The Impact of ACIAR Agricultural Research Programs on Poverty Outcomes: Developing a Methodology

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Centre for Strategic Economic Studies

Victoria University

Melbourne

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For further information:

T +613 9919 1340

F +613 9919 1350

Peter.sheehan@vu.edu.au#   #

1. Introduction

The Australian *Independent Review of Aid Effectiveness* (Holloway et al. 2011) concluded, in its Recommendation 23, that there should be more aid funding for research by Australian and international institutions, particularly in agriculture and medicine. The Australian Government, in its response to the Review, endorsed this finding in principle.

The Independent Panel set up by ACIAR to provide guidance on the implications of Recommendation 23 (Chubb 2012) concluded that, while Australian agriculture currently benefits perhaps 400 million people per year, the number of poor people assisted could be increased through well targeted investments in agricultural research in priority countries and regions, including Africa. The Panel noted that investing in agricultural research for development relates to three of the ten development goals in the Australian Government's aid strategy: improving food security, improving incomes, employment and enterprise opportunities for poor people and reducing the negative impact of climate change and other environmental effects on poor people.

These conclusions raise the question of what might be the likely impact of an increase in ACIAR's spending on people in poverty in the developing world. What would be the impact, in terms of the position of the poor, of a given increase in ACIAR spending on agricultural research? This is clearly a question that it is difficult to answer with a high degree of precision. The purpose of this report is to develop, in the light of Australian and international experience, a methodology to provide the best answer possible to this question.

1.1 Agricultural research, economic development and poverty alleviation

It is widely acknowledged that for two decades or so from the 1980s the role of agriculture as a key agent of economic growth was neglected, but that in the past decade or so this neglect is being addressed (eg Grewal et al 2011, de Janvry 2010). The lack of emphasis on agriculture from the 1980s reflected an emphasis on export-oriented industrial growth, seen as responsible for the 'East Asian miracle', as well as pursuit of privatisation, open domestic and international markets and a reduced role for governments in shaping and supporting growth. In this framework agriculture was conceived as a single, undifferentiated sector which was a source of labour for industrial growth, and where government savings has been made. Drawing on statements from a range of international agencies and other analysts, de Janvry (2010) has articulated the emerging new role for agriculture in an enlarged perspective on development, contributing to a range of diverse objectives such as food security, poverty alleviation and support more broadly-based development outside of major urban centres.

Two of the factors driving this revival are rising food prices and growing concern about food security, and the continued concentration of the poor in rural areas. With rapid if unequal growth in many developing countries, and rising demand for food, global food prices rose rapidly after 2005. In the first five months of 2012, the average level of the FAO Index of world food prices was 36% higher than the average level over 1900-2005, in spite of the low level of economic activity in many developed countries. Without continued strong growth likely in many developing countries, there are growing concerns about food supplies, food security and food prices in the longer term.

The renewed focus on agriculture also reflects the concentration of poverty in rural areas, with many of the poor dependent on agriculture – either directly or indirectly. IFAD (2010) indicated that nearly 72 per cent of those in poverty in developing countries live in rural areas, with 75 per cent in the sub-Saharan region and more than 80 per cent in South Asia. IFAD (2011) estimated that to halve poverty in Asia and the Pacific Region, would require a 28 per cent increase in agricultural expenditure, 23 per cent in fertiliser use and 24 per cent in agricultural investment between 2007 and 2013, together with a 56 per cent increase in agricultural Overseas Development Assistance. As poverty and inequality have proven stubbornly resistant to even rapid industrial growth in many countries the concern to address poverty has contributed to the renewed emphasis on agriculture. These two concerns also reinforce themselves, for it is the poor who stand to suffer most from higher food prices and from insecurity in the supply of food.

This renewed understanding of the role of agriculture in development will lead in due to course to increased emphasis on agricultural R&D, for one of the clearest and most well documented facts is the pivotal impact agricultural R&D in the growth of agriculture output and productivity, in both developed and developing countries and in both the long term and in recent decades. The focus of this study is, however, on poverty alleviation, and we do not pursue further the link between R&D and the growth of agriculture.

1.2 Understanding the impacts of ACIAR activities on poverty alleviation

ACIAR is a leading funder of agricultural research at the implementation and policy development end of the innovation spectrum. Its work focuses on a number of target regions and countries, with an emphasis on applied innovation, in the sense of bringing existing global technical and operational knowledge to bear on developing country contexts to which it has not yet been disseminated.

It is well established that ACIAR's activities over 30 years have been highly effective in bringing economic benefits to developing countries, and have also been highly cost-effective in doing so. ACIAR has an extensive and high quality impact assessment process, with economic evaluations of a wide range of projects by independent experts, independent assessment of these evaluations and several meta-analyses of the evaluation results. It has also undertaken a set of adoption studies, to examine the extent of adoption of core results achieved by selected projects, and to provide improved understanding of the pathways to change. Finally it has undertaken a number of impact pathway analyses, to provide a deeper understanding of the contextual environment and of the way in which it influences the likelihood that the project goals will be achieved. While some of these assessments have addressed poverty impacts, the focus of assessment to date has been largely on economic outcomes.

Internationally, there is an extensive literature on the impact of agricultural development on poverty and also on the impact of agricultural research and innovation on economic outcomes. Studies in both of these fields are well advanced, with the findings well documented. While there has been increasing focus over the past 10-15 years on the impact of agricultural research on poverty, this literature is still limited and less advanced.

The challenge facing this analysis is to develop ways of bringing together the international body of evidence, particularly about the impact of agricultural development and agricultural research on poverty alleviation, together with what is known about the (primarily economic) outcomes of ACIAR

programs, to derive a provisional estimate of the potential poverty impact of ACIAR's activities. It should also be noticed that the question to be addressed here - what will be the impact, in terms of the position of the poor, of a given increase in ACIAR spending on agricultural research? – is a forward looking one, while much of the evidence on which an answer would be based is historical, in terms of the outcomes of past projects. It is proposed to develop a methodology to address this challenge by exploring two sub-questions:

- How can the international evidence – about the impact of agricultural development on poverty and of the impact of agricultural R&D on poverty – be used to make inferences from existing impact data on ACIAR projects about the effect of those projects on poverty alleviation?
- What can be inferred about the extent of poverty alleviation that might have been achieved if those projects had been more directly focused on poverty, and what would have been necessary to achieve this?

1.3 Developing an approach to assess the potential poverty impact

The body of this report is in three further sections. In Section 2 we review the two key elements of the international literature distinguished above: the impact of agricultural development on poverty (2.1) and the impact of agricultural research and innovation on poverty alleviation (2.2). In Section 3 we turn to existing knowledge on the nature and impact of ACIAR's activities, outlining the nature of ACIAR's activities (3.1), the economic impact of projects to date (3.2) and summarising what is known from existing studies of the impact of individual ACIAR projects on poverty (3.3). Finally in Section 4 we bring the pieces together, outlining the overall approach to be proposed and commenting briefly on the next steps necessary to define further and to implement this methodology.

2. The International Literature

The focus of this work is clearly on poverty reduction, and on the role of agricultural development and in particular agricultural R&D in poverty reduction. The literature concerned broadly with agriculture and poverty can be divided into three overlapping parts: that concerned with links between agricultural development and poverty (however the development is achieved); that concerned with agricultural technologies and poverty; and that directly concerned with agricultural R&D and poverty reduction. Underlying especially the technology bases analyses is the key question of adoption: if the results of R&D, in the form of new technologies, are not adopted they will clearly have little impact. But if the analysis is undertaken on the basis that the technologies have been adopted then the processes that led to that adoption, including applied R&D of many forms, are also critical to the outcomes. Here we briefly examine the international literature under two heads: agricultural development and poverty, and agricultural R&D and poverty.

2.1 The impact of agricultural development on poverty

The impact of agricultural development on poverty has been recently reviewed, with particular attention to five countries (China, India, Indonesia, India and South Africa), in IAS 76 (Grewal et al 2011). Here we briefly review and update that analysis, targeting it more specifically to the present issues.

Selected individual studies

As Grewal et al (2011) point out, many early studies found that agricultural growth has been a major driver of poverty reduction in the developing world. For example, Ravallion and Datt (1996) found that growth in agriculture and rural economy had been highly beneficial to reducing rural poverty in India. Later, these authors, Datt and Ravallion (1998) provided theoretical reasons for expecting agricultural growth to reduce poverty, including the creation of jobs on the land; linkages from farming to the rest of the rural economy; and a decline in the real cost of food for the whole economy. This early study provides a cross-country estimation of the links between agricultural yield per unit area and measures of poverty. This provides strong confirmation of the hypothesised linkages and suggests that it is highly unlikely that any other interventions would be as capable of reducing the numbers in poverty as effectively. Later, Ravallion and Datt (2002) found that while higher farm yields, higher state development spending, higher non-farm output and lower inflation all had poverty reducing effects, the rates of growth in farm output was the most significant factor to produce benefits for the poor in Indian States.

Thirtle et al. (2003) was an important study, published in World Development, which contributed to the growing understanding of the role of agricultural productivity in alleviating poverty in developing countries. This paper constructs a dataset from the World Bank development indicators as of 2000, to try and find the impact of research-led agricultural productivity on poverty across three continents. The data is pooled over years and countries, and the authors develop a four equation econometric model to test their hypotheses. These four equations form a causal chain model, linking agricultural productivity measured as the value added per land, GDP per capita, the gini coefficient, and the poverty index. They found that there were significant relationships between productivity growth and poverty and nutrition, and that agriculture had a greater impact of poverty than other sectors. They estimated that on average, every 1 per cent increase in agricultural productivity reduces the percentage of people living on less than a $1 a day by between 0.6 and 1.2 per cent; that is, an elasticity of the poverty rate (at $1 per day) with respect to agricultural productivity of -0.6 to -1.2.

Virmani (2007) found that every 1 per cent growth in agriculture in India reduces the rate of poverty by 0.45 per cent while contributing to overall GDP growth. Generally, growth in agriculture reduces poverty by: a direct and relatively immediate impact on rural incomes; impact of cheaper food for both rural and urban poor; contributing to growth and generating economic opportunity in the non-farm sector; and playing a pivotal role in stimulating and sustaining economic transition, as countries (and poor people's incomes) shift away from primarily agriculture towards the broader base of manufacturing and services. As the actual impact of any given rate of growth depends on various factors, including the concentration of population close to the poverty line, the system of land ownership, agricultural wages, and these factors vary between countries, the precise impact will vary between countries.

Ravallion and Chen (2007) found that, between 1980 and 2001, the impact of the primary sector on headcount poverty reduction in China was 3.5 times higher than the impact of either the secondary or tertiary sectors according to. The poverty elasticity of growth (PEG) in China was found to be very high, being estimated by them at -7.85 for agriculture and -2.25 for the non-agricultural economy. This suggests that a one per cent growth in the primary sector led to a 7.85 per cent reduction in

poverty whereas that magnitude of growth in the non-primary sectors led to only a 2.25 per cent reduction in poverty. Montalvo and Ravallian (2010) confirmed this importance of the primary sector in reducing poverty in China through the use of provincial panel data.

Although agriculture is the most effective driver of poverty reduction in South Asia and sub-Saharan Africa, Hasan and Quibria (2004) found that in East Asia growth in the industrial sector had the most impact on poverty reduction and in the services sector in Latin America. Suryahadi et al. (2010, 2011) found that urban services, such as domestic services and those in the tourism industry have the greatest impact on poverty reduction in Indonesia. Also, in countries with highly mechanised agriculture there is likely to be little employment of unskilled labour, hence the impact of growth in agriculture is likely to have little or no impact on poverty alleviation. However, Warr (2002) has indicated that besides providing employment to unskilled workers, the agricultural sector contributes to poverty reduction by stimulating growth in the secondary and tertiary sectors. Improvements in agricultural activities can lead to increases in food processing industries, leading to labour mobility from rural to urban areas.

Some recent studies

In 2010, De Janvry and Sadoulet (2010) found that growth in agriculture reduced poverty nearly more than three times than growth in manufacturing and nearly double the growth in construction. In this study they found that the increases in productivity (value added per worker) in agriculture were large in East Asia between 1993 to 2002, when rural poverty rates also fell sharply. However, growth in agricultural productivity was instrumental in poverty reduction in the developing countries of Sub-Saharan Africa and other parts of Asia, but not in Latin America and the Caribbean. They estimated that poverty elasticity of growth in agriculture was -1.2 in China and India, but -0.3 in Brazil. Gains in agricultural productivity do not translate into lower poverty rates in Latin America and the Caribbean as these gains are driven by capital and hence fewer employment opportunities. The authors suggest that a sector's intensity to employ unskilled workers determines its impact on poverty and as agriculture and construction are the most prominent in this regard, they have a large impact on poverty reduction.

Loayza and Raddatz (2010) investigating the relationship between output growth and poverty in more than 50 countries, found that the composition of growth in terms of intensive use of unskilled labour, the kind of input that the poor can offer to the production process, has a significant impact on poverty reduction. More labour intensive sectors (in terms of their size) have a stronger effect on poverty alleviation. The study also found that agriculture has the greatest impact on reducing poverty, then construction and manufacturing, whereas mining, utilities and services have the least effect, in that they do not have any impact on reducing poverty.

Another empirical perspective provided by Christiaensen et al. (2010), in a study which brings together the different effects, such as the contribution of agriculture on its own growth and the indirect impact on growth in other sectors; the extent to which poor people participate in agriculture and the size of this sector in the overall economy and uses cross-country econometric evidence. It concludes that agriculture is significantly more effective than non-agriculture in reducing poverty amongst the poorest (as reflected in the $1-a day squared poverty gap.). They also found that agriculture is up to 3.2 times better at reducing $1-a day headcount poverty in low-income and resource–rich countries (including those in Sub-Saharan Africa), at least when societies are not

fundamentally unequal. Among the better-off poor (those in the $2-a day measure), non-agriculture is more effective. This is mainly due to the much larger participation of poorer households in agriculture and the lower poverty-reducing effect of non-agriculture in the presence of extractive industries.

These findings were further corroborated by another study, Cervantes-Godoy and Dewbre (2010) which found that the growth in agriculture plays a leading role in the reduction of extreme poverty (that is, at US1.25 a day), but non-agricultural growth is more powerful in reducing poverty among the better-off poor (that is, in reducing the US$2.0 a day poverty headcount. They found the dominance of agriculture in reducing extreme poverty declined as countries became less poor and as income inequality increased. This study found that more than 52 per cent of the average poverty reduction in 12 of the 25 countries examined was due to agricultural growth, 35 per cent to remittances and the remaining 13 per cent was due to non-agricultural growth. It also found that high initial inequality in a country reduced the impact of agricultural growth on poverty reduction.

Conclusion

Overall, the body of evidence noted above is powerful, demonstrating clearly the general proposition that growth in various agricultural variables can have, and has had, major poverty reducing effects. But the effects and the estimates are complex and diverse, and the impact of agriculture on poverty reduction depends on the interaction of several effects. First of all, the direct effect of growth in the agriculture sector is to raise income levels of those employed in this sector. Secondly, how much the poor people benefit from agricultural growth depends on the rate of participation of the poor in agriculture. This, in turn depends on the type of agriculture in a particular location. For example, in highly mechanised agriculture, the participation of the poor and unskilled people may be minimal. On the other hand, in subsistence agriculture, or in fruits and vegetable farming, the rate of participation of the poor may be relatively high. As noted above, Loayza and Raddatz (2010) emphasised the importance of unskilled labour intensity of agriculture in determining its ability to reduce poverty. Thirdly, the total contribution of agriculture to poverty reduction depends on how large the agriculture sector is, i.e., the share of the agricultural sector in the national economy. Finally, there are indirect contributions that growth in one sector of the economy makes for enhancing growth in the other sectors and helping in poverty reduction.

2.2 The impact of agricultural research and innovation on poverty

We turn now to the literature on the impact of agricultural research on poverty in developing countries. This literature also has a long history, although the field is generally regarded as less advanced than the agricultural development/poverty link. This reflects in part that, in this case, the complexity of poverty outcomes is matched by the diversity of types of agricultural research that are undertaken and hence need to be included in the assessment. The types of agricultural research that is assessed can include improved crop varieties, germplasm improvement, changes in irrigation, use of chemical fertilisers, soil fertility replenishment or other such technologies that increase nutritional value or lower prices. The impacts of agricultural research can be direct or indirect and could be on the adopters of the technology or on the consumers. The indicators used to measure the poverty impacts include income effects, wages, farm productivity, poverty headcount, relative prices of food, calorie intake per capita, and farm profits.

While many authors have contributed to this literature, the Consultative Group on International Agricultural Research (CGIAR) and particularly its Standing Panel on Impact Assessment (SPIA) have played key roles. The review below covers briefly a selected range of studies, including many included in a recent SPIA review (SPIA 2010), before focusing on two important studies: the CGIAR/IFPRI modelling study on agricultural research and food security, poverty and the environment (von Braun et al 2008) and the project on agricultural research and poverty based on detailed case studies carried out between 1998 and 2006 under the auspices of the SPIA, the final results of which were published in Adato and Meinzin (2007).

Selected individual studies and reviews

SPIA indicates that empirical evidence for direct and indirect effects of agricultural technology adoption was reviewed by Kerr and Kolavalli (1999). Most impact assessment studies tend to consider the direct effects, that is, incomes/livelihoods of adopters of new technology. Increasing availability of data on rural household income and consumption expenditure have enabled increased applications that help quantify the specific impacts of given technologies.

Studies that documented both direct and indirect effects on different groups included Scobie and Prada (1978) and Pinstrup-Andersen (1979) measured the differential effects of adoption of agricultural technology such as improved rice varieties, on both producers (direct and indirect) and consumers (indirect) using economic surplus analysis. Warr and Coxhead (1993) measured the impact of reduced food prices on the poorest quintile of the population. Studies including impact of technology adoption on wages and employment included Alauddin and Tisdell (1986), higher demand for labour by Goldman and Smith (1995), improvement in wages and employment of the landless labourers by Hazell and Ramaswamy (1991), facilitating movement from non-adopting to adopting regions by David and Otsuka (1994) and Renkow (2010) who looked at the impact on income distribution and equity, comparing poverty alleviation impacts in favourable and unfavourable areas.

A hallmark study that demonstrated the adoption of technology improved productivity faster than the decline in food prices so that both farmers and consumers benefitted was undertaken by Lipton and Longhurst (1989).

Lanjouw and Stern (1998) used data from household surveys to link changes in irrigation, modern variety adoption and chemical fertilizers to economic and social variables such as real income per capita, real wages in agriculture and the proportion of population below the poverty line. They found that new agricultural technology (not all due to research) increased incomes and reduced poverty.

Sanginga et al. (1999) used focus groups interviews, a survey of food consumption, rural appraisals and field observations for a multivariate analysis to measure the impact of improved soya bean varieties and utilisation technologies and found positive impacts on household income and distribution, human capital development, resource use and social equity and both short and long term effects on nutrition.

The Thirtle, Lin and Piesse (2003) study reviewed above indicated that twenty- per cent of the world's population, or 1.2 billion live on less than $1 per day, with 70 per cent of these living in rural

areas and 90 per cent in Asia and sub-Saharan Africa. Their study indicates that research-led technological change in agriculture generates sufficient productivity growth to give high rates of return in Africa and Asia and has a substantial impact on poverty, reducing the number by 27 million per annum, while productivity growth in in industry and services had no impact. They found that the per capita `cost' of poverty reduction by means of agricultural research expenditure in Africa is $144 and in Asia $180, or 50 cents per day, but is covered by output growth. The per capita `cost' in richer countries, such as Latin America, is over $11000.

Studies using household survey data to describe the impact of technological change and include Alwang and Siegal 2003, Walker et al. 2006). Moyo et al. (2007) investigated poverty prospects in an ex ante assessment based on household income formation. Ex ante assessments, based on Moyo et al. recommended that poverty impact should be measured at a national or regional context, these evaluations are reliable if the commodity assessed is a staple food crop and the impact considers an indicator such as the squared poverty gap that is sensitive to improvements in income for households living below the poverty line. Consumption expenditure data sets investigate the consequences on net sellers and net buyers of food.

Evenson and Golin (2003) linked agricultural research (crop improvement) to poverty related goals after estimating productivity gains from adoption of the technology by using the IMPACT model. Evenson and Rosegrant (2003) investigated the impact of agricultural research on a variety of indicators that included food prices, food production per capita, calorie availability per capita and concluded that without CIGAR research, food production in developing countries would have been 7-8 per cent lower, food and feed prices 18-21 per cent higher, calorie intake 4-5 per cent lower and between 13 and 15 million children would have been malnourished.

Some studies have used the sustainable livelihoods conceptual framework, involving varying disciplines and research methods to gain `a holistic understanding of the ways in which agricultural research interacts with people's livelihoods (Adato and Meinzin-Dick 2003).

Renkow and Byerlee (2010) in their review of recent evidence suggested that while CGIAR research contributions in crop genetic improvement, pest management, natural resource management and policy research all have yielded strong positive impacts – they did suggest that CGIAR needed to prioritise impact assessments of resource management and policy research to further deepen understanding of the impacts of its investments.

The CGIAR/IFPRI modelling study

The CGIAR/IFPRI study uses two methods jointly to arrive at their estimates of the benefits from increasing investment in agricultural research. The first part of the method involves using an optimisation model which maximises an objective constrained by technologies and endowments, and which is applied to two scenarios. The first scenario involves maximising total agricultural output constrained by the region's agricultural output response to R&D (production function of land, labour, fertiliser, tractors, and animal stock) and the level of R&D stock (endowments) in each region. The optimisation problem sees total investment doubled in five years and that the R&D investment is allocated to different regions each year. This model is solved each year, updating the R&D stock from previous years, and is in this respect a dynamic model. The second scenario uses the same model but rather than optimise total agricultural output it minimises poverty. These

optimisation results involve no price effects and no spillovers of R&D investments across regions. The second part of the method is to utilise the IMPACT model to investigate the effects of increased agricultural R&D impact upon food prices. The model is a set of simultaneous equations which is solved for prices and quantities (a mixed complementary problem). A number of exogenous variables are used to find the solution prices and quantities, including population, GDP, water availability, infrastructure, and a large number of elasticities. The IMPACT model was run for two cases, one being the business as usual and the second incorporating the effects of increased R&D investment and agriculture.

They found that increasing investment in public agricultural research in the specified countries from US$4.6 billion to US$9.3 billion during the next five years (2008-13), including doubling CGIAR investment from US$0.5 to US$1.0 billion, would raise the rate of output growth from research and development (R&D) from 0.53 to 1.55 percentage points. This doubling of R&D would reduce $1 a-day poverty by 204 million people by 2020, if the expanded investment were targeted to maximising agricultural output and hence especially to South/East Asia and South Asia rather than other regions. However, if the expanded research were targeted towards maximising poverty reduction, then R&D investments should be directed more towards Sub-Saharan Africa and South Asia. Under this scenario, overall agricultural growth would be somewhat less (from 0.53 to 1.11 per cent age points per year) but would lift 282 million people out of poverty by 2020. The IMPACT modelling of the effects of accelerated investment on R&D on international food prices suggested that in the baseline scenario, high investment in R&D could reduce maize prices by 67 per cent in 2025, wheat prices by 56 per cent and rice prices by 45 per cent, while also reducing unit costs of production.

This is high-level modelling, using simplified linkage patterns and a wide range of specific assumptions, but does have the advantage of producing 'orders-of-magnitude' estimates of the impact of higher agricultural R&D on poverty. For the case in which the increased R&D of $4.6 billion per annum by 2013 is focused on increased output, 204 million people were lifted from poverty (at the US$1 per day benchmark) by 2020. This implies an incremental annual R&D cost in 2013 per person lifted from poverty by 2020 of $22.8 per head. To the extent to which CGIAR's increased funding is responsible for these effects, the annual R&D cost per person for CGIAR funds would be considerably lower. For the case in which the increased R&D is targeted to reducing poverty the incremental annual R&D cost in 2013 per person lifted from poverty by 2020 in $16.5 per person, and again the CGIAR effective cost could be much lower if it is responsible for leveraging other public investment in R&D.

The CGIAR impact assessment based on case studies

Concerns expressed by Hazell and Haddad (2001) that not enough evidence existed to link CGIAR agricultural research to poverty reduction led them to shape a series of case studies of this relationship under the auspices of SPIA. The leadership of the second stage of this project passed to Adato and Meinzin-Dick, and seven impact assessments were prepared to study this link. Most of the studies used a sustainable livelihoods framework and measured the impacts on the poor both by quantitative and qualitative means. Seven case studies of different types of agricultural research that included: aggregate investments in agricultural research in China and India; rice, vegetable, and fishpond technologies in Bangladesh; soil fertility replenishment in Kenya; hybrid maize in Zimbabwe, and creolized maize in Mexico. By contrast with the aggregate modelling referred to

above, the case studies were specifically intended to explore the impact of agricultural R&D on poverty in a wide range of contexts, the wide range of channels through which the effect of R&D is felt and the many factors that can limit that impact.

The study found that, overall, 'agricultural research has made a significant contribution to poverty reduction, through direct and indirect channels' (Adato and Meinzin-Dick p360) but focused primarily on the complexity of the contexts, channels and the factors affecting adoption of new technologies. Adoption was influenced by the likelihood that the technologies would increase or decrease vulnerability, whether the poor have the assets needed to adopt, the nature of disseminating institutions, and cultural factors such as gender roles and taste preferences. The study identified a wide variety of direct impacts on adopting households, including those related to increased production, income, knowledge, changes in power relationships (favoring men or women; richer or poorer farmers), and increased or decreased vulnerability. Poor people benefited from these technologies if the technologies built on their assets, though the studies also showed that impacts on the poor were sometimes limited by asset requirements for adoption or by dissemination practices. Several indirect effects were registered. Declining food prices helped poor people, though benefits to poor farmers were dampened by falling output prices. Increased stability and even marginal improvements in agricultural production were valued by poor households for providing food security and a launching pad into other activities. Increased agricultural employment was also a major benefit, improving incomes and stability of employment.

Meinzin-Dick et al. (2003) and Adato and Meinzin-Dick (2007) identified criteria for future impact assessments, which included the identification at an early stage of critical factors, such as the priority poor people put on managing risk; the types of social differentiation (gender, class, ethnicity, etc.) that will affect the uptake and impacts of technologies; the variety of traits that farmers value; and the role of agriculture in livelihood strategies. With regard to methodology, the case studies underscore the need to consider direct and indirect impacts and to avoid restricting analysis to only impacts that can be easily quantified. Mixing disciplines and research methods are essential to conducting impact assessments. Finally, the study concludes that for impact assessment to make a difference, researchers must conduct research and impact assessment in a way that facilitates institutional learning and change. These and related themes were explored further in a document on *Strategic Guidance for Ex Post Impact Assessment of Agricultural Research*, prepared for SPIA in 2008 (Walker et al 2008).

3. Understanding ACIAR activities and their impact

In our view a methodology to assess the impact of ACIAR activities on poverty in developing countries will need to find ways of bringing the diverse international knowledge base to bear on the specific characteristics of ACIAR projects. Towards this end, in this section we review what is known about the outcomes of ACIAR projects, focussing on three matters: the extensive economic returns to these projects, the more limited information on poverty outcomes and the information contained in the ACIAR project database.

3.1 The economic returns to ACIAR projects

ACIAR has been undertaking formal, independent, impact assessment studies based on cost-benefit analysis for over 20 years. The most recent meta-analysis of these studies in Harding et al. (2009),

which updated earlier studies by Raitzer and Lindner (2005) and Pearce et al (2006), and analysed 37 of the impact assessments conducted on ACIAR investments in mandated regions. This study calculated benefits of $A12.6 billion for a total assessment of approximately $A234 million, in 2008 dollar-value terms. Of the total benefits, they attributed A$111.4 billion to developing countries and A$1.2 billion to Australia and they assessed the total benefit/cost ratio across all projects at 54 (Table 1). They estimated that the benefits directly attributable to ACIAR funding at $A6.8 billion, to ACIAR funding for an investment of A$128 million across projects. The total ACIAR's expenditure since its inception they estimated at $2.1 billion, in present day 2008 dollars.

Table 1 Summary of the benefits and costs of 37 ACIAR impact assessments for which there is quantitative information in the ACIAR Database for Impact Assessment

Total benefits (A$m)	12,632
Benefits attributable to ACIAR (A$m)	6,811
Total costs (A$m)	234
ACIAR costs (A$m)	128
Benefit/cost ratio	54

Note: Benefits and costs are expressed in 2008 dollar equivalents; base year for discounting is 2008; real discount rate used is 5% per annum.
Source: Harding et al (2009)

This analysis takes account of both past and estimated future benefits of the projects, with benefits extending out to 2034, but the annual benefits peak in 2008 and the majority of the benefits have accrued by 2012. While most (71%) of the projects have benefit/cost ratios of less than 50, only four have ratios of less than one, and 16% have benefits of over 100. Excluding these latter projects, the median benefit/cost ratio of the remaining projects is 20.6. No information is provided about the nature and magnitude of specific classes of benefits.

This study also found the major partner beneficiaries of ACIAR's research to be China and Vietnam, together totalling over half the total benefits and India was the next major beneficiary accounting for 15 per cent of total benefits. In regional terms the study assessed the major beneficiaries to be South-East Asia (34% of the total), followed by North Asia (29%), South Asia (15%), Australia (95) and Papua New Guinea and the Pacific (3%). The major research areas included crops and animals (54 per cent of total benefits) followed by forestry (15%) and natural resource management (14%).

While different in scope and purpose, these ACIAR cost/benefit assessments can be set in the context of more general meta-analyses of all CGIAR investments in ACIAR's area of interest. ACIAR investments are only a modest part of total CGIAR investments in these regions. Raitzer and Lindner (2005) conducted bilateral assessments in 2005, building on the meta-analyses undertaken by Raitzer (2003. McClintok and Griffith (2010) updated and complemented the Raitzer and Linder (2005) work but focused only on large scale verifiable benefits accruing to areas within the ACIAR's mandated regions. McClintok and Griffith (2010) selected 27 impact assessment studies to assess them for `transparency' and `demonstration of casualty.' They found that of the 27, 10 provided `substantially demonstrated' benefits, 4 were assessed as having `plausible benefits and another 3 were seen to have potential benefits. They excluded ten studies for various reasons, including that net present values (NPVs) were not reported. Overall, McClintok and Griffith estimated that under the most restricted setoff assumptions about credible benefits, every $1 million invested by the CGIAR system in ACIAR's mandated regions produces a return to the developing countries in this

region of at least $2.7 million and with more relaxed set of assumptions the return was up to $3.9 million (2010, p. 9)

In the remainder of this sub-section we provide some examples of impact assessments of ACIAR's research covered in the meta-analysis of Harding et al. (2009). Harris (2004) assessed the impact of water and nitrogen management on the North China Plain. It found that in present value terms, the net benefits of the project were A$216.2 million, representing the economic benefits that accrue to farmers growing wheat and maize on selected areas of the North China Plain. They estimated the benefit–cost ratio is 77 to 1. A progressive project evaluation up to the end of 2003–04 assessed the net benefits at A$24.9 million. The progressive benefit–cost ratio is about 10 to 1. They also estimated that the project would have significant poverty-reduction effects. For an average sized farm, input costs fell by 12–18% and project benefits were equivalent to an increase in income of between A$50 and A$109 per year.

Another ACIAR project in Vietnam and Australia involved the breeding and feeding of pigs (Tisdell and Wilson 2001). Nutrition research led to changes in the lysine/energy content of concentrated pig meal for fattening and finishing pigs, making it possible to produce leaner pork more cost effectively in Vietnam. The new feed formula was being adopted by Vietnamese-owned millers of concentrated pig feed, and benefits should flow to Vietnamese pig farmers. In addition, in the near future, results from the nutrition research component of this project would enable Vietnamese-owned mills to produce concentrated feed for weaner pigs for the first time. To date, this production has been exclusive to foreign-owned mills. The best estimate benefit–cost ratio for investment in this project was estimated at least 159:1 with a corresponding internal rate of return of 900% and a net present value of A$496 million. This was the total value, not an annual value. To give context to the number A$496 m, in 2000, 1.3 million tonnes of pig meat, worth A$2,323 million, was consumed in Vietnam in that year alone. The returns to the project are still significant even when the net present value up to, and including, 2001 is considered.

A water management project in public irrigation schemes in Vietnam improved farm-level productivity and reduced costs in providing irrigation services. Overall, in present-value terms, IAS 43 estimated that the net benefit of the projects was A$13 million, which implies a benefit–cost ratio of about 10 to 1. A progressive project evaluation up to the end of 2004–05 assessed the net benefits at A$0.3 million with a benefit–cost ratio of 1.2 to 1. The Improved water-management efficiency of the project will also have longer term environmental benefits by reducing soil degradation from increased salinity levels. The poverty alleviation impacts of this project are discussed later in this report.

Projects involved in research into crops included one in India for capacity building in sorghum production. This impact assessment of this project (Longmore et al. 2007) aimed not only to assess the usual impact but it also considered the contribution that the capacity building elements of the project have made to wellbeing in India and Australia and to other ACIAR projects. The study applied the approach specified in the ACIAR framework for capacity-building evaluation as developed in Gordon and Chadwick (2007) and attempted to contribute to testing and further development of the framework. The results of the impact assessment are presented in Table 2.

Table 2 Results of the benefit–cost analysis under varying discount rates for Sorghum production in India

Discount rate	Present value (PV) of costs A$m	PV of benefits India A$m	PV of benefits Australia A$m	Benefit:cost ratio
1%	2.07	1874	86.9	944.3
5%	1.99	161.8	39.7	100.7
10%	1.91	29.1	15.9	23.6
Internal rate of return			28.07	

Sources: CIE calculations; Australian benefits from Pearce et al.

The study estimated benefits of this project to India were the future improvements in grain production and yields as a result of the new varieties arising from the training received in the biotechnology field. It also stated that as sorghum is often cultivated by poor farmers, an improvement in yield would have a positive economic impact that is expected to lead to significant social impacts. The reduction in the incidence of poverty should lead to better nutrition and considerably improved health outcomes. Some credit-constrained families may also be able to send their children to school when they previously could not afford to, thus leading to greater human capital accumulation.

Another investment by ACIAR in India involved the improved management of white grubs in peanut cropping in the Raichur region of Karnataka state in southern India. The impact assessment of this project (Monck and Pearce 2008) found that the benefits estimated in this assessment amounted to $6.1 million over and above the costs. This gives the project a benefit/cost ratio of 5.7:1 and an internal rate of return of 29%. The authors also specified that should the project findings be extended beyond Raichur, these benefits could be much larger. They found no evidence, however, that the findings had been more broadly adopted. They found that higher incomes form higher peanut yields would lead to social benefits including educational outcomes. However, the lack of data prevented quantification.

3.2 Studies on the poverty impact of individual ACIAR projects

While the economic assessment of ACIAR projects is longstanding and highly developed, the poverty assessment of projects has been more limited and less systematic. Nevertheless, this dimension has been address for a number of specific projects, and some of these assessments are reviewed briefly below.

The water management project in public irrigation schemes in Vietnam mentioned above and assessed in Harris (2006) found that higher incomes resulting from better water management would help to reduce poverty among the farmers who rely on the irrigation schemes. The benefits they estimated were equivalent to an increase in net farm income of between A$29 and A$70 per year.

Farm household poverty is an important issue in Vietnam and many rural families have limited cash incomes and often rely on income supplements from family members with salaried jobs in urban areas. The impact assessment study found that this project would contribute to a reduction in poverty for many farmers who rely on water from the three schemes benefiting from the ACIAR projects.

Survey data collected for the projects indicated that net farm income averages around A$403 in the La Khe system, A$517 in Dan Hoai and A$739 in Cu Chi. The impact assessment thus estimated the poverty-reduction benefits, therefore, to be equivalent to an increase in net farm income of approximately:

- 7% in La Khe system
- 6% in Dan Hoai system
- 10% in Cu Chi system.

The water and nitrogen management project in the North China Plain, also mentioned above, was estimated to lead to an increase in income of between $A50 and $A109 per year (Harris 2004).

ACIAR's impact assessment 35 reviewed the returns to ACIAR's bilateral R&D investments as assessed by 29 studies. It found that the pig feeding and feed research led to increased livestock productivity which would lead to consumer price reductions, which could benefit poorer populations. However, it also indicated that income elasticity of pork meat, although lower than many non-food products, may be higher than many basic staples, such as rice. This meant that the distributional consequences of declines in pork prices were difficult t predict with the data available.

Raitzer and Lindner (2005) also considered a banana skipper bio control in Papua New Guinea. It reported that Bauer et al. (2003) claimed that this research lifted 43,000 people above the poverty line through averted income losses and cost increases. In addition, they found an income increase of 0.9% to 2.2% for 700,000 subsistence banana producers. If these figures were accurate, they appeared to indicate that the total annual research benefits of A$13.4 million for the year of analysis are relatively pro-poor. Given that banana is a subsistence staple crop primarily cultivated by smallholders in Papua New Guinea, it is almost self-evident that benefits should primarily accrue to the poor. The expenditure elasticity for bananas is low, which means that the poor spend proportionally much more of their income on bananas than do the better off. Thus, price reductions accrue primarily to the poor. Furthermore, as production is clearly dominated by subsistence smallholders, producer returns will also primarily accrue to this population.

A collaborative project in Lao PDR with World Vision to extend rice crop yield improvement was assessed in Harris (2011a). The study found that project was also generating some poverty alleviation benefits. Some adopting farmers had increased their rice sales and were earning higher farm incomes. It also reported that household incomes in the project impact area were low and heavily dependent on off-farm income. A survey undertaken by World Vision indicated that the average annual household incomes for the survey respondents were around A$445 in Phalanxai, Outhomphone and Atsaphangthong and around A$550 in Phine, Atsaphone and Xonnabouly.

The primary benefit of the rice extension component of the project had been a significant reduction in rice deficits during the dry season. Household diets had improved and there had been some small poverty alleviation benefits. The WVL survey results provide an indication of the average farm income generated from rice sales:

In Phalanxai, Outhomphone and Atsaphangthong, rice sales were worth A$68, about 15% of household income. In Phine, Atsaphone and Xonnabouly, rice sales were worth A$55, about 10% of household income. The survey results showed that the increased rice output had contributed to a

small increase in commercial rice sales. The extent of poverty reduction was constrained by the limited yield improvements. As the first priority for farmers was food security, the opportunities for sales of surplus rice were minimal. There could be higher poverty alleviation gains if the recommended fertiliser treatments and rice-growing practices were more widely embraced.

An ACIAR project to extend low-chill fruits in northern Thailand was assessed by Harris (2011b). It found that the project had had a small poverty alleviation benefit for the small number of farmers who had established and maintained a low-chill fruit enterprise. The potential income gains from growing low-chill fruits would vary according to the type of fruit trees and their yields. The survey results indicate the income generated by low-chill fruit sales in 2008–09 was limited: In Pang Khon, fruit sales were worth A$274, about 6% of farm income; and in other village areas, fruit sales of A$110 were about 5% of farm income.

Most of the project adopters appeared to treat their low-chill fruit enterprise as a secondary farming activity and other farming activities such as growing coffee, lychees, vegetables and macadamias were more important sources of income.

Poverty alleviation benefits for adopting farmers would improve as the fruit yields increased. But the gains will still be relatively small in comparison to other enterprises. The poverty alleviation benefits for the area of impact were limited by the small number of farmers who ultimately established a low-chill fruit enterprise with new cultivars. Only 22 Pang Khon farmers were growers in 2008–09. In the other village areas, an estimated 28 farmers have continued to produce low-chill fruits.

Overall, while several of the studies have successfully established the standard benefit-cost evaluation, poverty evaluation has been more difficult to estimate. Although some have attempted to estimate the impact on poverty, in many cases the highly aggregated nature of some studies, the limited information available, the problems in establishing baseline measures have made it difficult to measure the poverty alleviation impacts of much of ACIAR research.

3.3 The ACIAR project database

Economic cost/benefits analyses on their own do not provide a basis for poverty assessment because they do not provide information on the different types of economic benefits that projects generate. An important feature of the ACIAR's system is the establishment in recent years of the ACIAR Database for Impact Assessment. This has been set up to provide a repository of project input, output and impact data on all relevant projects. For example, Table 3 details the database categorisation of different types of impacts. Data are also available on types of R&D output, on adoption pathways for R&D and for benefits and costs.

The detailed content of the Database has not been considered in this project to date but, as noted below, this will be an important next step in refining and applying the broad methodology suggested in the next section.

Table 3: Categorisation of impacts from ACIAR projects in ACIAR Database for Impact Assessments

Level 1 Impacts	Level 2 Impacts
Demand	Market access
	Quality improvement
	Perceptions of product (more desirable)
	Other demand-side impacts
Supply	Input costs change – prices or volumes required
	Change in volume per unit (yield)
	Supply-chain management – transaction costs change
	Other supply side impacts
Environment	Waterway health/marine health
	Soil health (erosion, soil nutrients etc)
	Biodiversity (ecosystem health)
	Pollution (air, water, noise)
	Other environmental impacts
Society	Human health and safety
	Community wellbeing
	Community access to resources (basic needs)
	Other social impacts
Risk	Probability of risk
	Cost of risk
	Other impacts on risk

Source: CIE (2009), based on Davis et al (2008)

4. The proposed methodology

The question being addressed here - what will be the impact, in terms of the position of the poor, of a given increase in ACIAR spending on agricultural research? – is, as has already been noted, a forward looking one, while much of the evidence on which an answer would be based is historical, in terms of the outcomes of past projects. The broad methodology that we propose is in two stages (see Chart 1). First, bring the international body of evidence, about the impact of agricultural development and of agricultural research on poverty alleviation, together with what is known about the (primarily economic) outcomes of ACIAR programs, to derive a provisional estimate of the poverty impact of ACIAR's activities to date. Secondly, drawing again on the international evidence about the conditions for most effective poverty alleviation and about the typical characteristics of ACIAR projects, derive an estimate of the poverty impact that could be achieved by an additional round of projects closely targeted on the alleviation of poverty.

There will be many challenges to the more detailed specification and implementation of this methodology. While there is strong evidence of the direct effect of agricultural development on poverty and of the link between agricultural research on poverty alleviation, in both cases the relationships are complex and influenced by many industry, institutional and other factors, as well as by the nature of research undertaken. In particular, while aggregate measures are available, the recent literature emphasises the highly nuanced and context dependent nature of the agricultural R&D/poverty link. Issues of the adoption of new technologies and other innovations are critical but are also affected by a wide range of factors.
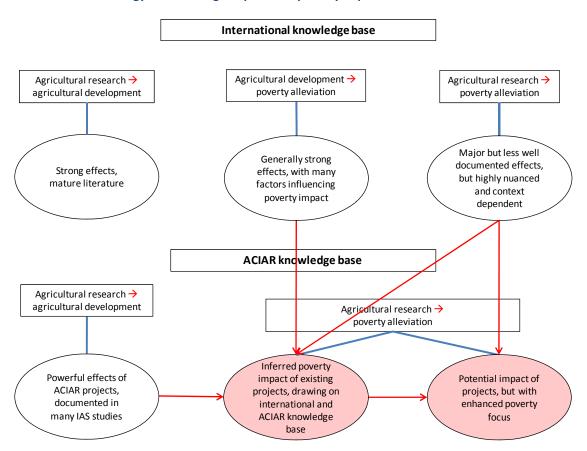
Chart 1: A methodology for assessing the potential poverty impact of ACIAR activities

Nevertheless, there are grounds for optimism about both the future impact of well-targeted agricultural research on poverty in developing countries and the likelihood of being able to derive a reasonably robust estimate of that impact for ACIAR projects through this methodology. The various factors driving the emergence of a renewed role for agriculture in development strategies will tend to enhance the impact of well-designed agricultural research programs. These include the continued concentration of the global poor in rural areas, and the rising inequality between urban and rural populations; increasing concerns about food security, in large part arising from increased demand from urban populations; and high and perhaps rising food prices. Rising food prices both threaten the poor, because they impact sharply on the most vulnerable, but also mean that bigger increases in rural incomes can be achieved by R&D programs that increase supply in the face of rising demand and prices.

The next step in defining and implementing such as strategy is seen as undertaking a detailed analysis of the ACIAR Database for Impact Assessment, to determine in particular the forms of impact, pathway and benefit data available on that system. Once that information is documented, the two bodies of international literature reviewed in sections 2.1 and 2.2 need to be revisited in detail, to determine appropriate relationships that can be applied to the particular variables that most descriptive of existing ACIAR projects to date. It is envisaged that this will give rise to a range of partial poverty impacts, specific to particular project types, contexts and adoption profiles. This will then provide the basis for an analysis of the potential poverty impact of ACIAR closely targeted to poverty outcomes, and hence to addressing the conditions in which such impact can be maximised.

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