55TH ANNUAL AARES NATIONAL CONFERENCE

2011

CONTRIBUTIONS OF AGRICULTURAL IMPROVED TECHNOLOGIES TO RURAL POVERTY ALLEVIATION IN DEVELOPING COUNTRIES: CASE OF IMAZAPYR-RESISTANT MAIZE IN WESTERN KENYA

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Abstract

Last two decades have been dominated by issues on poverty as major growth area with the adoption by United Nations member countries of the Millennium Development Goals, the first of which calls for halving the incidence of poverty and hunger by 2015, this has underlined the importance of introduction of improved agricultural technologies. Most poor rural households in developing countries usually depend on agriculture and have to cope with poverty stills a rural phenomenon. Agricultural production has continuously decreased, subject to serious limitations such as declining soil fertility, diseases, pests, drought and erosion plaguing crops growing areas. This situation should have encouraged rural households to increasingly consider the use of promising technologies. This study was done using a case of imazapyr-resistant maize (IRM) technology for combating noxious *Striga* weed which has devastating effects on maize production in western Kenya. A cross sectional survey that included randomly a total selected sample of 600 households of which 169 IRM users and 431 non-users was employed.

Contribution of IRM for *Striga* control on poverty reduction at household level still not well known and the literature has not been explicit on the IRM contribution in maize production. Conversely, filling this research gap is the principal objective of this study. Imazapyr-resistant maize had succeeded in reducing *Striga* seed-bank hence significantly ($P<0.05$) raising productivity from 2.2 ton/ha (non-IRM) to 2.8 ton/ha (IRM) with significant returns to land (US $173/hectare) and labour (US $8/man-day), improving nutrition for resource-poor households. Also the net present value (US $21.7 million), benefit-cost ratio (4.77) and net benefits per capita (US $41 063) for IRM enterprise were attractive. Two main conclusions can be drawn from this study. First and foremost, is that the use of IRM for *Striga* control is a promising option for farmers since this technology has been shown to be profitable compared with other maize varieties and, secondly, IRM contributed positively in alleviating poverty in western Kenya. Therefore, its use deserves attention from policy makers.

Keywords: IRM technology, *striga* control, poverty reduction, Kenya.

1. INTRODUCTION

Hunger has negative repercussion on health which affects agricultural productivity and development investments, perpetuating poverty. Hunger reduction through the introduction of improved crops and cropping practices, labour-saving technologies, improved quality of food storage, processing, and marketing has become critical for helping to stimulate growth, generate income, and reduce poverty. It is estimated that over 200 million people in Sub-Saharan Africa live in extreme poverty and among these are the rural poor in Eastern and Southern Africa where the world's highest concentration of poor people are found (Otieno, 2007). Given agricultural technology's central to growth in agricultural productivity in Africa, can improved agricultural technology contribute to alleviate poverty and help to achieve the Millennium Development Goals especially that of halving poverty by 2015?

Maize is currently the third most traded cereal, after wheat and rice, with a total production of 822 million tonnes in over 160 million hectares by 2008 (FAO, 2010). The trend for global cereal demand in the next decade is expected to increase, and in the case of maize it is expected to surpass the demand of wheat and rice. Considering FAO's latest estimations and CIMMYT (CIMMYT, 1999) predictions that shifting to maize will be reflected in a 50% increase in the demand from 1995 level of 558 million tonnes to 837 million tonnes by 2020 (CIMMYT 2010).

Taking into account the important maize production regions in the world according to UNDP (2010), the Americas have four major players: the United States, Brazil, Mexico and Argentina featuring as the most productive, with 427.4 million tonnes (MT) in 2008; In Asia: China, India, Indonesia and Iran are the main producers with 232 MT; while in Africa, their 56.6 MT were produced mostly by Egypt, Ethiopia, Malawi and Kenya.

In Kenya poverty has worsened consistently over the past two decades where maize is still a crop with high yield potential which could be a relief and help to solve the food crisis. There are however several factors which contribute to the reduction of household maize production, these include: poor weather conditions, high price of production inputs such as fertilizer and tractor hire, debility impact of HIV/AIDs among agricultural households around the Lake Victoria and *Striga* parasitic weed.

Particularly in western Kenya, an important maize production area, low maize productivity is attributed to many factors of which *Striga* the most important (Kanampiu *et al.*, 2006; Manyong et al., 2008a) threatening long-term global food, leading to food insecurity for millions of people. *Striga* parasitic weed is considered as one of the major constraints that impedes the realization of yield potentials of maize. *Striga* is colonizing over 216 000 hectares cropland resulting into maize losses of 182 000 tons per year that is valued at $29 million (Woomer and Savala, 2008). *Striga* depresses maize grain yield by 20–100%, often leaving farmers with little or no food grain at harvest (AATF, 2008). There is no doubt that western Kenya ought to fight it in order to attain self-sufficiency in maize grains.

Striga control technologies entailing traditional and novel ones such as push-pull that have been transferred to farmers over decades have failed to contain the problem. Therefore has emerged a new technology known as Imazapyr-resistant maize (IRM) involving coating maize seeds with a systemic herbicide called Imazapyr.

This study intends to show the contributions of IRM technology. In the remaining parts of the paper, section 2 discusses the materials and methods, section 3 itemized the results and discussion, while section 4 concluded with some recommendations that can contribute to increase the use of IRM technology.

2. MATERIAL AND METHODS

Study area

Nyanza and Western provinces in the Lake zone of Kenya were chosen for this study based on their importance on maize as major food and cash crop for small-scale farmers and on *Striga* which constitutes the most important biological constraint to the maize production (Manyong et al. 2008a). Nyanza province occupies a total area of 12 547 km^2 with about 968 014 households for a population density of 350 persons/ km^2 while Western province has also a high population density of 406 persons/ km^2 on a total area of 8264 km^2 with about 701 323 households (Republic of Kenya, 2001).

Source of Data

The data used for this study were collected between September and December, 2008 using a structured questionnaire and a multistage sampling procedure was adopted to get the total sample size of 600 households envisaged good for use in the study. The first stage involved the purposive selection of two provinces (Nyanza and Western) in western Kenya and three districts per province based on their importance in maize production and high levels of *Striga* infestation. The second stage involved a random selection of 100 respondents from each of the six districts.

3 DATA ANALYSIS

Performance of maize enterprises

Parameters used to express the performance of maize enterprises under *Striga* infestation included yield (tons per hectare), returns to land (gross margin per hectare) and returns to labour (gross margin per person-day). In order to compute revenues, crop yields were multiplied by 2008 average market price (mean of prices immediately after harvest and at the end of the season). Gross margins (returns) were computed by subtracting the recurrent costs from the gross revenue. The basic equation for GM computation is presented as follows in equation:

$$GM_{ij} = \frac{1}{n}\sum_{i=1}^{n}(P_{ij}Q_{ij} - TVC_{1j})$$

Where,

GM_{ij} = average gross margins earned by i^{th} household for j^{th} maize crop enterprise in Ksh;

P_{ij} = unit output price received by i^{th} household for j^{th} maize crop enterprise in Ksh/kg; Q_{ij} = quantity marketed/valued by i^{th} household for j^{th} maize crop enterprise in kg; TVC_{ij} = total variable costs incurred by i^{th} household for j^{th} maize crop enterprise in Ksh; n = number of households involved in j^{th} crop maize enterprise.

Returns to labour were expressed as the gross margins divided by the number of man-days of the family labour employed in the production process. One man-day is equivalent to one person working for 8 hours in a day. The monetary unit used in this report is the US $ at an exchange rate of Ksh 72 to US $1.

Economic viability of IRM

The analysis of long-term economic viability of community IRM project was pertinent to inform community targeting policy interventions. Some plausible assumptions made in this analysis include: (a) The time horizon of 10 years was chosen, (b) Maize yields double every year, (c) Fixed costs were not considered because the components of what could have been part of such cost structure are either provided by nature or were done once forever, (d) As reported by farmers, the average maize productivity for the 2007 short rain season was about 65% of that long rain season, (e) The discount rate of 10% (see Pagiola, 1996; Senkondo *et al.*, 2004) was assumed. The financial streams of revenues and costs were discounted to determine the net present value (NPV) and Benefit/Cost Ratio (BCR). The discounted budgeting technique was used in this study despite the criticisms vested in its underlying static production economics theory which ignores dynamics practically facing farm firms in real world. According to Bradford and Debertis (1985), the problem of static assumption is that budgeting cannot address the problem of future inflationary shifts or market prices of inputs and outputs. However, budgeting has remained a useful planning tool in farm production and management. Net present value is the present value of a series of future net benefits that will result from an investment. The criterion for the acceptance of a project is that the NPV value must be positive and BCR must be greater than 1 (see Stutely, 2002; Mullins *et al.*, 2002). The computation of present value of the stream revenues and costs was done in the Excel worksheet using built-in command. Mathematical Equations underlying the computation of NPV and BCR are as follows:

$$\mathbf{NPV_s} = \sum_{t=1}^{n} \mathbf{R_t}\left(\frac{1}{(1+r)^t}\right) - \sum_{t=1}^{n} \mathbf{C_t}\left(\frac{1}{(1+r)^t}\right)$$

$$\mathbf{BCR_s} = \sum_{t=1}^{n} \frac{\mathbf{R_t}\left(\frac{1}{(1+r)^t}\right)}{\sum_{t=1}^{n} \mathbf{C_t}\left(\frac{1}{(1+r)^t}\right)}$$

Where,

NPV_s = Net Present Value of the scheme (Ksh)

BCR_s = Discounted BCR of the scheme

R_t = revenue in year t (Ksh)

C_t = costs in year t (Ksh)

r = discount rate (10%)

$t \ldots n$ = year t to nth of the project time horizon

$\sum$ = the sum of each of the years' discounted net benefit stream

The net returns or benefits per capita expressed the project entire benefits to the beneficiary population. The population of farmers served by the project was computed by multiplying the region average household size and the total of beneficiary households. The challenge is that for a 10-year time horizon the household size is not static it keeps on changing over the years. Mathematical equation underlying the computation of net benefits per capita is as follows:

$NBC_t = NB_t / N_t$

Where,

NBC_t = net benefits per capita in year t (US $)

NB_t = net benefits in year t (US $)

N_t = number of project beneficiaries in year t

4. RESULTS AND DISCUSSION

Socioeconomic Characteristics of Households

Table 1 shows a few demographic and socioeconomic characteristics of more relevance in IRM contribution. About 74% of households in western Kenya were headed by male as in most developing countries. Farmers are engaged in different income generating activities, and the main sources of income is crop and livestock selling, and information on household income was captured for the both seasons and was calculated at an average of Kshs 53,719 ($746) per household, with the income indicating that IRM users had significantly ($P<0.05$) higher household income than non-users. This suggests that, the use of IRM technology was associated with high household income probably due to higher purchasing power to support all the costs requirements for IRM cultivation. The per capita household income corresponded to about US$ 0.59/day for users and US$ 0.36/day for non-users, characteristic of extreme poverty in western Kenya which is defined as under the World Bank poverty line of US$ 1/day/person.

Table 1: Socio-economic characteristics of sample households

Statistics	IRM users	Non-users
Average Total land holding	0.85 (0.50)	1.01 (0.54)
Average land allocated to maize	0.41 (0.27)	0.47 (0.29)
Average HH income (Kshs)	80972 (55497)	43033 (41931)
Per capita HH income (Kshs)	15 467	9 319
Per capita per day HH income (US $)	0.589	0.355

HH=Household, HHH=Household head; Figures in brackets indicate the standard deviation

Performance of maize enterprises

Farmers in western Kenya grow several varieties of maize which could be grouped into three: IRM, other hybrid variety and local maize variety. Local maize variety is by far the most common one followed by hybrid maize varieties. In addition to these two types of varieties, the novel one, the IRM which is been adopted to control the effect of *Striga*. The gross margin (GM) of the different types of maize is shown in Table 2 below. Returns to labour and GMs vary among different types of maize. A comparison between maize crops shows that in average GM per ha of IRM was significantly (P<0.01) higher than that of hybrid. Also GM per ha of IRM was significantly (P<0.01) almost double than that of local maize. In terms of variable costs, local maize is the cheapest but its relative low output per unit makes it a disadvantaged crop in terms of returns to land. Therefore, IRM is likely to be the first crop in relative profitability.

Table 2: Gross margins across different maize enterprises, values in Ksh, 2008

Item	Maize farming system typical for		
	Local maize (N=291)	**IRM (N=169)**	**Hybrid maize (N=312)**
Gross revenue in Ksh/ha	28 494	55 555	49 240
Total operational costs in Ksh/ha	1 928	3 802	4 196
Gross margin in Ksh/ha	26 566	51 753	45 032
Gross margin in Ksh/ha (St. Deviation)	4 628	9 455	4 663
Gross margin in Ksh/ha (Minimum)	11 400	21 067	9 590
Gross margin in Ksh/ha (Maximum)	39 450	67 967	53 330
Gross revenue			
	Local Vs IRM: -t = 26.02***	Local Vs Hybrid: -t = 25.86***	IRM Vs Hybrid: t = 5.88***
Total operational costs			
	Local Vs IRM: -t = 7.69***	Local Vs Hybrid: -t = 5.39***	IRM Vs Hybrid: t = 3.93***
Gross margin (Mean)			
	Local Vs IRM: -t = 22.26***	Local Vs Hybrid: -t = 20.48***	IRM Vs Hybrid: t = 4.32***

***Significant at P<0.01

Table 3 shows that IRM grown resulted into significantly ($P<0.01$) higher yield than that of other hybrid. Also the recorded mean IRM yield of 2.8 ton/ha was significantly higher ($P<0.01$) than that obtained with local maize.

Table 3: Yield of maize under different types

Type of maize	Descriptive statistics of yield (ton/hectare)		
	N	Mean	Standard Deviation
Local maize	291	1.4	0.22
IRM	169	2.8	0.44
Hybrid maize	312	2.5	0.19
Local Vs. IRM: -t = 26.02***	Local Vs. Hybrid: -t = 25.86***	IRM Vs. Hybrid: t =5.88***	

*** Significant at $P<0.01$

The comparison of maize yield differential between non-IRM and IRM varieties is carried out because the two types of maize varieties were grown under the same conditions in the same area during the long rainy season of 2008. The likely source of yield variation was the type of maize grown, a pair-wise comparison of the yield between maize varieties indicates that the mean yield of IRM (2.8 ton/ha) was significantly ($P<0.05$) higher than the mean yield of the non-IRM (2.2 ton/ha) amounting to a 27.3% yield advantage (Table 4). This confirms that there is a positive contribution in maize output from adopting IRM.

Table 4: Maize productivity differential by maize variety

Category	Maize yield (ton/ha)	Standard deviation	T-Value
IRM	2.8	0.45	7.92*
Non-IRM	2.2	0.73	

*Significant at $P<0.05$

After taking into account prices and costs of production, the yields of maize realized during the long rainy season of 2008 were expressed in financial returns to land from maize as shown in Table 5. The returns to land realized under IRM were significantly ($P<0.05$) higher to that of local maize. Contrary to physical yields, returns to land realized under IRM were significantly less ($P<0.05$) than those obtained under hybrid maize. Given that IRM recorded high yield compared to hybrid maize (Table 3 above), lower returns from the former could be resulting from differences in the output prices and costs of production among farmers. Generally, an increased adoption of improved maize would improve crop income even other factors such as better output prices and lower costs of inputs associated with maize are constant.

Table 5: Returns to land from different types of maize

Type of maize	**Descriptive statistics of returns to land (Ksh/hectare)**		
	N	Mean	Standard Deviation
Local maize	291	9 522	6 572
IRM	169	12 457	9 752
Hybrid maize	312	18 436	11 881
Local Vs. IRM: -t = 8.72***	Local Vs. Hybrid: -t = 8.80***	IRM Vs. Hybrid: t = 3.08***	

*** Significant at $P<0.01$

The returns to labour reflects the level of reward for each man-day of the household workforce engaged in the production process and the results in Table 6 show that the pattern of returns to labour followed a different trend like returns to land. Financial reward to family labour input of IRM enterprise significantly ($P<0.01$) exceeded that of hybrid maize which in turn significantly ($P<0.05$) exceeded that of the local maize. This indicates the possibility that farmers tended to allocate less labour in local maize enterprise than they do for improved maize. Generally, IRM enterprise demonstrated higher mean return to labour than other hybrid and local maize enterprises, indicating the potential of the former in reducing poverty and vulnerability associated with *Striga*.

Table 6: Returns to labour from different types of maize

Type of maize	Descriptive statistics of returns to labour (Ksh/man-day)		
	N	Mean	Standard Deviation
Local maize	107	363	287
IRM	79	600	411
Hybrid maize	144	501	303
Local Vs. IRM: -t = 2.30**	Local Vs. Hybrid: -t = 2.45**	IRM Vs. Hybrid: t = 5.03***	

Significant at P<0.05, * Significant at P<0.01

IRM Technology has made a difference, this improved maize technology in *Striga* zone, especially for small-scale farmers, hastens poverty reduction through increased crop yields.

Economic viability of IRM technology

Table 7 presents the economic viability indicative parameters extracted from Appendices 1 and 2. The net present current worth of 10-year time horizon is US $21.7 million equivalent to more than hundred times what is obtained from local maize under 20% annual yield decrease; and this illustrates the fruit of investing in IRM. These results indicate that IRM cultivation fetches higher returns whereas benefit cost ratio is reasonably lower than that of local maize.

Table 7: Economic viability between local maize and IRM

Indicative parameters (in US $)	Entire IRM yield	Entire local maize yield
Net benefits/capita	42.26	35.38
Benefit/Cost Ratio (BCR)	4.77	5.60
Net present value (NPV)	21 680 401.78	158089.53

The returns to labour is a good indicator of income and hence poverty reduction as a result of the employment created through farming. In the income poverty analysis, the return to labour indicates the magnitude of a daily income that can be gauged on absolute poverty thresholds to reflect the depth of poverty. During the long rainy season of 2008, farmers with IRM plots realized Ksh 600 (US $8) for each person-day of the household workforce involved in producing maize. This means that return to labour realized by IRM producers in the project is eight times above the global poverty line of US $1 per person-day, reflecting the daily impact of IRM use on poverty reduction. The same section presents the yields of IRM realized during the long same season. These are expressed in financial returns to land amounting to Ksh 12 457 (US $173) per hectare which is substantial in the long-term economic viability of IRM project.

Findings from gross margins to returns to labour, coupled by the long-term economic viability indicative parameters of IRM enterprise were good in depicting that IRM is more viable economically in terms of returns to investment compared to other maize enterprises and consequently contribute in poverty alleviation western Kenya prone by *Striga*.

CONCLUSION

Focusing on three groups of maize varieties used by farmers, the paper analyzes the performance of these maize varieties and how it changes with changes in economic factors. The potential of the three maize enterprises in contributing to poverty alleviation is also determined and finally, the paper concludes by drawing some policy implications and suggesting the way forward. The results have demonstrated that gross margins and returns to labour for the three types of maize are positive. Therefore, farmers are able to recover their costs and remain with a positive balance. The highest gross margins have made IRM to be a viable and potential option in western Kenya which is devastated by *Striga*. The novel IRM guarantee significantly higher yields than local and other hybrid maize. Thus the long-term economic worth indicators have shown that IRM has the potential for poverty reduction and minimizing food security problems. Also its net present value, benefit-cost ratio and net benefits per capita are attractive. IRM technology occupies a central role in the design of comprehensive *Striga* Eradication Initiatives in maize fields and therefore should be prioritized particularly in western Kenya. Hence a significantly positive public investment and technology transfer is needed to improve IRM use and its efficiency; this would, in turn, improve the adaptive capacity of western Kenya farming households and communities against *Striga*. IRM is still a plant with a wide variation in growth, production and quality characteristics. A lot of investigations remain to be carried out in order to improve the performance of the crop in a way that is economically, environmentally, and socially sustainable. We are however very confident that the integrated approach of investigation followed by AATF, CIMMYT, IITA will permit to overcome the constraints that limit the full exploitation of IRM potentialities in rural poverty alleviation in Kenya.

Acknowledgements

This paper is an output from a PhD study funded by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria through a research grant received from AATF, which is also acknowledged for their support.

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Appendix 1: Cash Flow Analysis of Community IRM Project in western Kenya

ITEMS	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
IRM PROJECT BENEFICIARIES										
Households served by the project *[1]*	169	169	169	169	169	169	169	169	169	169
Average household size (with 2.3 growth rate) *[2]*	5.75	5.88	6.02	6.16	6.29	6.44	6.59	6.74	6.89	7.05
TOTAL NUMBER OF BENEFICIARIES *[3=1x2]*	971.75	993.72	1017.38	1041.04	1063.01	1088.36	1113.71	1139.06	1164.41	1191.45
OUTPUT AND BENEFITS										
Area under IRM (ha)- short rain season *[4]*	25.60	25.60	25.60	25.60	25.60	25.60	25.60	25.60	25.60	25.60
Area under IRM (ha)- long rain season *[5]*	38.21	38.21	38.21	38.21	38.21	38.21	38.21	38.21	38.21	38.21
Yield (ton/ha)- IRM *[6]*	2.80	5.60	11.20	22.40	44.80	89.60	179.20	358.40	716.80	1433.60
Average price in US $*/ton *[7]*	278.00	278	278	278	278	278	278	278	278	278
Total acreage under IRM *[8=4+5]*	63.81	63.81	63.81	63.81	63.81	63.81	63.81	63.81	63.81	63.81
Total annual output (ton) *[9=6x8]*	178.67	357.3399	714.6798	1429.36	2858.719	5717.439	11434.88	22869.75	45739.51	91479.02
Annual revenue (US $) *[10=7x9]*	49670.25	99340.5	198681	397362	794724	1589448	3178896	6357792	12715584	25431167
GROSS BENEFITS (US $) *[11=10]*	49670.25	99340.5	198681	397362	794724	1589448	3178896	6357792	12715584	25431167
OVERHEAD AND PRODUCTION COSTS										
Community labour for IRM cultivation (man-days) *[12]*	2072.00	2072.00	2072.00	2072.00	2072.00	2072.00	2072.00	2072.00	2072.00	2072.00
Wage rate per man-day (US $) *[13]*	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
IRM cultivation costs (US $) *[14=12x13]*	2009.84	2009.84	2009.84	2009.84	2009.84	2009.84	2009.84	2009.84	2009.84	2009.84
Seeds planted (US $) *[15]*	2001.11	2001.11	2001.11	2001.11	2001.11	2001.11	2001.11	2001.11	2001.11	2001.11
DAP used (US $) *[16]*	1715.28	1715.28	1715.28	1715.28	1715.28	1715.28	1715.28	1715.28	1715.28	1715.28
CAN used (US $) *[17]*	675.56	675.56	675.56	675.56	675.56	675.56	675.56	675.56	675.56	675.56
Manure used (US $) *[18]*	809.03	809.03	809.03	809.03	809.03	809.03	809.03	809.03	809.03	809.03
Pesticide used (US $) *[19]*	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
Oxen hiring charge (US $) *[20]*	1061.67	1061.67	1061.67	1061.67	1061.67	1061.67	1061.67	1061.67	1061.67	1061.67
Tractor hiring charge (US $) *[21]*	237.50	237.50	237.50	237.50	237.50	237.50	237.50	237.50	237.50	237.50
Land rent (US $) *[22]*	89.77	89.77	89.77	89.77	89.77	89.77	89.77	89.77	89.77	89.77
INVESTMENT COSTS (US $) [23=14+15+16+17+18+19+20+21+22]	8607.43	8607.43	8607.43	8607.43	8607.43	8607.43	8607.43	8607.43	8607.43	8607.43
NET BENEFITS (us $) *[24=11-23]*	**41062.82**	**90733.07**	**190073.6**	**388754.6**	**786116.6**	**1580841**	**3170288**	**6349184**	**12706976**	**25422560**
DISCOUNTED REVENUE (US $) *[25]*	**21733290.71**									
DISCOUNTED COSTS (US $) *[26]*	**52888.93**									
BENEFITS/COSTS RATIO *[27=24/23]*	**4.77**									
NET BENEFITS PER CAPITA (US $) *[28=24/3]*	**42.26**	**91.30647**	**186.8265**	**373.429**	**739.5194**	**1452.498**	**2846.601**	**5574.056**	**10912.8**	**21337.5**
NPV (US $)	**21680401.78**									

*Exchange rate: 1 US $ = 72 Ksh; Discount rate= 10%

Appendix 2: Cash Flow Analysis of Community Local Maize Project in western Kenya (Annual yield decrease: 20%)

ITEMS	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
IRM PROJECT BENEFICIARIES										
Households served by the project *[1]*	291	291	291	291	291	291	291	291	291	291
Average household size (with 2.3 growth rate) *[2]*	5.75	5.88	6.02	6.16	6.29	6.44	6.59	6.74	6.89	7.05
TOTAL NUMBER OF BENEFICIARIES *[3=1x2]*	1673.25	1711.08	1751.82	1792.56	1830.39	1874.04	1917.69	1961.34	2004.99	2051.55
OUTPUT AND BENEFITS										
Area under Local Maize (ha)- short rain season *[4]*	70.90	70.90	70.90	70.90	70.90	70.90	70.90	70.90	70.90	70.90
Area under Local Maize (ha)- long rain season *[5]*	105.82	105.82	105.82	105.82	105.82	105.82	105.82	105.82	105.82	105.82
Yield (ton/ha)- Local Maize *[6]*	1.42	1.14	0.91	0.73	0.58	0.46	0.37	0.30	0.24	0.19
Average price in US $*/ton *[7]*	278.00	278	278	278	278	278	278	278	278	278
Total acreage under Local Maize *[8=4+5]*	176.72	176.72	176.72	176.72	176.72	176.72	176.72	176.72	176.72	176.72
Total annual output (ton) *[9=6x8]*	250.94	201.4608	160.8152	129.0056	102.4976	81.2912	65.3864	53.0160	42.4128	33.5768
Annual revenue (US $) *[10=7x9]*	69761.99	56006.10	44706.63	35863.56	28494.33	22598.95	18177.42	14738.45	11790.76	9334.35
GROSS BENEFITS (US $) *[11=10]*	69761.99	56006.10	44706.63	35863.56	28494.33	22598.95	18177.42	14738.45	11790.76	9334.35
OVERHEAD AND PRODUCTION COSTS										
Community labour for Local Maize cultivation (man-days) *[12]*	5457.64	5457.64	5457.64	5457.64	5457.64	5457.64	5457.64	5457.64	5457.64	5457.64
Wage rate per man-day (US $) *[13]*	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Local Maize cultivation costs (US $) *[14=12x13]*	5293.91	5293.911	5293.911	5293.911	5293.911	5293.911	5293.911	5293.911	5293.911	5293.911
Seeds planted (US $) *[15]*	2214.24	2214.24	2214.24	2214.24	2214.24	2214.24	2214.24	2214.24	2214.24	2214.24
DAP used (US $) *[16]*	1340.97	1340.97	1340.97	1340.97	1340.97	1340.97	1340.97	1340.97	1340.97	1340.97
CAN used (US $) *[17]*	192.22	192.22	192.22	192.22	192.22	192.22	192.22	192.22	192.22	192.22
Manure used (US $) *[18]*	886.11	886.11	886.11	886.11	886.11	886.11	886.11	886.11	886.11	886.11
Pesticide used (US $) *[19]*	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60
Oxen hiring charge (US $) *[20]*	606.67	606.67	606.67	606.67	606.67	606.67	606.67	606.67	606.67	606.67
Tractor hiring charge (US $) *[21]*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Land rent (US $) *[22]*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INVESTMENT COSTS (US $) [23=14+15+16+17+18+19+20+21+22]	10570.72	10570.72	10570.72	10570.72	10570.72	10570.72	10570.72	10570.72	10570.72	10570.72
NET BENEFITS (us $) *[24=11-23]*	**59191.27**	**45435.38**	**34135.9**	**25292.84**	**17923.61**	**12028.23**	**7606.698**	**4167.727**	**1220.038**	**- 1236.37**
DISCOUNTED REVENUE (US $) *[25]*	**223042.04**									
DISCOUNTED COSTS (US $) *[26]*	**64952.50**									
BENEFITS/COSTS RATIO *[27=24/23]*	**5.60**									
NET BENEFITS PER CAPITA (US $) *[28=24/3]*	**35.38**	**26.55363**	**19.48597**	**14.1099**	**9.792237**	**6.418344**	**3.966594**	**2.124939**	**0.608501**	**- 0.60265**
NPV (US $)	**158089.53**									

*Exchange rate: 1 US $ = 72 Ksh; Discount rate= 10%