AN ECONOMIC EVALUATION OF THE IMPACT OF ACIAR-FUNDED AGRICULTURAL RESEARCH BASED IN AFRICA

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Introduction

As part of its project evaluation activities, the Economic Evaluation Unit of ACIAR has over the last 15 months or so been involved in an evaluation of all ACIAR-funded completed projects in Africa The evaluation when completed will cover projects in four main areas in Africa, namely:

a) Two land and water projects on the improvement of dry land agriculture in semi-arid tropics (in Australia and Kenya);

b) Three projects addressing the shortage of fuel wood and construction timber in Africa (based in Kenya and Zimbabwe);

c) Three Animal Sciences projects on the control of ticks and tick-borne diseases (Australia, Kenya and Zimbabwe); and

d) One project dealing with the problem of high levels of hydrogen cyanide in cassava for human consumption in Africa.

This paper summarises estimates of the costs and benefits of the impact of 11 ACIAR funded research projects based in Africa from 1983 to 1994. Table 1 gives a summary of the results.

The paper provides estimates of the following 11 projects

Table 1: The projects - research costs, total benefits and rates of return

ACIAR Program	Project activity	Total research cost $A (m), 1991	Number of projects	Total benefits over 30 years $A (m), 1991	Internal rate of return (%)
Animal science	Develop tick models to show intensive dipping may not be optimal	$0.26	1	$2.06	30
	Develop better ways to manage tick resistance to acaricides	$1.13	1	$12.34	33
	Develop a vaccine for tick fever	$1.50	1	$35.24	40
Crop Sciences	Find a way to reduce hydrogen cyanide in cassava	$0.59	1	$1.6 to $20*	13 to 27*
Forestry	Address shortage of fuel wood and construction timber in Kenya and Zimbabwe	$3.2	5	$30.1	26.66
Land and Water	Improved methods of dry land agriculture in Machakos, Kenya	$7.23	2	$25.55	20.32
Total		$13.91	11	106.89 to 126.89*	not applicable

* Depending on assumptions made about the use in Africa of cassava cultivars with high hydrogen cyanide potential

The projects and what they achieved

PN 8303: 'Ecology and epidemiology of ticks and tick-borne diseases in sub-Saharan Africa'

The project was funded from 1983 to 1986. A major impact of this project was that it provided the scientific basis for a shift from intensive dipping to less frequent, strategic dipping, a policy decision which could only be taken at government as opposed to individual farmer level. The reviewers of the ACIAR project PN8303 noted the following:

> 'The results obtained by the project have been discussed with national authorities and have already resulted in the initiation of field tests to evaluate the effectiveness of strategic dipping procedures which have been suggested by models formulated under the project. Such tests are now being carried out in Burundi, Zambia and Zimbabwe and if successful, will be extended in the future'.

There has been a shift in the dipping practices from the intensive weekly dipping practice (irrespective of tick challenge levels) to the practice of less frequent but strategic dipping in sub-Saharan Africa. In the case of Zimbabwe this shift has been expressed in the Animal Health Cattle Cleansing regulations which the Zimbabwe Ministry of Lands, Agriculture and Water Development introduced in 1993. In these regulations, instead of requiring cattle owners to deep every week irrespective of tick challenge levels, the regulations require dipping in only those cases where cattle are tick infested. This shift has reduced the cost of production of beef and milk to producers in both the traditional and the commercial sectors in Zimbabwe, Kenya, Burundi, and other countries in sub-Saharan Africa. Other benefits associated with a shift to strategic dipping include:

- reduction in the use of acaricides which in turn led to savings in foreign exchange earnings previously used for acquisition of acaricides,
- increased the time taken before the development of tick resistance to acaricides which meant that acaricides are used for longer periods before they need to be replaced;
- reduced the toxic effects of acaricides on livestock because of reduced exposure

9047: Resistance to acaricides in Zimbabwe and Australia

Acaricides and other pesticides are used to control ticks, but ticks can develop genetic resistance to these chemicals, resulting in instances where ticks have survived in concentrated dip solutions. This problem is costing the Australian cattle industry conservatively $A 150 millions annually[1] This project aimed:

- to identify genetic markers for resistance in tick to acaricides;
- to determine precisely the type and level of resistance to select acaricides in ticks in Zimbabwe; and to determine the distribution of species and strains of ticks;
- to complete a preliminary study on the immunological cross reactivity of ticks in Zimbabwe and Australia; and

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1 Dr Joan Opdebeeck, The University of Queensland News, July 14 1993

- to develop a molecular probe to rapidly identify resistance of ticks to pesticides, compared to with pre-research biological methods which can take up about six weeks to determine resistance.

The project resulted in a genetic assay kit for identifying resistant genes which in turn contributes to better management of the spread of tick strains resistant to acaricides. The project aimed at reducing the length of time required to pesticide resistance in a tick population to within 24 hours from the current time of about six weeks.

9118: Control of bovine babesiosis and anaplasmosis in Zimbabwe and Australia

This project had the following objectives

- to assist Zimbabwe in developing protocols for the production and distribution of effective, living vaccines against bovine babesiosis and anaplasmosis;
- to collaborate in the design and implementation of field and laboratory studies required to establish the efficacy and purity of the vaccines produced in Zimbabwe,
- provide the expertise required to culture Babesia in vitro;
- develop better methods for differentiating species and strains of Babesia and apply these methods in problem-solving research in Australia and East Africa;
- develop a better alternative than the present card agglutination test for Anaplasma marginale

Project 9118 achieved the prime objectives of producing and testing, in the laboratory and field, new vaccines of high quality for against Babesia bigemina and Anaplasma marginale in Zimbabwe and for their production and quality control (Pers comm., Dalgliesh, February 1996 and Krishna et al, 1995)

The availability of a vaccine against these tick-borne diseases lead to the following benefits:

- reduction in the use of acaricides to control ticks. This benefit is of greater significance because of there are now strong arguments against the practice of the frequent use of acaricides on economic, safety and environmental grounds;

- extension of the period of time acaricides can be used without inducing tick resistance to the chemicals; and

- improvement in host immunity to ticks and tick-borne diseases.

The research component in Australia has provided the following benefits (Dr R. J. Dalgliesh, QDPI, Personal communication, February 1996):

- new tools (molecular markers) that allow Australian scientists to distinguish between strains (within species) of Babesia;
- new diagnostic tests for epidemiological studies in Australia and for screening of export animals in accordance with requirements of Australia's trading partners.

9007 : Cassava cyanide: improved techniques for estimation, and influence of environment on concentration (Australia, Indonesia Philippines, and International Institute of Tropical Agriculture in Nigeria)

The most important source of impact from this project is the discovery, during the duration of the project , of cultivars of cassava with very low hydrogen cyanide potential The project's research outputs has not yet been expressed in terms of new cassava varieties or changes in cassava agronomy However, it is estimated that the project is likely to have an impact on new cassava varieties in 10 years' time The time lag between the end of the project and the start of impact is due to the length of time it takes for breeders to take the results of a research project and incorporate them in a new cultivar ready for release to farmers A permanent control of cyanogenesis can be achieved by breeding cassava varieties with low hydrogen cyanide potential This is in line with the main contribution of the ACIAR project PN9007

In addition to fatal effects of consuming cassava with high hydrogen cyanide potential, regular exposure to sublethal quantities of cyanide, either in the diet or inhaled during cooking, may cause various disorders including (1) epidemic spastic paraparesis known in central Africa as konzo - konzo occurs abruptly and affects mainly women in the fertile age group and children above the age of three, and leads to the crippling and in some cases the death of affected women and children, (2) tropical ataxic neuropathy, TAN - this condition develops slowly with a patient progressively getting worse, attacks both male and females of all age groups with a mean age of 40, and with peak incidence in the 5th and 6th decades of life, (3) the worsening of iodine deficiency disorders including goitre, the enlargement of the thyroid gland, and cretinism, a severe form of mental retardation, and (4) risk of diabetes. The adoption of the results from the project is likely to lead to a reduction in the incidence of konzo and TAN. This project is likely to generate significant human health benefits to the populations in Africa who are currently consuming cassava with high level of hydrogen cyanide The major beneficiaries of this project are women and children in Africa

8320-8331, 8808-8809 and 8357: Australian hardwoods for fuelwood and agro forestry (Australia, Kenya, Zimbabwe, Thailand)

This suite of projects was designed to address the acute shortage of fuelwood in many developing countries with a focus on sub-Saharan Africa Shortages of fuelwood depress living standards and commonly have serious indirect consequences. These include: adverse changes in catchment hydrology, accelerated erosion following denudation, reduction in food production where animal manures and other wastes are burnt as substitutes for fuelwood further reducing the amount of natural fertiliser available to the soil Before the project, more than half the districts in communal lands in Zimbabwe had deficits of fuelwood and construction wood at the start of the 1980s It was estimated that in the communal areas, at least 5% of households used dung as fuel, and around half use crop residues as a minor cooking fuel The availability of poles was even more critical than fuelwood supply with many travelling more than 10 kilometres from the household to obtain construction wood. The projects were designed to reverse these negative trends The benefits to the Africa region from this ACIAR activity includes the following

- increased supply of fuelwood and poles in a shorter time than that required if these countries relied on indigenous tree species Some of the faster growing Australian species can be harvested for fuelwood and poles after 5 to 6 years whereas the indigenous species take over 20 years

- reduced deforestation as the pressure on forests in communal lands is reduced;
- soil fertility benefits: some of the Australian Acacia species trialed in the projects are nitrogen fixing and are likely to lead to higher crop yields;
- increased livestock productivity as a result of shade and browse effects of having trees in the grazing fields;

These benefits have already taken effect since there is already some adoption of technologies developed under these projects

8326-8735: The improvement of dry land crop and forage production in semi-arid sub-Saharan Africa (Australia, Kenya)

The aim of the project was to find effective management responses and affordable technological innovations as solutions to some of the problem of dry land farming in the semi-arid tropics. The projects lasted for 10 years and were conducted in three main phases. Phase 1 was funded under ACIAR project number 8326 from 1983 to 1987 and phases 2 and 3 were funded under ACIAR project number 8735 from 1988 to 1993

The projects were based in Machakos District in Kenya with a population of 1.5 million in 1989 and with, according to some estimates, over 60 % of non-arable land severely eroded and 26 percent of cultivated land eroded. The project had three main economic impacts:

- The direct welfare impacts - the project has made a difference to farmers in the countries where the research was undertaken (Kenya and Australia). The technologies advanced under the project have been adopted by some farmers these technologies have impacted on producers of maize, sorghum, food legumes and livestock in Kenya and Australia.
- The impact on scientific knowledge of dry land farming, and therefore potential contribution to future research on improved technologies,
- The impacts on human capacity building - that is, training of research scientists and equipping them with the tools and enhancing their capacity to research and develop solutions relevant to dry land agriculture in the semi-arid tropics.

The innovations requiring little direct cash outlays (inorganic fertilisers, terracing and early planting) are the most widely adopted. These comprise the poor person's technology. Terracing and boma manure are complementary techniques for improved soil and water management, which place high demands on available labour but do not necessarily require cash for their implementation. The impact of the project on Australia has not yet been estimated.

Methodology

Two types of models were used in the research evaluation of the projects. A closed economy model was used in the evaluation in the two land and water projects in Machakos, Kenya. Figure 1 is a diagrammatic representation of the closed economy model applied in the analysis. The same model was used in the crop sciences project on cassava. However, a human capital model was used in estimating the cost reduction associated with reduced levels of hydrogen cyanide in cassava for human consumption. An open economy model in Figure 2 was used in the research evaluation of the majority of projects, namely the three animal sciences and the five forestry projects The equations used to estimate the benefits are standard and well-known (Alston et al , 1995 and Davis et al, 1987)

The data on production and consumption levels for the different commodities was obtained from FAO(1994) The elasticities of demand and supply were obtained from the ACIAR Economic Evaluation Unit's database which contains data obtained from review of literature on econometric estimates of elasticities The most important estimate on which the estimates of benefits was based are the estimates of the unit cost reduction attributable to a given technology developed in research project These unit cost reductions are summarised in Table 2 Details of the methodology used are given in Lubulwa (1995a, 1995b), Lubulwa and Hargreaves(1995), Lubulwa and Hargreaves(Forthcoming), Lubulwa et al (1995a), and Lubulwa et al (1995b)

The cost reductions are estimated on the assumption that a smallholder in the partner country adopts the technologies developed under the project However, adoption of these technologies varies widely depending on how expensive the technologies are The adoption patterns are estimates by project scientists of the proportion of farmers who have to date adopted the technologies and who are likely to adopt the technologies in the future It is estimated that for the livestock projects ceiling adoption levels for the technologies developed in ACIAR projects is likely to be about 30 percent This estimate takes into account the difference in resistance to tick-borne diseases between the livestock in the traditional sector and the European breeds of livestock introduced in Africa and used mainly in the commercial sector In the case of cassava, the ceiling adoption of 50 percent is used in the estimation of benefits Adoption levels for the Australian species introduced in Africa under the forestry research projects is estimated to range between 1 to 5 percent In the case of the land water research project in Machakos Kenya, a number of technologies were developed The adoption rates were estimated to be different depending on the how expensive the given technology was as shown in the table below

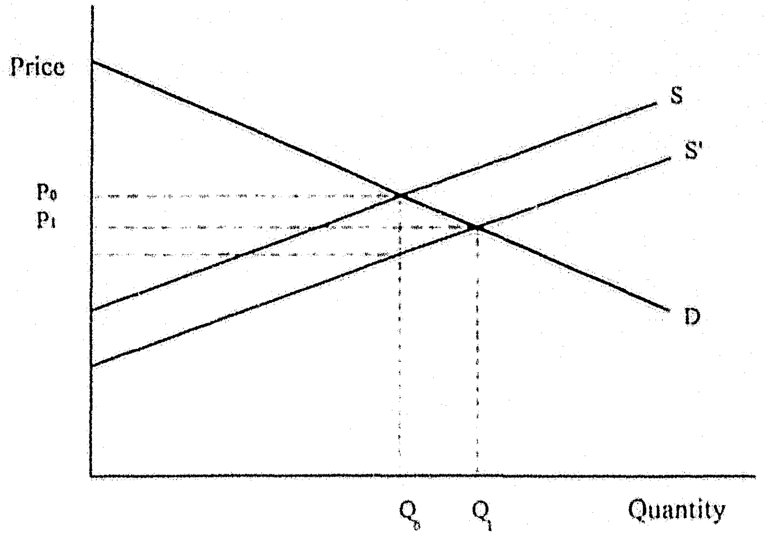
Technology	*Adopters as proportion of all farms* 1980[a]	*Adopters as proportion of all farms* 1990[b]
Well adapted cultivar (KCB seed)	0 31	0 30
Early planting date	not estimated	0 56
Medium planting date	not estimated	0 37
Late planting date	not estimated	0 07
Use of boma manure (organic fertilisers)	0 68	0 83
Use of nitrogen fixing legumes	not estimated	0 22[c]
Use of nitrogen fertilisers (inorganic)	0 08	0 18
Pesticides	0 15	0 17
Mulching	0 00	0 00
Terracing	not estimated	0 78[c]

Sources a Rukandema et al (1981)
b Muhammad and Parton (1992)
c Ockwell et al (1991)

Table 2: Estimates of unit cost reductions and other impacts of ACIAR projects in partner countries used in estimation of benefits from research

Project number	Title	Research area	Technology	Commodity	Farm level cost per MT before research	Farm level cost per MT after research	Unit cost reduction in partner country	Percent change in unit costs (percent)	Percent change in output (percent)	Incidence of disease (per 1000 000 of population before	Incidence of disease (per 1000 000 of population after	Research costs in $A M 1991	Research Benefits ($A, M 1991)	Internal rate of return (percent)
8303	Ecology and epidemiology of ticks and tick-borne diseases in sub-Saharan Africa	Animal health	Developed tick models to show intensive dipping may not be optimal	Milk	$150	$136	($13)	-8.99%	17%	na	na	$0.29	$2.07	30%
				Beef	$837	$829	($8)	-0.99%	8%	na	na			
9047	Better management of ticks resistance to acaricides	Animal health	Developed better methods to manage tick resistance to acaricides	Milk	$175	$172	($3)	-1.87%	4%	na	na	$1.13	$12.34	33%
				Beef	$638	$553	($85)	-13.38%	18%	na	na			
9116	Vaccine for babesiosis and anaplasmosis	Animal health	Developed a vaccine for babesiosis and anaplasmosis	Milk	$174	$159	($16)	-9.03%	20%	na	na	$1.50	$35.25	40%
				Beef	$634	$544	($90)	-14.16%	28%	na	na			
9007	Hydrogen cyanide potential in cassava in sub-Saharan Africa	Human health	Found cultivars of cassava with lower hydrogen cyanide potential for use in Africa	Konzo	na	na	na	na	na	1000	0	$0.59	$1.57	12.76%
				TAN	na	na	na	na	na	18000	0			
8326-8735	Improvement of dryland crop and forage production in semi-arid tropics Machakos, Kenya	Pre-farmgate, soil degradation	Improved methods of dryland agriculture in Machakos, Kenya	Maize	$187	$101	($86)	-46.00%	182%	na	na	$7.23	$25.53	20.41%
				Sorghum	$179	$113	($66)	-36.89%	182%	na	na			
				Beef	$365	$332	($33)	-9.00%	30%	na	na			
				Milk	$492	$415	($78)	-15.80%	41%	na	na			
8320-8331 8808-8809 8357	Overcoming the shortage in fuelwood and poles in Africa and Thailand through forestry research	Genetic improvement	Addressed shortage of fuelwood and construction timber in Africa	Fuelwood	$27	$13	($14)	-52.59%	525.00%	na	na	$3.21	$30.08	26.66%
				Other industrial roundwood	$52	$16	($36)	-69.[illegible]%	525.00%	na	na			

Figure 1: Simple Research Impact Supply Demand Model - Closed Economy.



Notes:
P stands for price of the commodity covered in the research project.
Q is the quantity of the commodity. D is the demand function.
S is the supply function.
ED and ES are excess demand and supply functions respectively.
k is the cost reduction due to research.
The area 'abcd' is the benefit from research.

Figure 2: Research Impact Supply-Demand Model - Open Economy, no research spillover.

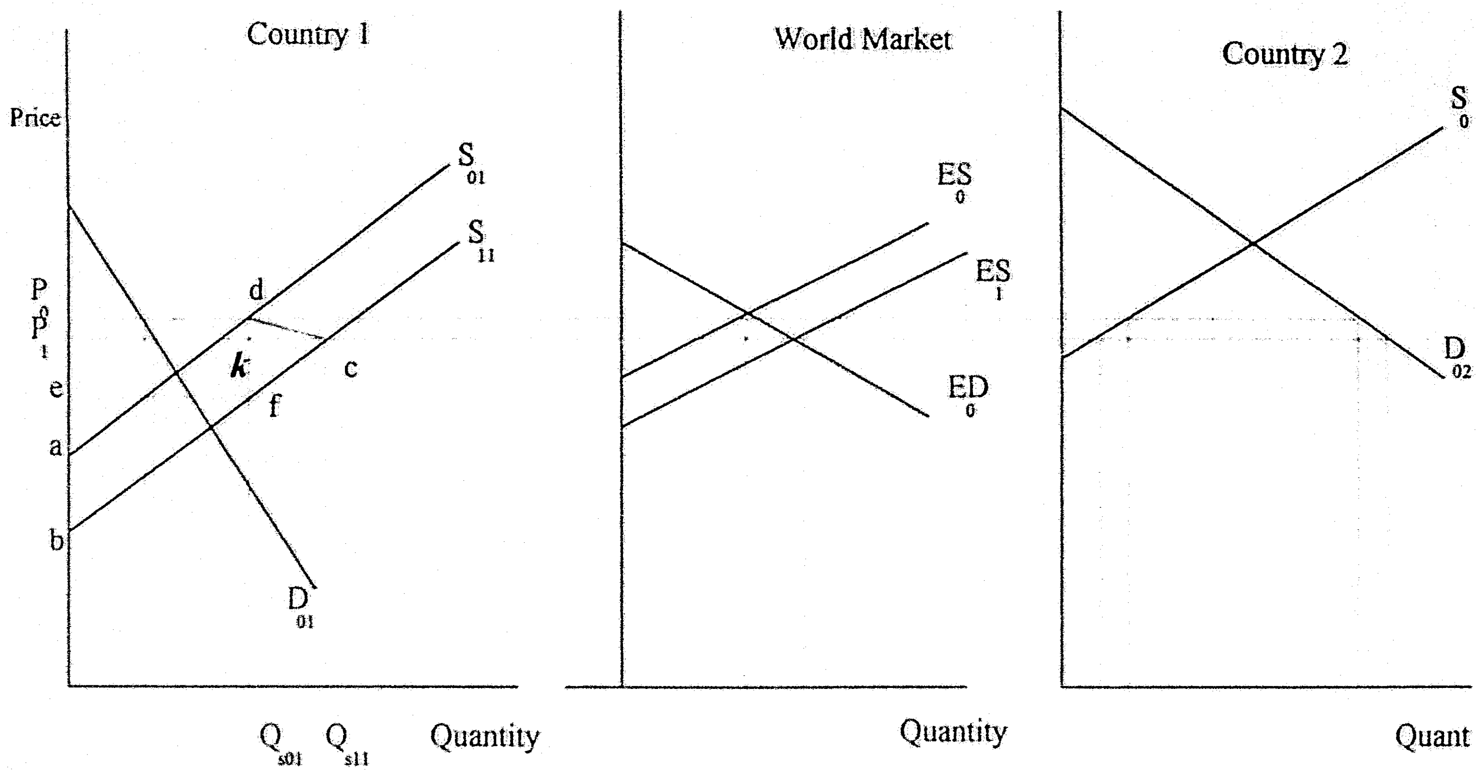


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Table 3: Estimates of benefits by country

ACIAR Program	Project activity	Australia	Kenya	Zimbabwe	Rest of Africa*	Thailand	Total
		$Am, 1991	$Am, 1991	$Am, 1991	$Am, 1991	$Am, 1991	$Am, 1991
Animal science	Develop tick models to show intensive dipping may not optimal	0.09	0.18	0.96	0.84[a]	0	2.07
	Develop better ways to manage tick resistance to acaricides	8.27	0	4.07	0	0	12.34
	Develop a vaccine for tick fever	23.75	0	11.49	0	0	35.24
Crop Sciences	Find a way to reduce hydrogen cyanide in cassava	0			1.6[b]	0	1.6
Forestry	Address shortage of fuel wood and construction timber	0	4.75	5.1	0.05[c]	20.2	30.1
Land and Water	Improved methods of dry land agriculture in Machakos, Kenya	0	25.55	0	0	0	25.55
Total		32.11	30.48	21.62	2.49	20.2	106.9

* The estimation of benefits includes only benefits to collaborators in the projects Estimate do not include potential technical spillovers to other sub-Saharan African countries

a. Benefits to Burundi, Malawi, and Zambia.
b. This project was with the IITA, Ibadan which has an Africa-wide mandate for cassava
c. These are world-price related spillovers to other African countries

Table 4: Estimates of benefits by commodity

ACIAR Program	Project activity	Beef	Milk	Cassava	Fuelwood and construction timber	Maize	Sorghum	Total benefits
		$Am, 1991	$Am, 1991	$Am, 1991	$Am, 1991	$Am, 1991	$Am, 1991	$Am, 1991
Animal science	Develop tick models to show intensive dipping may not optimal	0.81	1.26	0	0	0		2.07
	Develop better ways to manage tick resistance to acaricides	8.4	3.94	0	0	0		12.34
	Develop a vaccine for tick fever	26.66	8.58	0	0	0		35.24
Crop Sciences	Find a way to reduce hydrogen cyanide in cassava	0	0	1.6	0	0		1.6
Forestry	Address shortage of fuel wood and construction timber	0	0	0	30.1	0		30.1
Land and Water	Improved methods of dry land agriculture in Machakos, Kenya	0.15	3.03	0	0	21.45	0.92	25.55
Total		36.02	16.81	1.6	30.1	21.45	0.92	106.9

Conclusion

Preliminary estimates indicate that over a 30 year time period benefits totalling about $A 107 million are likely to accrue from research that ACIAR funded in Africa from 1983 to 1994. These estimates do not include benefits likely to spillover to other sub-Saharan countries as the technologies developed become more widely known in the region. About 30 percent of these benefits are likely to accrue to Australia.

Overall the assessment shows that ACIAR has made an impact in Africa. The project that the Economic Evaluation Unit has assessed to date cost a total of about 14 million million dollars. This is the total of funds committed to the projects by ACIAR, by the Australian Commissioned Organisation and by the Governments of the collaborating countries.

Current estimates indicate that these projects will eventually (over a 30 year time horizon) generate benefits to Australia and to African countries of at least $A107 million dollars leading to a benefit cost ratio of over 7. This benefit cost ratio is likely to be higher when the potential spillover benefits to the rest of Africa, not estimated to-date, are taken into account.

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