Economic impacts of international agricultural research:

Case of US-Egypt-IRRI collaborative project on the generation of new rice technologies

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I. Introduction

Agricultural research managers and scientists are under increasing pressure to demonstrate the efficient and socially-effective use of funds spent on agricultural R&D. These pressures stem from heightened expectations of transparency and accountability in the use of public funds, as well as from the growing demand for evidence of impact on target social groups and environmental services. Finally, advances in agricultural biotechnology research and the ensuing dialogue about the desirability of using biotechnology tools for increasing food production in developing countries have highlighted the need to assess the impacts of international agricultural research in developed countries such as the US, the developing countries, and the international agricultural research centers (IARCs). This paper attempts to assess the economic impacts of international collaborative research among scientists in the US, Egypt and an IARC, focusing on the technology generated by the application of biotechnology tools in rice research and on the benefits to Egypt.

Rice Sector in Egypt

In Egypt, rice is grown during the summer season in the irrigated agricultural lands. Rice is grown in sequence with winter crops of which clover (berseem) is the most important but wheat, broad beans; sugar beets, etc. are also common. In summer, rice is also grown in sequence with cotton and maize. The medium grain "Japonica" variety comprises approximately 85 percent of the rice crop and is preferred by Egyptian consumers to the higher-yielding, long grain "Phillipini" variety. Government policy is aimed at developing new varieties with higher yields, a shorter period of maturity, and more resistance to insects and diseases in order to save about 3 billion cubic meters of irrigation water annually for its ambitious land reclamation projects in the

South of the Nile valley. The Egyptian Agricultural Research Center (ARC) Rice Program has developed several new rice varieties with an average yield of about 14 metric tones per hectare, or about 40 percent higher than the average yield of traditional varieties. The Ministry of Agriculture estimates that new varieties are being used in about 90% of the total rice area during 2001/2002 seasons. The government's objective is to have the entire rice area planted with high yielding, short duration varieties by the end of 2002.

Egypt is a net rice exporter,[1] primarily to other Arabic countries with a sizable expatriate Egyptian communities that prefer short-grained rice. Rice exports are estimated at 560,000 metric tonnes (MT) for the 2000/2001 season. However, in July 2001 the government implemented a new subsidy program for rice in an attempt to encourage exports. The government is paying an export subsidy of Egyptian pounds (LE) 100 per MT for medium round grain varieties and LE 200 per MT for long grain varieties. There is also some potential for exporting long-grained varieties to EU countries. With the liberalization of acreage and price controls, rice has become a preferred summer crop, particularly with (during the mid to late 1990s) the release of higher yielding, more pest resistant rice varieties.

Rice technology generated from application of biotechnology tools in US-Egypt-IRRI Collaborative Research

The USAID-funded Egypt-Agricultural Technology Utilization and Transfer (ATUT) project began in 1995, and its Food Crops Component, managed by USDA, involves 22 collaborative sub-projects implemented by Egyptian, U.S. and IARC scientists. These sub-projects focus on overcoming critical problems related to the production of staple food crops - wheat, maize, rice and faba beans – with a focus on the use of biotechnology and on possibilities for improved

[1] A very small quantity of high-quality, name-brand, packaged rice is imported to sell in up-scale supermarkets.

utilization of scarce water resources. Six projects on rice involve collaborative research among plant breeders, molecular geneticists, and other agricultural scientists in the US, Egypt and IRRI. ATUT rice research accelerated the use of three methods for improving the speed and reliability of the screening and evaluation process for identifying salt resistant varieties: shuttle breeding, anther culture and marker-assisted selection. ATUT initiated the application of Marker Assisted Selection (MAS) technology for screening Egyptian rice germplasm

ARC/ATUT rice research activities have achieved various degrees of success in delivering intermediate technology and other research outputs, but the time lags associated with agricultural R&D mean that few of the new technologies and practices developed have yet been adopted in farmers' fields. The ATUT project was scheduled to terminate in September 2001 and there was great interest in assessing the likely outcomes of past and on-going ATUT investments as a basis for evaluating the attractiveness of further research. However, there is relatively limited capacity within ATUT to undertake economic impact assessments of R&D**.**

Economic Impact Assessment

IFPRI's Global and Regional Program on Agricultural Science and Technology Policy (GRP1) has considerable experience in both the conceptual and empirical aspects of R&D evaluation, impact assessment, and priority setting. This paper present some initial findings of a a pilot ATUT impact assessment study undertaken by the IFPRI group (Wood, Nagarajan and Pardey 2002). The pilot study assesses the potential economic benefit of technology outputs for just a single commodity – rice - under a range of adoption, market and trade scenarios. These assessments are intended to better inform USAID and Egyptian R&D policymakers about the likely magnitude and distribution of payoffs to these specific lines of work. The results will also

allow scientists and policymakers to better judge the utility of generating more of this type of impact assessment information for other ATUT sub-projects.

ATUT project activities aimed at delivering larger economic benefits to Egyptian rice farmers more quickly and cost-effectively than would have occurred otherwise, as well as making a contribution to better use of scarce water resources. The US-based, IRRI and Egyptian scientists organized themselves around thematic areas; breeding, weed control, pest management, and germplasm information exchange, that could best support the ARC Rice Program's research strategy of developing a viable "pipeline" of rice technologies. The primed pipeline, evaluated by the IFPRI group, contains;

- Short duration materials. In addition to enriching the pool of breeding materials and methods, ATUT support accelerated the commercialization of advanced lines. Specifically, the new short duration varieties Sakha 103, Sakha 104, and Giza 182 scheduled for release in 2003.
- Saline-resistant, short-duration varieties, likely to be ready for release in 2003-2005.
- Hybrid rice varieties for both saline and non-saline areas, likely to be ready for commercial release in 2006-2008.

These pipeline technologies will embody various levels of "ATUTness". Some varieties – such as the short-duration HYVs to be released in 2003 – benefited less from ATUT's scientific inputs. Others - such as hybrid rice varieties (and the hybrid rice program that matured over the life of the ATUT project) – will have been shaped to a far greater extent.

From an agronomic perspective, the ARC rice improvement strategy supported by ATUT targets two broad characteristics – improved land productivity (yield per hectare of land), and shorter maturity period (days per growth cycle). The goal of improved productivity was

addressed through breeding for specific traits such as saline resistance, pest resistance (particularly to stem borer), and improved genetic potential. The main driving force behind the parallel research focus on faster maturing rice varieties is water conservation. Water is *the* binding constraint for agricultural development in Egypt, but as food demand increases, so too does competition for water from non-agricultural users, domestic water supply and the industrial sector in particular. Thus, developing short-duration rice varieties is an essential strategy in achieving national goals for improved water use efficiency.

Irrigation water is provided without cost to farmers[2], so water conservation represents a direct cost saving to government or, from an economic perspective, represents the opportunity for better social returns by using the water elswhere in the economy. Elsewhere, in this context, could involve producing more agricultural outputs, and indeed farmers who replace 150-160 day rice varieties by those that mature in 120-130 days can explore the potential of a second summer crop or an earlier winter crop. While such an intensification of production would necessarily require additional irrigation water, most crops are less water-demanding than rice, so net water savings can still be realized.

II. Methodology

Assessment Approach

The economic evaluation deals with three key areas in which the ARC pipeline technologies are expected to have significant beneficial impacts:

[2] The Government of Egypt underwrites the capital, operation, and maintenance costs of water impoundment, diversion, and conveyance. Farmers pay for lifting water from local feeder canals into their own fields.

1. Improved productivity of the rice crop in both normal and saline areas through the enhanced yield performance of the new short-duration varieties scheduled for release between 2003 and 2005, as well as of the hybrid rice varieties to be released by 2008.
2. Improved options for farmers to intensify their production systems because of the shorter cropping cycle.
3. Reduction of net water consumption per hectare of rice cropland. This reduction is to be expected even if a second summer crop or earlier winter crop is grown.

The overall framework linking the ATUT project, ARC's Rice Research Program, the pipeline rice technologies, and potential impacts is presented in Figure 1.

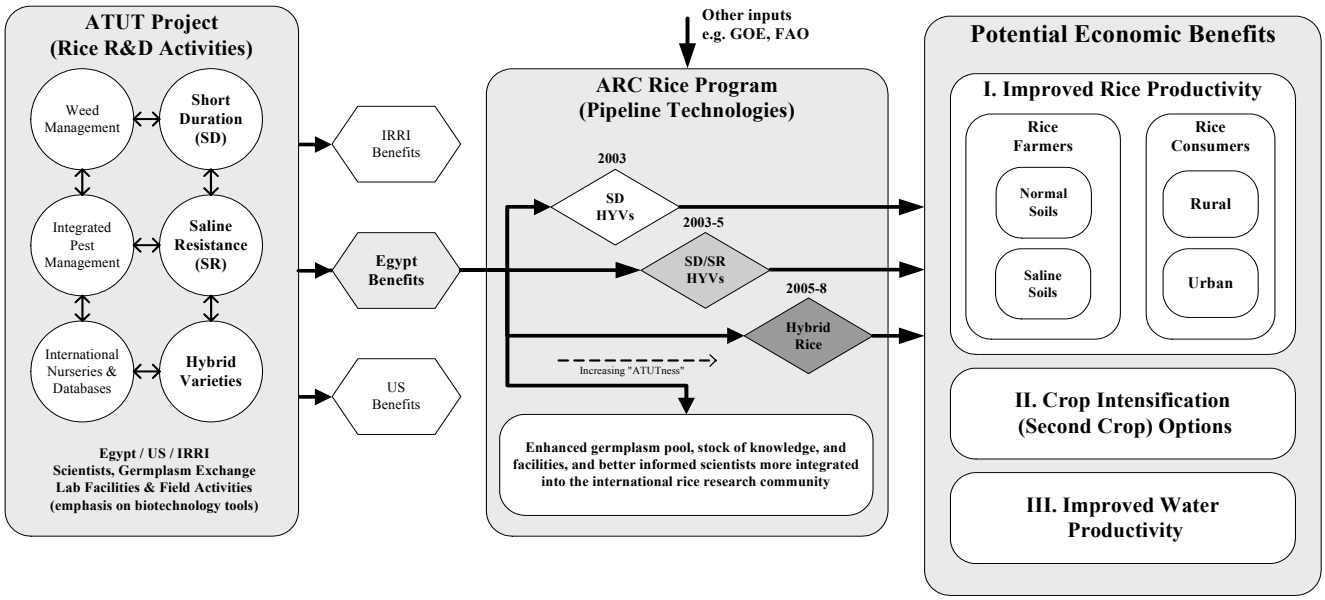
To calculate economic benefits, a multi-region, partial-equilibrium approach described by Alston, Norton and Pardey (1995) was adopted. This approach, called *D*ynamic *R*esearch *E*v*A*luation for *M*anagement (DREAM), provides a general but rigorous approach to assessing the market consequences – and hence changes in producer and consumer welfare benefits - arising from the adoption of new technology.[3] The approach allows for the exploration of the influence of a broad range of policy, market, technology and adoption factors on the timing, magnitude, and distribution of the economic benefits of R&D.

The DREAM approach was applied to assessing the benefits of changes in rice productivity. Assessments of the economic benefits associated with both the second crop and water savings were made in accordance with the technology adoption and performance projections made in the DREAM analysis. However, reduced form analyses were used for these assessments since market level analyses were impractical. The following sections briefly describe the linked, but independently estimated assessments of the potential economic impacts.

[3] The International Food Policy Research Institute (IFPRI) has developed a software implementation of the DREAM approach that was used to undertake the rice productivity evaluation described here. The software can be downloaded free of charge from the IFPRI website (http://www.ifpri.org/dream.htm).

Figure 1: *Evaluating the Potential Benefits of Pipeline Technologies from Egypt's (ARC) Rice Research Program*

The linkages between the ATUT project, the ARC Rice Research Program, and the potential economic benefits of "pipeline" rice technologies



SD - Short Duration Varieties
SD/SR - Short Duration, Saline Resistant Varieties

We focus on the results of the rice productivity analysis – using the DREAM approach, we illustrate some of the results from the water saving analysis, and present only estimated aggregate benefits of the second crop analysis.

The DREAM Approach

The DREAM economic surplus approach for the research evaluation is described in detail in Alston, Norton and Pardey (1995: *386-394*) method.[4] The DREAM model was built around the following conditions and assumptions:

- multiple regions, *i*
- producing a homogeneous product
- with linear supply and demand in each region
- with exponential (parallel) exogenous growth of linear supply and demand
- with a parallel research-induced supply shift in one region (or multiple regions)
- with a consequent parallel research-induced supply shift in other regions
- with a range of market-distorting policies
- with a research lag followed by a linear adoption curve up to a maximum
- with an eventual linear decline

Through appropriate parameterization the model can be used to assess annual changes in producer and consumer economic surpluses as a consequence of the adoption of new technologies. Thus,

$$\Delta PS_{j,t} = (k_{j,t} + PP^R_{j,t} - PP_{j,t})[Q_{j,t} + 0.5(Q^R_{j,t} - Q_{j,t})] \qquad (1a)$$

$$\Delta CS_{j,t} = (PC_{j,t} - PC^R_{j,t})[C_{j,t} + 0.5(C^R_{j,t} - C_{j,t})] \qquad (1b)$$

where, suppressing the subscripts for region *j* in time *t,* ΔPS and ΔCS are the producer and consumer research benefits, *k* is the realized supply curve shift (reduction in the unit cost of

[4] This remains the most complete and authoritiative description of the model, although some significant conceptual and methodological enhancements have been made since, and are embodied in the DREAM software.

production), PP^R and and PP are producer prices with and without research, Q^R and Q are the annual production totals with and without research, and PC^R and PC are consumer prices with and without research. These series of gross annual research benefits can be converted into present value totals by conventional discounting techniques where, say, for a thirty year stream of benefits;

$$\begin{aligned} VPS_i &= \Sigma_{t=0}^{30} \Delta PS_{i,t} / (1+r)^t \\ &= \Delta PS_{i,0} + \Delta PS_{i,1} / (1+r) \\ &\quad + \Delta PS_{i,2} / (1+r)^2 + \ldots + \Delta PS_{i,30} / (1+r)^{30} \\ VCS_i &= \Sigma_{t=0}^{30} \Delta CS_{i,t} / (1+r)^t \\ &= \Delta CS_{i,0} + \Delta CS_{i,1} / (1+r) \\ &\quad + \Delta CS_{i,2} / (1+r)^2 + \ldots + \Delta CS_{i,30} / (1+r)^{30} \end{aligned}$$

where VPS_i and VCS_i are the present values for producer and consumer surplus respectively for region i, and r is the real discount rate.

Perhaps the most problematic model parameter in terms of both estimation and model sensitivity is $k_{i,t}$, the downward measure of the supply curve shift attributable to technical change, in region i and time t. We can define,

$$k_{i,t} = E(c_i) \,.\, a_{i,t} \,.\, PP_{i,0}$$

where, for region i, $E(c_i)$ is the expected percentage cost saving per unit of output attributable to new technology, $a_{i,t}$ is the projected adoption level of that technology in time t, and $PP_{i,0}$ is the intial producer price. Much of the empirical work in a DREAM analysis is spent in developing realiable estimators of the expected output enhancing or cost reducing nature of new technology, the $E(c_i)$, as well as of the projected levels of technology adoption, $a_{i,t.}$.

Assessing the economic benefit of improved rice producicity

Productivity improvements in the fields of rice farmers translate into economic benefits for those farmers and for rice consumers. However, the magnitude and distribution of benefits is determined by a broad range of factors. Key amongst those, as highlighted in the preceding section, are the nature of the technology and the extent of its adoption, as well as the openness of the Egyptian rice market, and the share of Egyptian exports in the international (japonica) rice trade. All of these factors were represented in the DREAM model.

Furthermore, from a both a research and a producer perspective it was considered important to differentiate rice production conditions between those areas with normal soils and those that are salt-affected. Not only does salinity have a significant impact on productivity, but saline tolerance was a specific focus of ATUT-supported research, and the saline varieties scheduled for release in 2005 represent one component of the pipeline rice trechnologies being evaluated.

With regard to demand for rice, since consumption patterns and policy issues often differ considerably between rural and urban areas, it was decided to assess the potential economic impacts of increased rice productivity on both urban and rural consumers.

In addition to producer and consumer benefits within Egypt, the expansion of rice production brought about by the availability and adoption of new rice varieties (unless it stimulates a simultaneous increase in domestic consumption) should also expand rice exports. Egypt is already a major exporter of japonica rice. To capture the potential repercussions of changing the productivity of the Egyptian rice sector, "Rest of World" (*RoW*) production and consumption of japonica rice were represented in the scenario for the assessment. No attempt was made to model the global indica market. The two markets were treated as independent.

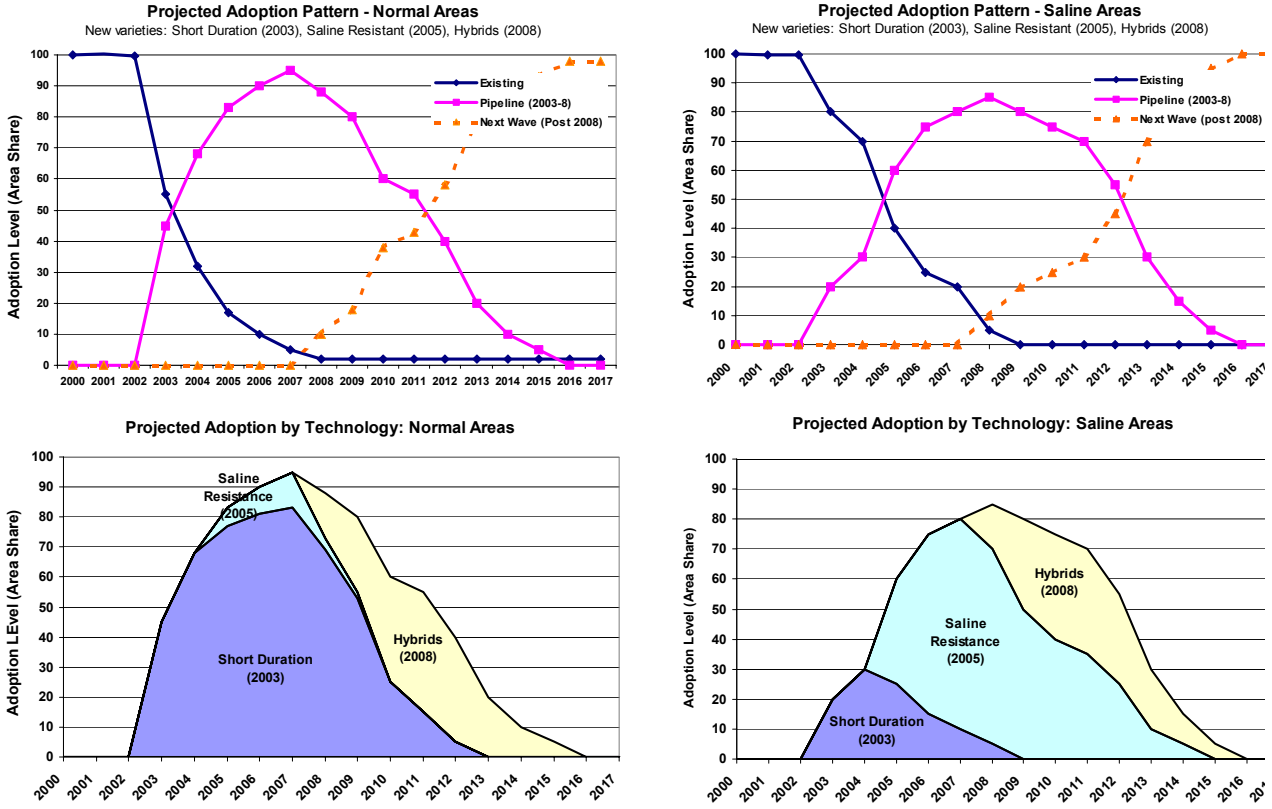
In accordance with the above formulation, a DREAM scenario was defined that containing the following units of analysis (henceforth called "regions"):

- Egyptian production from normal (non-saline) areas
- Egyptian production from saline areas
- Egyptian rural consumption
- Egyptian urban consumption
- Countries importing significant quantities of rice from Egypt
- The remaining (*RoW*) rice producing and consuming countries that make up the world japonica rice market

The scenario involved a simulation from the base year of 2000 until 2017. This period was considered sufficient to be able to trace through the major impacts of the rice technologies being evaluated. DREAM generated annual estimates of the change in welfare (economic surplus) for producers and consumers according to equations 1(a) and 1(b) above, as a new technology was adopted and as the consequent changes in market quantities and prices were realized. The benefit streams were discounted back to the year 2000 using a real discount rate of 5 percent per year.

To make plausible assessments of the likely pattern of adoption of the pipeline technologies, the IFPRI group analyzed planted-area by variety data, trends on the average age of rice varieties in farmers' fields, government's changing policies with regard to irrigation water provision, plans for seed supply, and available experimental and demonstration data. The projections for both normal soil and saline areas, and for each of the pipeline technologies are shown in Figure 2. One important assumption in building these adoption profiles was that technologies currently in the pipeline will soon be displaced, starting in 2008, by the next new

Figure 2: *Projected Varietal Adoption: Saline & non-Saline Areas 2000-2017*



wave of technologies. There are important conceptual issues related to this assumption, regarding how technology (and the scientific knowledge stock that leads to the development of new technology) is best seen to be accumulated and lost, but these issues will be covered in full in the technical report (Wood, Nagarajan and Pardey 2002). For the purposes of the Egypt assessment this approach was considered appropriately conservative and more intuitive for the purposes of communicating both the approach and the results.

Assessment of the likely productivity enhancing characteristics of the pipeline technologies, once adopted, was based primarily on experimental data with supplementary information from scientist and extension worker elicitation. Elicitation was more important in dealing with the pipeline hybrid materials, since existing experimental data covers a very broad range of promising lines. A key element in this part of the analysis was the establishment of an appropriate counterfactual (what would be the yield levels in saline and normal soil areas in the absence of the pipeline technologies?). The case selected was to take the adoption levels of existing varieties as projected for 2002 as the counterfactual varietal area mix (since the first new technology is to be released in 2003), and to assume that each variety would maintain the same yield level as it obtained in 2000 (the last year for which varietal industry-level yield data was available). The yields of each variety are treated as constant over time. Table 1 shows the estimated unit cost reductions, the $k_{i,t}$ generated by this process. These values are derived from estimates of production increases attributable to research-induced yield gains. Gains are computed on the basis of projected varietal mix with and without the pipeline technologies. The k values show the percentage decrease in the unit cost of production attributable to the adoption of the pipeline technologies, relative to the counterfactual of 2002 conditions of varietal adoption and yield.

Table 1: *DREAM Input Data: Expected Unit Cost Reductions*

Year	Unit Cost Reduction, k_t	
	Saline	Normal
	(percent)	
2000		
2001		
2002		
2003	0.88	3.03
2004	0.50	4.53
2005	6.38	5.66
2006	12.88	6.18
2007	15.55	6.58
2008	20.53	7.46
2009	23.20	7.92
2010	22.81	7.55
2011	21.65	7.72
2012	17.40	6.22
2013	10.05	3.35
2014	5.03	1.67
2015	1.93	0.84
2016		
2017		

Note: Table shows the expected unit cost reductions that would be achieved in saline and normal production areas if the pipeline technologies were adopted as shown in Figure 1, and empirically-based yield gain estimates proved reliable.

III. Results and Analysis

Rice productivity increases

Some aggregated results from the DREAM analysis are presented in Table 2. These show the net present value of the economic benefits that Egypt might expect to gain from the ARC rice technologies in the current pipeline will be around half a billion US dollars. This is the value in 2000 of the annual stream of benefits of improved rice productivity that the new technologies will deliver between 2003, when the first technology will begin to be adopted, and 2015 when the last of the pipeline technologies is projected to be totally replaced in farmers' fields (replaced by the next wave of new technology, presuming investment in research and extension is sustained).

By far the dominant share of the benefits will accrue to rice producers, particularly rice producers in the normal soil areas – since they grow over 80 percent of Egypt's rice. However, producers in the saline areas will actually benefit more on a per hectare basis, since the the pipeline technologies offer particular promise for improved performance under such conditions. Domestic consumers gain only around US$ 10 million, or about two percent of the total benefits. This reflects the assumption that Egypt is well integrated into international rice markets and domestic prices will move in line with world prices. The fact that the model projects any consumer benefits suggests that Egypt is not truly a "small" country since expansion of production and exports was projected to exert some downward pressure on international prices (and hence the feedback to benefits to local consumers). The expansion in Egyptian exports, and its price effect on the world market are also projected to benefit the consumers (importers) of Egyptian rice by some US$ 3 million.

Table 2: *Potential Gross Economic Benefits of the Enhanced Productivity from Pipeline Rice Technologies: 2000-2017*

Regions	Net Present Value of Gross Benefits (2000)	Benefit Sensitivity				
		Yield Gains		One Year Sooner	RoW Growth Rate	
		+50%	-50%		+20%	-20%
		(US$1,000)				
Egypt						
Producers-Normal Soils	337,666	510,277	167,622	356,817	333,757	341,662
Producers-Saline Soils	158,995	243,431	77,863	168,152	156,946	161,101
All Producers	*496,661*	*753,708*	*245,485*	*524,969*	*490,704*	*502,763*
Consumers -Rural	5,981	8,975	2,990	6,386	5,888	6,076
Consumers - Urban	4,382	6,577	2,190	4,524	4,354	4,410
All Consumers	*10,363*	*15,552*	*5,180*	*10,910*	*10,242*	*10,485*
Egypt Total	*507,024*	*769,260*	*250,665*	*535,879*	*500,945*	*513,248*
Foreign Consumers	3,119					

Notes: Net present values calculated using a real discount rate of 5 percent per annum applied to the stream of annual benefits generated between 2003 and 2015. The "one year sooner" sensitivity test indicates the benefits gained by (technology generation and) farmer adoption being attained one year earlier than assumed in the baseline analysis. Rest of World (RoW) growth rate sensitivity test assesses the change to benefits in Egypt if growth rates in the international japonica market differ from the growth trends assumed in the baseline analysis. Foreign consumers – refers only to the benefits accruing to the consumers of imported Egyptian rice.

The potential economic benefits of reduction in the net irrigation water needs of rice farmlands

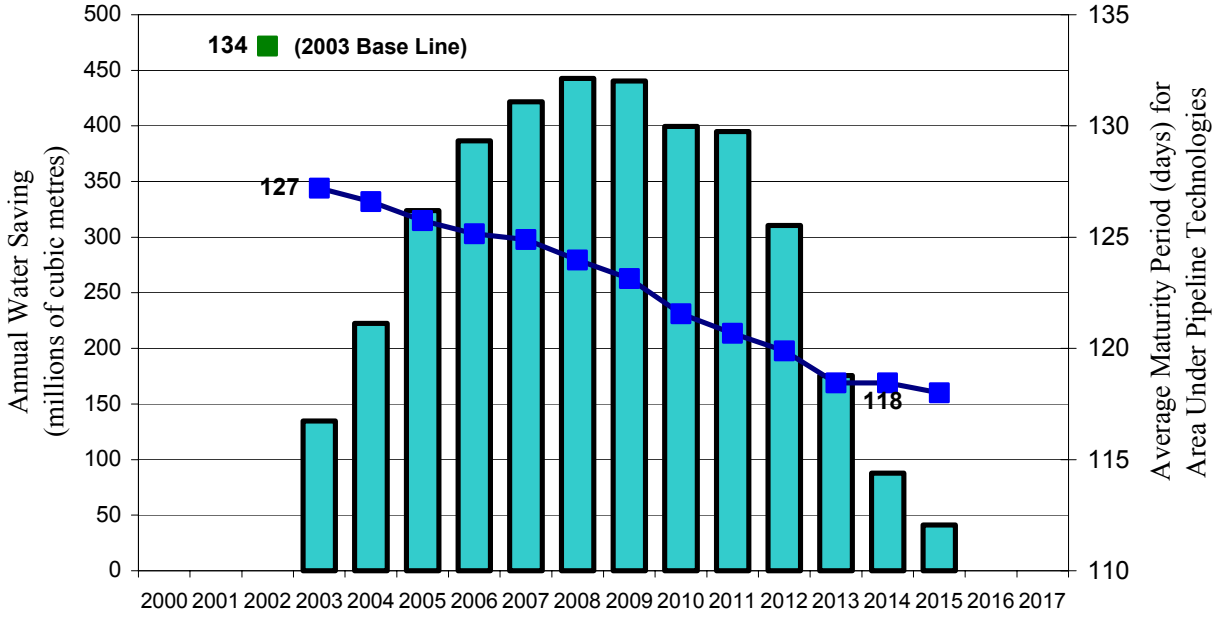
In assessing the potential economic value of water savings associated with the adoption of shorter duration rice varieties, we relied heavily on the studies performed by ATUT (El Kady 2001) and by APRP (1999, 2001). It is clear from the APRP studies that the net water saving over the entire cropping year in larger irrigation command areas is significantly less than the theoretical 25 percent water saving that short duration varieties could produce in a farmer's field during a single rice cropping season. In part this is due to the water requirements of the second crop, and in part to the technical problems in synchronizing field operations across larger areas. A peak water saving of around 440 million cubic metres by 2008 was projected, *relative to the water use in 2002* (the baseline year before the first new technology is released). See Figure 3. This water saving provides additional discounted benefits of around $24M if only the O&M costs of water provision are considered (at a unit rate of 0.03LE/cubic metre). If the marginal returns to irrigation of other crops is considered, the potential benefit grows significantly to some $124M.

Summary and assessment of the gross potential economic benefits of ARC's pipeline rice technologies

Table 3 summarizes the initial estimates of the potential benefits of the pipeline rice technologies. These benefits sum to around US$940 million, assuming the water benefits are assessed on the basis of the returns to alternative uses.[5]

[5] Specifically, the benefits accruing to irrigating additional cropland in non-rice producing areas, rather than the cost of water provision (the amount that could be saved by delivering less water).

Figure 3: *Water Savings as a Consequence of the Adoption of Pipeline (2003-08) Technologies*



Notes: Bar graph shows the quantity of water that would be saved each year as a consequence of the adoption of the pipeline technologies to be released over the period 2003-08. The line graph shows the average maturity period (in days) within the production areas occupied by the pipeline technologies (assuming to the projected adoption patterns shown in Figure 2). The baseline (counterfactual) average maturity period of rice varieties prior to the release of the first of the pipeline technologies (short duration varieties in 2003) is projected to be 134 days.

Table 3: Potential Gross Economic Benefits of ARC's Pipeline (2003-2008) Rice Technologies

Source of Benefit	Potential Gross Benefits		
	Net Present Value (2000)	Average Annual Benefits[a]	Remarks
	(Millions of 2000 US$)		
I. Potential Benefits to Rice Producers:			
- Increased productivity of rice crop	507	52.9	Increased rice yields in saline and normal areas
- Increased productivity of second crops	315	32.8	Shorter duration improves second crop productivity[b]
II. Other Potential Benefits:			
either			
- Potential irrigation O&M cost savings	24.3	2.54	Benefit based on avoided cost water supply
or			
- Economic value of saved water	125	13.0	Benefit based on using saved water to irrigate additional cropland

Notes: a – During the period 2003 to 2016 over which benefits of the pipeline technologies are projected to be generated. b – Second crop productivity based on the net return of an extra cut of clover.

It is clear that the potential benefits of the current pipeline technologies of ARC's rice program are very large. The ATUT project would only need to have contributed less the one quarter of one percent (0.22 percent) towards the total benefits of these technologies for the project to have "broken even". While it has been argued by some Egyptian scientists that the ATUT project did little to develop the short duration varieties scheduled for release in 2003 (Sakha 103 and 104) it is agreed that ATUT funds helped in bringing these selected lines to commercialization. There is also broad agreement that ATUT made much larger contributions to the development of the saline tolerant rice lines (with varieties scheduled for release in 2005), and has made very significant contributions to the establishment of the hybrid rice program (first varieties due for release before 2008).

Areas for Further Studies

A key aspect of the ATUT-funded tripartite scientific collaboration is the perception that benefits are likely to be endowed beyond the target beneficiaries - Egyptian rice farmers, consumers and scientists. Although quantification of the benefits of ATUT to the US and international rice research communities was beyond the scope of this study, a qualitative assessment was undertaken. This revealed that *all* scientists had a perception that significant benefits from the collaboration would accrue to both the US and to IRRI, and to the rice farmers that they serve. More specifically, the potential for large benefits were identified through the access gained by participating scientists to improved breeding materials. In the case of saline resistance for example, there is a belief that US scientists now have breeding lines, as a direct consequence of ATUT, that could provide significantly improved levels of saline resistance in Californian rice varieties.

Notwithstanding the positive picture painted by this study, there are questions about the long-term viability of irrigated rice production in a country where water is such a scarce commodity and growing scarcer. While there are technical reasons to believe that rice cultivation is a sustainable option in the saline, heavy soil areas found in the northern Nile delta, there are agronomic and economic pressures to increase cultivation of cotton at the expense of rice in other areas. If prices were undistorted, cotton does appear to have an often significantly higher comparative advantage in such areas.

A final observation is that there appears to be no systematic mechanism in the ARC, USDA and USAID for compiling and retrieving disaggregated information on either the costs or outcomes (as opposed to outputs) of past investments required by the economic impact assessment used in this paper. Given the increasing emphasis being placed on accountability in the use of public funds, there appears to be considerable scope for improvement in this area.

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