POTENTIAL ECONOMIC AND POVERTY IMPACT OF IMPROVED CHICKPEA TECHNOLOGIES IN ETHIOPIA

Ibrahim Macharia[a]*, Alastair Orr[b], Franklin Simtowe[b] and Solomon Asfaw[c]

[a] Kenyatta University Kenyatta, Department of Agribusiness Management and Trade, P.O Box 43844 –00100, Nairobi, Kenya; mach4ibra@yahoo.com

[b] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), PO Box 39063-00623 Nairobi, Kenya. AOrr@cgiar.org and F.p.Simtowe@cgiar.org

[c] Food and Agriculture Organization of the United Nation (FAO), Viale delle Terme di Caracalla 00153 Rome, Italy. Solomon.Asfaw@fao.org

Selected Poster prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil

18-24 August, 2012.

Abstract

This study assessed the potential economic and poverty impact of 11 improved chickpea varieties released by the national agricultural research organization of Ethiopia in collaboration with the International Crops Research Institute for the Semi-Arid Tropics. The economic surplus model applied estimated a total benefit of US$ 111 million for 30 years. Consumers are estimated to get 39% of the benefit and producers 61%. The benefit cost ratio was estimated at 5:1 and an internal rate of return of 55%, indicating that the investment is profitable. The generated benefit is expected to lift more than 0.7 million people (both producers and consumers) out of poverty. Thus, further investments in the chickpea and other legume research in Ethiopia is justified as a means of poverty alleviation.

Keywords: Economic impact, chickpea, improved varieties, Ethiopia

1 Introduction

Africa's Green Revolution has proved elusive. By 2000, only 22 % of food crop area was planted to improved varieties (Maredia and Raitzer, 2006). Progress has also been uneven, with significantly more success in wheat and rice than in other crops. In particular, there has been limited progress in the development and diffusion of improved varieties of tropical grain legumes. Chickpea, pigeon pea, cowpea, common bean, and soybean are widely grown, often as intercrops with cereals. Between 1980 and 2005, total production of these crops in Sub-Saharan Africa (SSA) grew by 5% per year. However, adoption of improved varieties and production technology was limited. Most of the increase in production came from expansion in area planted, which almost doubled from 14 to 27 million ha. The rate of growth in yields of tropical grain legumes was less than 1% per year.

One reason for Africa's elusive Green Revolution has been low investment in agricultural research and development (R & D). Agricultural research in Africa relies almost exclusively on the public sector and foreign aid. Donor funding to R & D in Africa peaked in the mid 1980s, and has continued to decline (Pardey *et al.*, 2007). National investment in agricultural R & D has also declined and currently averages only 0.7% of Gross domestic product (GDP).

Investment in agricultural R & D in SSA has shown relatively high rates of return (Table 1).

Table 1. List of impact studies conducted in Africa with estimated benefits

Source	Crop	Technology	Countries	B/C or IRR[a]
Ahmed *et al.* (1994)	Sorghum	Improved variety	Sudan	97%
Ajayi *et al.* (2007)		Fallow system	Zambia	21%
Bokonon-Ganta *et al.* (2002)	Mango	Biological (Mango mealybug)	Benin	145:1
Coulibaly *et al.* (2004)	Cassava	Biological control (Green mite)	Ghana, Nigeria Benin	111%-Ghana, 125%-Nigeria 101%-Benin

Macharia *et al.* (2005)	Cabbage	Biological control (Diamondback moth)	Kenya	24:1
Rohrbach *et al.* (1999)	Pearl millet	Improved variety	Namibia	50%
Yapi *et al.* (1999)	Sorghum	Improved variety	Chad Cameroon	95%- Chad 75%- Cameroon
Zeddies *et al.* (2001)	Cassava	Biological control (Green mite)	27 countries in SSA	200:1

[a] With percentage are the internal rate of returns (IRR)

Most studies have focused on cereals and fruits. Evidence for grain legumes is lacking. Grain legumes, including ‘orphan crops’ like chickpea, have significant potential to generate cash income, reduce poverty and food insecurity, and to enhance soil fertility. Chickpea is an excellent source of protein, fiber, complex carbohydrates, vitamins, and minerals. It can reduce malnutrition and improve human health, particularly for the poor, who cannot afford livestock products (Asfaw, 2010). It has the capacity to fix atmospheric nitrogen in soils and thus improves soil fertility and save fertilizer costs in subsequent crops. Chickpea can also be grown as a second crop using residual moisture. This promotes more intensive and productive use of land, particularly in areas of land scarcity. Compared to cereals, chickpea residues are rich in digestible crude protein, making it a valuable fodder and increasing the productivity of livestock. Finally, the growing demand in both the domestic and export markets provides a source of cash for smallholder producers.

This article analyzes the potential welfare impact of agricultural R & D on chickpea in Ethiopia. Ethiopia is the major producer of chickpea in SSA, accounting for nearly 52% of the total area and 73% of production. The annual area planted to chickpea in Ethiopia is estimated at about 204,000 ha with a production total of 227,000 tonnes. Ethiopia is also the continent’s largest exporter of chickpea, accounting for nearly 76% and 78% of the total volume and value, respectively, of Africa's chickpea exports. Hence, investment in R & D to raise the productivity of chickpea in Ethiopia is expected to yield significant welfare benefits.

In collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Ethiopia has developed and released several high-yielding and stress tolerant varieties of chickpea with desirable agronomic and market traits. Between 1974 and 2005, a total of 11 improved chickpea varieties have been released through this collaborative research program. These include: Shasho (ICCV93512), Arerti (FLIP 89-84C), Chefe (ICCV-92318), Habru (FLIP 88-42C), Teji (FLIP97-266C), Ejeri (FLIP97-263C), DZ–10–04, DZ–10–11, Dubie, Marye (K850*F378), Worku (ICCL 82104) and Akaki (ICCL82106). Until now, however, there has been no systematic study to assess the economic impact of this research investment in Ethiopia, and the potential impact of these improved varieties in terms of productivity enhancement and poverty reduction remains unknown.

The general objective of this article is to estimate the potential impact of R & D for chickpea in Ethiopia. The specific objectives are to estimate:

1. The economic rate of return on investment in R & D;
2. The distribution of benefit between producers and consumers; and
3. The potential impact on poverty.

2 Data and Methods

2.1 Conceptual framework

Impact assessment aims to determine the consequences of an intervention in the development process. The analysis can either be *ex-ante*, i.e. conducted prior to the intervention, or *ex-post*, *i.e.* after the project is implemented. In the former case it can help with difficult decision making in the allocation of limited resources and is based on some type of prediction model, while in the latter case it can determine the impact of past investment in research on target beneficiaries and is a way to learn some of the lessons of the past, as it is measured at some point in time after the intervention has taken place.

The need for impact assessment arises for several reasons: a) the assessment is important for accountability for the use of scarce public funds, b) the assessments are intended to better inform policymakers about the likely magnitude and distribution of payoffs to the technologies under evaluation, c) the results can allow scientists and policymakers to better judge the possible impact of the technology in other project countries, d) evaluation of cost effectiveness of technology transfer mechanisms used by the project, in the interests of possible improvement *i.e.* it help in learning about more and less successful approaches to development and poverty reduction thus improve targeting of research programs and help adjust resource allocation across programs.

The starting point consists of inputs in terms of financial and human resources (Figure 1). These inputs enable the breeding of the improved chickpea varieties. After the development of improved varieties, financial and human resources are again required in the diffusion of these varieties to the famers in terms of demonstrations, outreach programs and availing the improved seeds to the farmers (step 4). It is assumed that this will prompt the farmer acceptance and use of the technology (step 5). The adoption then increases the chickpea yields and consequently increases the farmers' income, which will lead to reduction in poverty as well as welfare gain to the farmer and the society as a whole.

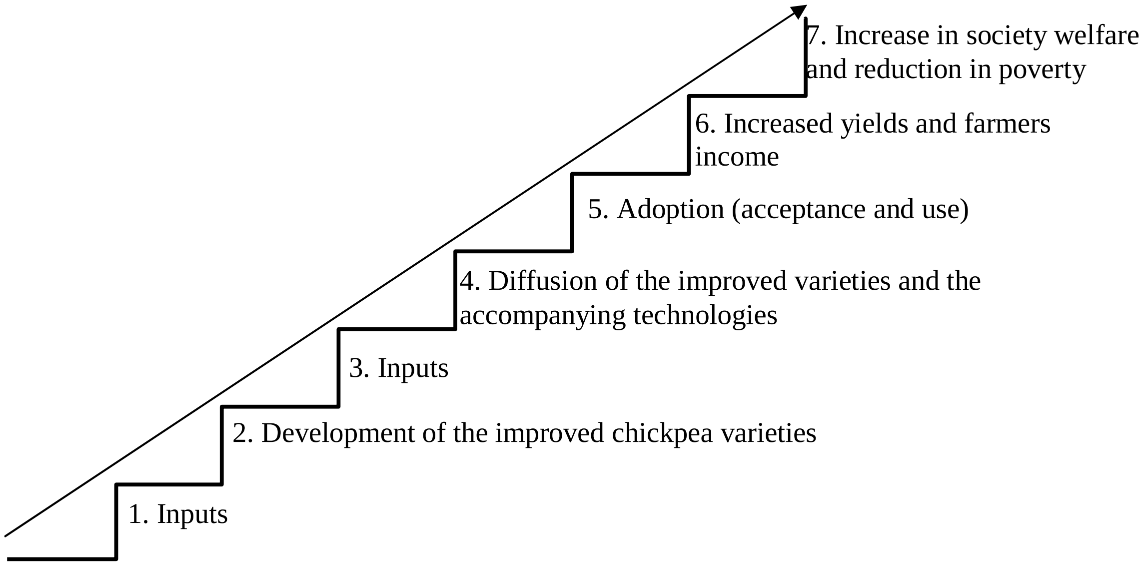

Figure 1. Improved chickpea technologies impact pathway

There are two major challenges in this study. The first is to establish causality between the intervention and the final impact as it is often difficult to link the intervention with the end result. This gap lies between adoption and increased income as well as between increased income and increase in society welfare and reduction in poverty. The second challenge is to establish a realistic counterfactual, i.e. a reference point for the situation without intervention. This is crucial because impact is defined as the difference between the situation without intervention and the situation after intervention.

The framework is therefore built essentially upon key principles which include: (1) demonstration of causality (2) clearly derived and explained assumptions, (3) comprehensive description of data sources, and (4) full explanation of methods and treatment of data. Generally, the establishment of plausibility relies primarily on well-founded argument regarding the impact rather than the presentation of rigorous proofs (Baur *et al.,* 2003)

2.2 Analytical framework

2.2.1 Welfare effects

To assess the wider economic and welfare effects of adoption of improved chickpea technologies, analyses at the sector-level and beyond are needed.

The economic surplus model is the most common approach for the evaluation of such technologies effects as it uses a partial equilibrium approach to estimate the net benefit due to technologies and the distribution of such gains between producers and consumers, expressed as changes in producer and consumer surplus (Alston *et al*., 1995). The principles' behind this model is that when the supply increases, price and demands adjust, so that part of the benefits goes the consumers.

A number of spreadsheet templates have been developed specifically for economic surplus computation. These include: 1) MODEXC originally developed by International Center for Tropical Agriculture-CIAT (Lynam and Jones, 1984), 2) RE4 developed by the Australian Centre for International Agricultural Research-ACIAR, (Davis *et al.*, 1987), and 3) Dynamic Research EvAluation for Management (DREAM) developed at ISNAR/IFPRI (Alston *et al.*, 1995)

DREAM was selected for this assessment because of its simplicity. Examples of impact assessments that have utilized the DREAM model include: Pachico *et al*. (2002) Lusty and Smale (2003), Macharia *et al*. (2005).

The model is based on the assumption that the technology adoption leads to an outward shift in the product's supply curve that trigger a process of market-clearing adjustments in one or multiple markets affecting the flow of final benefits to producers and consumers (Alston *et al*., 1995).

$$\Delta PS_{i,t} = (k_{i,t} + PP^R_{i,t} - PP_{i,t})\left[Q_{i,t} + 0.5(Q^R_{i,t} - Q_{i,t}\right] \tag{1}$$

$$\Delta CS_{i,t} = (PC_{i,t} - PC^R_{i,t})\left[C_{i,t} + 0.5(C^R_{i,t} - C_{i,t}\right] \tag{2}$$

where, *i* is the intervention region in time *t*, *k* is the realized supply curve shift (reduction in the per unit cost of production), *ΔPS* and *ΔCS* are the producer and consumer benefits, *k* is the supply curve shift (reduction in the unit cost of production), PP^R and *PP* are producer prices with and without technology, Q^R and *Q* are the annual production totals with and without technology and PC^R and *PC* are consumer prices with and without the technology. Thus, the producer experiences a change in income due to a lower production cost per unit while the consumer experiences a gain in income by buying at lower prices.

These series of benefits can be converted into present value totals by conventional discounting techniques where, say, for a thirty year[i] stream of benefits.

$$\begin{aligned} VPS_i &= \sum_{t=0}^{30} \Delta PS_{i,t} \,/\, (1+r)^t \\ &= \Delta PS_{i,0} + \Delta PS_{i,1}/(1+r) + \Delta PS_{i,2}/(1+r)^2 + ... + \Delta PS_{i,30}/(1+r)^{30} \\ VCS_i &= \sum_{t=0}^{30} \Delta CS_{i,t} \,/\, (1+r)^t \\ &= \Delta CS_{i,0} + \Delta CS_{i,1}/(1+r) + \Delta CS_{i,2}/(1+r)^2 + ... + \Delta CS_{i,30}/(1+r)^{30} \end{aligned} \tag{3}$$

Where VPS_i and VCS_i are the present values for producer and consumer surplus respectively for region i, and r is the discount rate. Typically, there are three investment indicators that are used in assessing the impact, i.e. net present value (NPV), internal rate of return (IRR), and benefit-cost ratio (BCR). The NPV is defined as the sum of the present values of the cumulative cash flow induced by an investment generated over a defined time period. Costs and benefits of the technology that occur in future periods are discounted.

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} \tag{4}$$

where B_t is benefits of the technology, C_t represents the technology costs, r is the discount rate, and n is time periods for which the technology will be there. A technology project is profitable and acceptable if the NPV exceeds zero.

The IRR is the discount rate, r^*, at which the project's NPV equals zero. Thus the IRR is a measure of the actual investment efficiency regardless of the discount rate.

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r^*)^t} = 0 \tag{5}$$

The third investment criterion used to measure the efficiency of investment is the benefit-cost-ratio (BCR). Its computation is similar to that of the NPV but it is expressed as a ratio of the sum of a project's discounted benefits to the sum of the project's discounted costs.

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}} \tag{6}$$

A program is deemed to be acceptable if the BCR is greater than or equal to one.

2.2.2 Poverty reduction

With the emphasis on poverty alleviation as a central objective of many donors and governments, tracing the impacts of research on poverty is a logical extension of the economic surplus approach. Generally, the adoption of improved chickpea varieties can reduce poverty in a number of different ways. First, it can help reduce poverty directly by raising the incomes or home consumption of the farmers. Second, can reduce poverty indirectly through the lower chickpea prices for consumers as well as increased employment in the value chain.

To estimate the number of household that would escape poverty due to the adoption of improved chickpea technologies, the methodology by Alene *et al.* (2009) for West and Central Africa is used.

$$\Delta N = \left(\frac{ES}{AgGDP} x \ \ 100 \right) x \frac{\delta \ln \ (N)}{\delta \ln \left(AgGDP \right)} x \ \ N \qquad (7)$$

where ΔN is the number of households who escape poverty, *ES* is the total benefits from the introduction of improved chickpea varieties, *AgGDP* is the total value of agricultural production (agricultural GDP), *δln* is the elasticity of poverty reduction with respect to agricultural GDP growth, and *N* is the total number of poor households (Alene *et al.*, 2009).

2.3 Data

The input data required in the DREAM model includes: (1) "equilibrium" quantities and prices, to define the size and structure of the market under consideration at a specified point in time; (2) evidence of how the technology will change either producers' cost structures or consumers' willingness to pay for different quality products where the technology will be adopted (the K factor), (3) adoption rate, (4) economic parameters on the market response to change (elasticities of both supply and demand), to predict how producers and consumers will react to new prices generated by market forces, (5) research and extension costs incurred in obtaining the new technology.

As is typically similar for many impact assessment studies, there was no baseline data collected in this study before the intervention. This has thus precluded the possibility of using the "before and after" approach of comparing the same households in tracing changes associated with the adoption of the varieties. The study hence make use of the panel data collected in two household surveys, a baseline survey in 2008 and a follow up surveys in 2010 (for more information see Macharia *et al*., 2011) and secondary data. For this study, the financial year 2001/02 was chosen as the base year. This year was considered to be most appropriate given that only <1% of the chickpea production area was allocated to the improved chickpea varieties (CSA, 2002). The analysis used "real" values based on 2001/02.

2.3.1 Economic surplus parameters

Table 2 shows the summary of the data used in the model estimation. The total annual average (1993-2009) chickpea production is estimated at about 170,551 tonnes, while the area under production is estimated at 178, 621 ha, giving yield of 1 ton/ ha. The data also indicates that the cultivated area under chickpea and production of chickpea have increased by 63% and 183%, respectively during the same period. For the analysis the 2001 production of 175,734 tonnes is used. Since in Ethiopia foreign trade in chickpea is negligible, a closed economy[ii] market-clearing model is assumed to assess the overall benefits and their distribution. In a closed economy, the equilibrium price is entirely determined by domestic supply and demand.

Most of the information on national chickpea prices come from the FAO Statistical Database (FAOSTAT, 2011) whiles those for farm level from household surveys (Macharia *et al.,* 2011). Due to lack of chickpea variety yield trial data[iii], the measurement of benefits associated with the adoption of the improved varieties is based on comparative analysis of net benefit between the improved and local varieties analyzed using the panel data of 2008 and 2010 (Macharia *et al.*, 2011). The result shows that the improved varieties have higher yields (33%), and a better selling price as compared to the traditional varieties. However, the average cost of production per ha is 340% higher for improved varieties. In terms of profit, the improved technologies obtained significantly higher benefits than traditional varieties (31%).

In *ex ante* studies, future adoption rates are normally based on expert estimates (Hareau *et al.*, 2006). To make plausible assessments of adoption rate the proportion of area allocated to improved chickpea to the total chickpea hectarage is used. The improved varieties have shown an impressive adoption rate starting at 0.69% in 2001 at a national level (CSA, 2002) reaching over 63% in 2009 (Macharia *et al*., 2011). Maximum adoption level of 75% is assumed with a base value of 0%.

In the absence of country specific demand estimates, the demand elasticity for the semi-subsistence farming system in developing countries like Ethiopia are often approximated with a value close to one (Alston *et al*., 1995). We assumed a supply elasticity of 0.9. Given that the price responsiveness of demand is usually higher in the developing countries, a demand elasticity coefficient of -1.4 was as well assumed (Qaim, 1999). Because of high population growth in Ethiopia and expectation of higher demand in future an annual growth rate of 2.6% on average (World Bank, 2011) was used to extend future demand.

The analysis further assumes a planning horizon of 30 years. To define present values of project costs and benefits, a discount rate of 10% is assumed (Gatzweiler, *et al.*, 2007)

Because of non-availability of project costs, this study estimated the costs for research, adaptation and extension. International and local research, extension, and seed multiplication costs are estimated by determining annual staff costs. These costs are then increased by 10% of the total research costs to account for the costs of fixed factors[iv] such as land, buildings, and equipment that are shared with other projects. International research includes the costs of breeding, research materials, training, and evaluation costs provided by ICRISAT, while local research and extension costs are the cost borne by National Agricultural Research Systems (NARS) partners in Ethiopia. Research expenditure was calculated in terms of full-time-equivalent (FTE) [v] scientist per year. Cost of research is estimated at US$ 1.75 million/variety based on Kate and Laird (2000). Costs for testing and adaptive breeding program was estimated at US$ 80,000/variety, based on 2 full-time equivalent (FTE) scientists, and median cost per researcher estimated at US$ 20,000 (Bohn *et al*., 1997) ,and at least two years of testing. The total expenditure was then estimated at about US$ 22 million[vi].

Table 2. Major data and assumptions for the DREAM model

Parameters	Base	Source
Chickpea supply and demand (1,000 tonnes)	176	FAOSTAT, 2011
Price of chickpea ($/tonne)	164	FAOSTAT, 2011, Macharia *et al*., 2011
Price elasticity of chickpea supply	0.9	Qaim, 1999
Price elasticity of chickpea demand	-1.4	Qaim, 1999
Consumption: growth rate (%/year)	2.6	World Bank, 2011
Benefit (%)	31	Macharia, *et al*., 2011
Maximum adoption level (%)	75	Estimates
Discount rate (%)	10	Gatzweiler, *et al*., 2007
Research costs (million US$)	22	Bohn *et al*., 1997; Kate and Laird, 2000

A sensitivity analysis was conducted to test the robustness of the results by changing the main parameter of interest i.e. production benefit, elasticities, adoption rate and research costs. All were decreased by 50% and increased by 25% from the baseline values.

2.3.2 Poverty parameters

Due to non availability of the AgDGP data of Ethiopia, the GDP of US$ 8111 million (UN, 2001) and shares of AgGDP of 38% (Fan *et al.*, 2008) is used to derive the AgDGP of 3,082 million. For the elasticity of poverty reduction with respect to AgGDP, the value utilized by La

Rovere *et al.* (2009) for Ethiopia (–1.67) is employed. The total number of poor people (*N*) was estimated at 25 million[vii].

3 Results and Discussion

3.1 Economic surpluses

Estimates of economic surpluses are shown in Table 3. The total benefits from the adoption of the improved chickpea varieties have a present value of about US$ 111 million when summed over the 30 year period of the simulation. The biggest portion of these benefits goes to producers (61%). The total benefit is about 5 times the amount spent in chickpea improvement research including extension. The IRR of 55% can be said to be attractive because the return is above the prevailing discount rate during the same period (10%).

Table 3. Economic surplus expected

Economic surplus (million US$)			Costs discounted (million US$)	Benefit/ Cost ratio	Internal rate of return (%)
Producer	Consumer	Total			
68	44	111	22	5	55

3.2 Sensitivity analysis

When the yield benefit was assumed to be 16% (instead of 31%), total benefits amounted to US$ 54 million, with a benefit/cost ratio of 2:1 (Table 4). With a more optimistic scenario of 39% yield benefit, which can be achieved if farmers become efficient in input allocation, the benefit cost ratio became 6:1. Increasing the discount rate by 25% brings the economic surplus down to US$ 86 million and the benefit cost ratio to 4:1.

Sensitivity analysis was also conducted on the demand and supply elasticities. Assuming supply elasticity being reduced by half, the benefit cost ratio remains as 5:1. Using the lowest price

(US$ 82) resulted into an economic surplus of US$ 56 million and a benefit cost ratio of 3:1, while highest price resulted in a benefit cost ratio of 6:1.

With the conservative assumption that research costs will increase by 25% the benefit/cost ratio would drop from 5:1 to 4:1, while reducing the cost by half result in a benefit/cost ratio of 10:1 Even in a worst-case scenario with the lowest benefit (15%), lowest adoption, highest discount rate (13%) and lowest elasticities the benefit-cost ratio of 1:1, still justified the investment.

Table 4. Sensitivity analysis of economic impact of chickpea technologies

Parameter	Alternative [a]	Economic surplus (Million US$)			Benefit cost ratio	Internal rate of return (%)
		Producers	Consumer	Total		
Benefit (%)	15 39	33 86	21 56	54 142	2 6	24 78
Discount rates (%)	5 13	130 52	83 34	213 86	10 4	55 55
Supply Elasticites	0.45 1.13	81 62	26 50	107 112	5 5	53 55
Demand elasticites	0.7 1.75	49 73	63 38	112 111	5 5	54 56
Price US$ /ton	82 205	34 85	22 54	56 139	3 6	25 76
Costs (million US$)	11 27	68 68	44 44	111 111	4 10	42 195
Adoption (%)	38 94	33 86	21 55	54 141	2 6	25 78
Worst case scenario (benefit 15%, discount rate 13%, elasticities 0.45 and 0.7, adoption rate 38%), cost US$ 27 million)		13	8	21	1	11
Best case scenario (benefit 38%, price US $ 205, adoption rate 94%)		136	88	224	10	200

[a] 50% reduction and 25% increase to the base parameters in Table 2

3.3 Poverty reduction

With a total of US$ 111 million generated due to adoption of improved chickpea varieties more than 0.74 million people, both among producers and consumers, are expected to be out of poverty. Because poverty in Ethiopia is more pronounced in the rural areas as than in the urban areas, this also means that the poor farmers will have less need to resort to damaging coping strategies such as reducing food consumption, selling assets or withdrawing children from school. A national reduction of 3% in the number of the poor people is also expected. Assuming the best case scenario i.e. highest benefit and adoption rate achieved, a national reduction of 6% of the people below the poverty line can be realized.

4 Conclusions

This study provides an *ex-ante* evaluation of the potential impacts of adoption of improved chickpea varieties in Ethiopia. The economic surplus model based on DREAM model was applied to estimate the economic impact. With an annual chickpea production of 175,734 tonnes, chickpea price of US$ 164/tonne, a 31% production benefit, a supply and a demand elasticity of 0.9 and -1.4 respectively, and an annual increase of consumption of 2.6%, the economic surplus produced was estimated at US$ 111 million for 30 years. Consumers are estimated to get 39% of the benefits due to price reductions and producers 61%. With project costs of US$ 22 million, the benefit cost ratio was estimated at 5:1 and an internal rate of return of 55%, indicating that the investment is profitable. With the worst-case scenario-lowest benefit (15%), highest discount rate (13%), lowest elasticities and price, the benefit-cost ratio of 2:1, still justified the investment.

The generated benefit significantly reduces poverty as more than 0.7 million people are expected to escape poverty. However, the benefit can be considered as a lower boundary, since the calculation used conservative parameters. Moreover, if as expected, farmers continue to grow the improved varieties beyond 2030 the returns on investments to this project will become even more significant.

Additionally, technology spillovers to geographic areas not intentionally targeted by the research investment (neighboring countries) could significantly increase the benefit. Similarly, since chickpea like other legumes have the capability of fixing nitrogen, it may also generate significant environmental and sustainability benefits that improve ecosystem health if area under the crop expands beyond what was grown under traditional varieties. The government will also benefits from increased tax revenues received from both producers and consumers. Thus, further studies on social economic impact are recommended.

5 References

Ahmed, MM, Masters, WA & Sanders, JH, 1994. Returns to research in economies with policy distortions: Hybrid sorghum in Sudan. Agricultural Economics 12, 183–192.

Ajayi, OC, Place, F, Kwesiga, F & Mafongoya, P, 2007. World agroforestry center: Impacts of improved tree fallow technology in Zambia. In: Waibel, H, Zilberman, D (Eds), International Research on Natural Resource Management: Advances in Impact Assessment FAO and CABI, Wallingford.

Alene, AD, Menkir, A, Ajala, SO, Badu-Apraku, B, Olanrewaju, AS, Manyong, VM, & Ndiaye, A, 2009. The economic and poverty impacts of maize research in West and Central Africa. Agricultural Economics 40, 535– 50.

Alston, JM, Norton, GW, Pardey, PG, 1995. Science under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting Cornell University Press, Ithaca, NY.

Asfaw, S, 2010. Estimating Welfare Effect of Modern Agricultural Technologies: A Micro-Perspective from Tanzania and Ethiopia Unpublished manuscript. http://wwwchronicpovertyorg/uploads/publication_files/asfaw_agricultural_technologies pdf. Accessed 05 February 2011.

Baur, H, Bosch, M, Krall, S, Kuby, T, Lobb-Rabe, A, Schutz, P-T, & Springer-Heinze, A, 2003. Establishing Plausibility in Impact Assessment German Federal Ministry for Economic Cooperation and Development (BMZ) Mimeo.

Bohn, A, Byerlee, D, & Maredia, MK, 1997. Investment in wheat improvement in developing countries In: Maredia, MK, Byerlee Derek (Eds), CIMMYT Research Report CIMMYT, Mexico, DF.

Bokonon-Ganta, AH & De Groote, H, Neuenschwander, P, 2002. Socioeconomic impact of biological control of mango mealybug in Benin. Agricultural Ecosystem and Environment 93, 367–378.

Coulibaly, O, Manyong,VM,Yaninek, S, Hanna,R, Sanginga, P, Endamana, D, Adesina, A, Toko, M & Neuenschwander, P, 2004. Economic impact assessment of classical biological control of cassava green mite in West Africa. Mimeo, IITA, Cotonou, Benin Republic.

CSA, 2002. Ethiopia, Statistical Abstract 2001, Addis Ababa, Ethiopia.

Davis, JS, Oram, PA & Ryan, JG, 1987. Assessment of agricultural research priorities: an international perspective. Canberra, ACIAR Monograph No 4.

Fan, S, Johnson, M, Saurkar, A, & Makombe, T, 2008. Investing in African agriculture to halve poverty by 2015. IFPRI Discussion Paper 00751, International Food Policy Research Institute. Washington, DC.

FAOSTAT, 2011. Agriculture database Available at: http:/appsfaoorg/page/collections?subset=agriculture. Accessed 07 February 2011.

Gatzweiler, F, Reichhuber,A, & Hein, L, 2007. Why financial incentives can destroy economically valuable biodiversity in Ethiopia Center for Development Research, Universität Bonn, Bonn.

Hareau, GG, Mills, BF, & Norton, GW, 2006. The potential benefits of herbicide-resistant transgenic rice in Uruguay: lessons for small developing countries. Food Policy 31, 162–79.

Kate, K, & Laird, S, 2000. The Commercial use of biodiversity Access to genetic resources and benefit-sharing. Earthscan, London, UK.

La Rovere, R, Kostandini, G, Abdoulaye, T, Dixon, J, Mwangi, W, Guo, Z, & Bänziger, M, 2009. Potential impact of investments in drought tolerant maize in Africa. CIMMYT, Addis Ababa, Ethiopia.

Lusty, C, & Smale, M, 2003. Assessing the Social and Economic Impact of Improved Banana Varieties in East Africa, (eds) Proceedings of an Interdisciplinary Research Design Workshop jointly organized by INIBAP and IFPRI in Kampala, http://wwwifpriorg/divs/eptd/ws/papers/eptws15pdf. Accessed 07 February 2011

Lynam, JK, & Jones, PG, 1984. Benefits of technical change as measured by supply shifts: An integration of theory and practice. Mimeo Cali, Colombia.

Macharia, I, Löhr, B, & DeGroote, H, 2005. Assessing the potential impact of biological control of the diamondback moth in cabbage production in Kenya. Crop Protection 24(11), 981–89.

Macharia, I, Löhr, B, & DeGroote, H, 2005. Assessing the potential impact of biological control of the diamondback moth in cabbage production in Kenya. Crop Protection 24(11), 981–989.

Macharia, I, Orr, A, Simtowe, F, & Asfaw, S, 2011. The adoption and profitability of chickpea technologies in Ethiopia. A report to International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Nairobi, Kenya.

Pachico, D, 1998. "Conceptual framework for natural resource management research and basic methodological issues in impact assessment" Paper presented at the international workshop, assessing the impact of research in natural resource management. Nairobi, Kenya

Pardey, PG, Alston, J, James, J, Glewwe, P, Binenbaum, E, Hurley, T & Wood, S, 2007. Science, Technology and Skills Background paper for the World Development Report 2008, Agriculture for Development. Washington, DC: World Bank.

Qaim, M, & von Braun, J, 1999. Crop biotechnology in developing countries: A conceptual framework for ex ante economic analysis ZEF Discussion Papers on Development Policy No 3. Center for Development Research, Bonn

Rohrbach, DD, Lechner,WR, Ipinge, SA, & Monyo, ES, 1999. Impact from Investments in Crop Breeding: The Case of Okashana 1 in Namibia. Impact Series no 4 ICRISAT, Patencheru, India.

UN (United Nations) 2001. http://datаunorg/CountryProfileaspx?crName=Ethiopia. Accessed 07 February 2011

World Bank, 2011. http://dataworldbankorg/indicator/SPPOPGROW. Accessed 07 February 2011.

Yapi, AM, Debrah, SK, Dehala, G, Njomaha, C, 1999. Impact of Germplasm Research Spillovers: The Case of Sorghum Variety S 35 in Cameroon and Chad Impact Series no 3 ICRISAT, Patencheru, India.

Zeddies, J, Schaab, RP, Neuenschwander, P, Herren, HR, 2001. Economics of biological control of cassava mealybug inAfrica. Agricultural Economics 24, 209–219.

[i] Empirical studies that have specifically analyzed lag times for agricultural research have concluded and recommended that a 30-year lag is necessary to capture all the benefits (Pardey and Craig, 1989; Chavas and Cox, 1992).

[ii] Assuming that there is little or no international trade in the commodities concerned.

[iii] A problem may also arise in obtaining an accurate measure of the yield advantage, because the absolute yields of improved varieties grown in farmers' fields under farmers' conditions are in many cases lower than yields in variety trials.

[iv] This is a simplified way estimating depreciation to fixed factors that are often shared between various activities. 10% is comparable figures for public agricultural research in the United States.

[v] (1.75*11) + (0.08*11) + (20.13*0.1). This is the main proxy measure used to analyze the allocation of research resources as a scientist may be involved partly in research and partly in other activities. It was assumed that the expenditure associated with a unit of scientist time remained constant.

[vii]. Poor were defined as those living below international poverty line of US$ 1.25 per day.