whereas 39% weeded three times. About 67% of adopters weeded Longe 1 twice and 27% three times. These results show that farmers on the whole followed the recommended manual weed control regimes.

Virtually none of the farmers in the sample used herbicides to control weeds. Sixty-seven percent of nonadopters of Longe 1 did not use herbicides because they were not aware of them, while 27% did not use herbicides because they were expensive. Among Longe 1 adopters, 36% did not use herbicides because they were not aware of them, while 62% did not use them because they were expensive.

The most important insect pests in maize were stalkborers and termites. Fifty-four percent of nonadopters and 58% of adopters cited stalkborers as the major pest problem in the study area. Termites were mentioned as the second major pest problem by 23% of nonadopters and 9% of adopters. Weevils were reported to be the third major pest problem.

5.4 Fertility Management

Almost none of the sample farmers used inorganic fertilisers. Ninety-seven percent of adopters and nonadopters used no inorganic fertilisers, while 2% used inorganic fertilisers on crops other than maize. The major reasons that nonadopters gave for not applying fertilisers were that they were not aware of their existence (64%) and that they were expensive (13%). Adopters gave the same reasons for not applying fertilisers (39% and 31%, respectively). Adopters had known about fertilisers for a significantly longer period (7.7 years) than nonadopters (3.3 years) (significant at the 5% level). National fertiliser consumption has fallen from an estimated average of 1.4 kg/ha in the 1960s to 0.2 kg/ha at present, making fertiliser use in Uganda among the lowest in the world (Laker-Ojok 1994).

5.5 Maize Storage and Marketing

Seventy-four percent of nonadopters and 70% of adopters shelled maize and stored it in bags, while the rest stored maize on the cob. Although many farmers knew about the recommended storage structures constructed using local materials, most of them kept maize in their houses (88%). The main reason given by both groups for doing so was fear of theft (80%). Few farmers (7%) stated that the current storage method was better, while the rest had various other reasons for using it.

Most nonadopters sold their maize either at the farm gate (46%) or at nearby trading centers. For adopters, 62% sold their maize in trading centers, while 32% sold it at the farm gate. The average household consumption of maize grown on the farm is significantly higher for nonadopters than adopters (significant at the 5% level). On average, nonadopters consume two bags of maize, whereas adopters consume 1.6 bags. The mean amount of maize sold was 6.0 bags for adopters and 5.5 bags for nonadopters. Nonadopters sell their maize five weeks after harvest on average, whereas adopters sell it 5.8 weeks after harvest.

6.0 Factors Influencing the Adoption of Improved Maize

6.1 Access to Credit, Hired Labour, and Extension

Farmers' access to credit, hired labour, nonfarm income, and extension is shown in Table 6. The bulk of nonadopters (84%) reported that they had no access to credit. Nonadopters' credit sources included neighbours (33%), local money lenders (22%), and Entandikwa (44%). The majority of adopters (57%) obtained farm credit from Entandikwa; other sources of credit included neighbours (29%) and local money lenders (14%). Nearly 17% of adopters had access to credit; of these, only about 5% used it to purchase improved seed. The impact of credit on adoption of improved maize varieties is therefore minimal. The major reason that nonadopters (84%) and adopters (74%) gave for failure to access farm credit was that it was not available.

Table 6. Access to credit, hired labour, and extension/information

	Nonadopters		Adopters		
	Number of farmers	Percent of farmers	Number of farmers	Percent of farmers	χ^2
Access to credit					0.01 (NS)
No	47	83.9	35	83.3	
Yes	9	16.1	7	16.7	
Source of credit					0.29 (NS)
Neighbour	3	33.3	2	28.6	
Local money lender	2	22.2	1	14.3	
Entandikwa	4	44.4	4	57.1	
Attended field day					9.2**
No	38	67.9	16	37.2	
Yes	18	32.1	27	62.8	
Attended farmer training course					6.9**
No	47	83.9	26	60.5	
Yes	9	16.1	17	39.5	
Source of information					
Extension agent	22	40.0	21	48.8	..[a]
Cooperative	..	..	1	2.3	..[a]
Contact farmer	4	7.3	5	11.6	..[a]
Neighbour	25	45.5	9	20.9	..[a]
NGOs	3	5.5	7	16.3	..[a]
Own a radio					0.35 (NS)
No	16	28.6	10	23.3	
Yes	40	71.4	33	76.7	
Listen to agricultural programmes					0.3 (NS)
No	19	34.5	12	29.3	
Yes	36	65.5	29	70.7	

Note: NS = not significant; * = significant at P<0.1; ** = significant at P<0.01.

a χ^2 not calculated because of empty cells.

Table 2 shows the use of hired labour by nonadopters (36%) and adopters (65%). This labour was used mainly for planting, ploughing, weeding, and harvesting maize. About 76% of sample farmers did not hire labour because it was too expensive. Some adopters (33%) and nonadopters (17%) were employed off of the farm, but farming remained the primary form of employment and source of livelihood for the majority of sample farmers.

In 1995 and 1996, adopters (51%) received more extension information than nonadopters (35%) (Table 2). Other extension activities, such as attendance at field days and farmers' training courses, are higher for adopters than nonadopters (Table 6). In addition, more adopters tend to participate in extension groups. Farmers' major sources of information on improved maize technologies are extension agents and neighbours. Nonadopters received information from extension agents (40%) and neighbours (46%). Among adopters, 49% and 21% received information from extension agents and neighbours, respectively. About 77% of adopters owned a radio compared to about 71% of nonadopters. The majority of the sample farmers listened to agricultural programmes.

6.2 Logistic Model Estimates

Table 7 indicates that 72% of the total variation in the sample is explained by the logistic model, which is reasonable for cross-sectional data. Figures for correctly predicted adopters and nonadopters were 66% and 77%, respectively. The Chi-square in Table 7 indicates that the parameters included in the model are significantly different from zero at the 5% level.

The variable for extension visits in 1995 or 1996 as well as the variable for the farmer hosting a demonstration plot were removed from the model. These variables showed multicollinearity with the farmer being a member of a contact group. All of these variables are related to extension, but the last variable showed a statistically significant influence on the decision to adopt Longe 1.

Explanatory variables that lacked significant correlations were the age of the household head, farm size, credit, livestock ownership, nonfarm income, radio, extension, demonstration trial, and gender. However, farmer experience, extension service, and infrastructure were key explanatory factors for adoption of clonal coffee in Mukono-Uganda (Nabbumba 1994).

The maximum likelihood estimates for the logistic regression are presented in Table 7. The use of hired labour, education, group membership, and land tenure were statistically significant at the 10% level.

The odds in favour of adopting Longe 1 technology increased by a factor of 2.8 for farmers who hired labour versus those who did not, which is not an unexpected finding. The Longe 1 technology package is labor intensive. Owing to Longe 1's short maturity compared to local varieties and Kawanda Composite A, planting, weeding/thinning, and harvesting of Longe 1 must be undertaken in a shorter time span to maximise returns. In addition, labour-saving technologies such as herbicides and draught power are lacking.

Level of education also had a statistically significant impact on a farmer's choice to adopt Longe 1. Farmers who received any kind of education were more likely (by a factor of 4.3) to adopt Longe 1 than farmers who were illiterate. Literate farmers are more disposed to understand new ideas and concepts provided by extension workers and other informants. Other studies have indicated similar effects for education (Demir 1976; Nkonya 1997).

Table 7. Parameter estimates of a logistic model for factors affecting adoption of Longe 1 improved maize technology

	Improved maize variety		
Explanatory variable	**Exp. B**	**Wald statistic**	**Variable mean**
Intercept	..	1.23	
Household head age	1.0063	0.08	36.23
Household head size	1.0324	0.27	8.27
Education	4.2649	3.39***	
Farm size	0.9774	0.85	5.7
Use of credit	0.7366	0.22	
Livestock	1.3626	0.30	
Use hired labour	2.7740	2.97***	
Nonfarm income	2.1667	1.41	
Own a radio	0.4483	1.5	
Group member	2.9905	3.7***	
Gender	1.4634	0.33	
Tenure	0.2359	3.21***	
Model χ^2	21.58**		
Overall cases correctly predicted	72.04%		
Correctly predicted adopters	66%		
Correctly predicted nonadopters	77%		
Sample size (N)	93		

Note: *** = statistical significance at the 10% level; ** = statistical significance at the 5% level.

Membership in farmers' associations (extension contact groups) is significant at 10%, and the odds in favour of adopting the Longe 1 technology are raised by a factor of 3.0 for group members compared to nongroup members. In the current T&V extension approach implemented by the Extension Directorate of MAAIF, extension contact groups are the focal point for delivering technical advice to the farmers. It should be noted that although some of the groups were involved in nonagricultural activities such as music, dance, drama, handicraft-making, and brickmaking, their meetings still constitute vital fora where government research and extension systems, as well as NGOs, can disseminate agricultural knowledge. Moreover, farmers tend to have more confidence in technologies and information obtained from colleagues. This flow of information is enhanced by interpersonal linkages, which are strengthened in group meetings. As mentioned previously, Rogers (1964) observed that sources of information such as neighbours and friends played an important role in technology adoption in addition to formal extension services. Finally, land tenure status is significant at the 10% level. The odds of adopting the Longe 1 technology decrease by a factor of 0.24 if a farmer/family owns land compared to farmers who rent land. Farmers who rent their land are more likely to use the improved variety to maximise profits.

The regression coefficients and the model were used to calculate predicted probabilities of technology adoption for changes in the significant explanatory variables. Probabilities were calculated keeping the continuous variables constant at their mean levels and the dummy variables at zero. The predicted probabilities show the likely effects of changes in the significant variables (Table 8). The change in probabilities as a result of a change in membership in an extension group, use of hired labour, access to education, and land tenure are statistically significant.

Table 8. Impact of significant factors on predicted probabilities of the use of improved maize variety

	Changes in probabilities (%) for improved variety	
Factor	**Illiterate**	**Literate**
Not member of extension group	20.0	51.7
Member of extension group	41.0	74.8
Did not use hired labour	20.0	51.7
Used hired labour	42.9	76.2
Farmer rented land	20.0	51.7
Land owned by farmer/family	5.6	20.1
Member of extension group, used hired labour, and rented land	67.5	89.9

The probability that an average illiterate farmer will adopt improved varieties is 20%. This increases to 41% if a farmer is a member of an extension group and to 43% if the farmer hired labour. If the farmer or family owns the land, adoption decreases to 6%. The combined effect of the two factors increases the probability of the use of improved varieties to 68% for farmers who rent their land. The probability of adopting improved varieties for an average literate farmer is 52%. This increases to 75% if a farmer is a member of an extension group and to 76% if a farmer hires labour. If the land is owned by the farmer or family, adoption falls to 20%. The combined effect of the two factors increases the probability of the use of improved varieties to 90% for farmers who rent their land.

7.0 Conclusions and Implications for Research, Extension, and Policy

This study of the technical and socioeconomic factors that affect maize production in Iganga District found that adopters were older, owned larger farms, were more educated, used more hired labour, participated more in farmers' groups/associations, had more access to extension services, had a higher rate of nonfarm employment, and sold more maize. Adopters and nonadopters did not differ in access to credit, household size, age, and livestock ownership.

On the whole, farmers complied with the recommendations on planting populations, hand weeding, and thinning for Longe 1. Virtually no-one used the recommended fertilisers and herbicides. A few observed the recommended drying procedure. Lack of awareness was the major reason for nonadoption of fertilisers and herbicides, whereas fear of theft made farmers reluctant to adopt the storage recommendations for Longe 1. Nonadopters of Longe 1 cited large kernels, high yield, and sweetness as the major criteria for selecting a maize variety to adopt.

Results of the logistic regression model revealed that use of hired labour, membership in farmer groups, education, and land tenure all had statistically significant effects on the adoption of the Longe 1 technology.

The evidence from this study strongly suggests that literacy is a strong determinamt of farmers' adoption of improved technologies. A government policy ensuring universal primary education should be upheld so that the economy can benefit from the stimuli arising from literate farmers' greater use of improved maize production technology.

The survey also found that farmers who did not grow Longe 1 kept growing Kawanda Composite A, using recycled seed preserved from previous harvests. This would suggest that Kawanda Composite A offers attributes that possibly counter some shortcomings of Longe 1. The Maize Research Programme and Uganda Seed Project should consider renewing supplies of Kawanda Composite A, which is still recognised as an official improved variety although it is no longer available through official distribution channels. The availability of at least two varieties provides maize farmers with a choice. Regarding plant nutrition and weed management, it should be noted that a large gap between yields in farmer-managed maize fields and potential yields at the farmer's level will prevail if constraints associated with soil nutrient deficiencies and weed competition are not addressed. It is urgent that researchers strengthen their efforts to refine fertiliser and herbicide packages. Extension workers and farmers must update their skills to counteract the adverse effects of continuous cropping, which erodes naturally available soil nutrients, and weed competition.

New extension contact groups should be formed and old ones strengthened, because these groups are vital precursors of technology transfer. Extension workers should liaise with local administrators (local councils) who are already engaged in community management, mass mobilisation, and education so as to take advantage of the group effect.

Hired labour is another key determinant of farmers' ability to adopt the Longe 1 technology package. A deliberate policy should be developed to incorporate labour-saving technologies such as herbicides and draught power for tillage and/or transport into the programme for improving crop production in general. This would offset labour costs and improve the efficiency of labour.

The Longe 1 package, together with associated post-harvest activities, requires the use of purchased inputs rather than local varieties and traditional practices. Nevertheless, very few sample farmers used farm credit to purchase improved technologies. Farmers' groups could be used as a mechanism of extending credit to farmers. The group revolving credit arrangement, which takes advantage of peer pressure to encourage the repayment of loans, could also be taken up by NGOs, UNFA, and the formal banking sector. Local farmers' groups should also consider incorporating/emphasising saving and credit dimensions among their priorities.

In reviewing the recommendations given here, it is important to remember that by 1986 Uganda had suffered a near total collapse of agricultural research system, seed multiplication capacity, output markets, input distribution networks, and extension services (Laker-Ojok 1994). However, Laker-Ojok (1994) has also shown that investment in maize research has had positive returns, even when the high costs of physical rehabilitation, training, and extension were included and benefits were limited to OPVs, which exhibit the fewest institutional constraints to diffusion. Thus continued investment in maize research and attention to recommendations such as those provided here should offer considerable potential for further reinvigorating the maize sector in Uganda.

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