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Final Report

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2 Executive summary

Given the need for international food security and poverty reduction to be supported by agricultural policy settings based on comparative production advantage, rather than on self-sufficiency principles, this project and its predecessor projects represent a major commitment by the Australian Centre for International Agricultural Research (ACIAR) to assisting in the modernisation of India's agricultural policy settings.

Previous projects found that for India to enjoy positive growth and employment opportunities associated with agricultural trade liberalisation, domestic agricultural policy reforms were required that enable more direct price transmission between consumers and producers. An important next step in this series of projects was therefore to introduce a contemporary, market failure based, public policy framework that could be used to identify those agricultural policy settings that are unnecessarily impeding price transmission in India's agricultural supply chains.

In this latest project in the series, collaborators moved to quantify the benefits from reforming India's agricultural subsidies, with benefits in the form of changed and more efficient production patterns and reductions in agriculture's greenhouse gas (GHG) emissions. Importantly, this work has significantly contributed to opening a high-level policy dialogue around how a subsidy reform pathway might be structured.

Collaborators then sought to strategically introduce the prospect of a new agricultural policy initiative in the form of a carbon offset scheme, whereby Indian agriculture might sell carbon mitigation services to India's large GHG point source emitters. Such programs could assist in the reform of existing subsidies by supplementing farm incomes and could position agriculture to play a positive role in reducing the cost of India's national GHG abatement effort. A key further project outcome was collaborative project research that confirmed the existence of demand and supply conditions supportive of a viable carbon offset market.

The project provided some key findings across the following four major areas

- influence of national policy settings in India and Australia on agricultural emissions.
- benefits that agricultural offsets could provide to energy and industry sectors in India.
- scope for cost effective emission abatement within India's agricultural sector.
- the economy-wide effects of agricultural subsidies related to the level of greenhouse gas emissions

The project assessed the **influence of policy settings on agricultural emissions** and found some examples of policies and actions that lead to unintended emissions. The Indian government has been providing agricultural subsidies on inputs including seeds, fertilisers, power and water to meet its policy objectives. However, lower prices for these inputs have naturally encouraged over use and reduced efficiency. These same policies have also inadvertently encouraged high emission production activities and the use of energy-intensive inputs. In contrast, Australian agriculture generally operates in largely a deregulated setting meaning that climate specific policy levers like carbon pricing and offset schemes are needed to bring about mitigation in the agricultural sector. Both Australia and India could benefit however, from R&D that develops more sustainable practices and systems that improve both productivity and lower emissions.

The project explored the extent of **benefits that agricultural offsets could provide to energy and industry sectors in India**. The marginal abatement costs facing India's energy and industry sectors were assessed. While these costs can vary widely, depending on the particular technology in question, they were in many cases much higher than the cost at which GHGs can be abated or sequestered in agriculture. Indeed, India's large point source emitters have the option of purchasing Solar Renewable Energy

Certificates as a mitigation option at that price of INR5000 per tonne CO2e (or approximately $75US). If this is taken as an upper limit on the price of feasible mitigation technologies available to the energy and industry sectors, the essential conditions for the establishment of a viable agricultural offsets market in India exist.

The third area of major focus was to assess the **scope for cost effective emission abatement within India's agricultural sector and the economy-wide impacts of mitigation**. The extensive modelling undertaken found the existence of significant low cost abatement and sequestration opportunities within Indian agriculture. This supported the results of an earlier IFPRI study but drew on more robust analytical methods funded through the project. While opportunities typically exhibit wide regional variation, there is a significant margin between the level of abatement costs in agriculture compared to those in the industry and energy sectors. In terms of targeting future government programs for maximum gain however, it is also clear that policies should pay particular attention to target areas and practices that are best suited to deliver the mitigation service e within and across states given the extent of regional variation.

Some particularly important results from this project research are contained in the following table. Results are provided for three levels of a potential government program budget and the cost per ton of CO2e abated is found to be small and well under US$1 per ton. The economic potential for climate change mitigation is significant with some 45 million tons of CO2eq being available, representing about 13 percent of the annual GHG emissions from agriculture.

Alternative policy approaches were assessed in the form of a per hectare payment in exchange for changes in farm practices, versus a more direct payment for the actual amounts of CO2e mitigated. The analysis found that for a yearly payment of US$2 per hectare, around 12 million hectares transition to alternative practices for a cumulative yearly reduction in global warming potential (GWP) of about 46 million tons of CO2eq. With required expenditures of about 25 million US$ per year, this equated to a cost per ton of CO2eq abated of US$0.54. The effects of an equivalent payment per ton of CO_2e abated generated similar results and overall the findings were found to reinforce the idea that there is a core amount of land with high mitigation potential, achievable at a very low cost.

Table 1: Effects of alternative budget allocation to mitigation efforts in food-crop production

	Total Implementation Cost					
	Per hectare compensation			**Per ton of CO_2eq compensation**		
	10 Million US$ yr^{-1}	20 Million US$ yr^{-1}	50 Million US$ yr^{-1}	10 Million US$ yr^{-1}	20 Million US$ yr^{-1}	50 Million US$ yr^{-1}
Total GWP reduction ($TgCO_2eq\ yr^{-1}$)	45.2	46.1	48.0	45.6	46.4	48.8
Implicit price per Mg carbon sequestered (US$ $MgCO_2eq^{-1}\ yr^{-1}$)	0.22	0.43	1.41	0.22	0.43	1.02
Total Area Converted to Alternative Practice (Million ha)	11.9	12.2	13.2	11.0	12.0	12.7

GHG mitigation arising from direct farmer payments was also compared with potential GHG mitigation arising from the adoption of different irrigation practices triggered by

changes in the price of diesel and electricity. While there was limited response to changes in diesel prices, a 100 percent increase in the electricity price reduced water use by more than 8 percent and CO2e emissions by 14 percent, but had limited effect on the extent of crop production. Hence, a reduction in electricity subsidies can trigger reductions in CO2e emissions, improve energy and water use efficiency whilst leaving crop production basically unchanged.

The more aggregated country-wide analysis of mitigation was supplemented with two regional case studies to provide a more detailed assessment of the scope for abatement/sequestration under alternative policy settings. Results of this downscaled analysis support the findings of the country-wide analysis confirming that there is a high potential for cost effective reduction of emissions in land allocated to crop production. The state-wide analysis found an average price of $US0.6 and $US3.1 per abated ton of CO2e for the states of Punjab and Bihar, respectively. Local conditions influence the cost of reducing emissions and more opportunities for mitigation were found in Punjab relative to the State of Bihar.

Overall, this third area of the project demonstrated that there are significant opportunities for cost-effective mitigation of GHGs in Indian agriculture. These opportunities lay both in agricultural management practices alternative to the status quo, and in a reduced use of irrigation pumps. Reductions in subsidies to rural electric use for agriculture would discourage the use of electricity for extraction of groundwater from deep aquifers with a consequent reduction in emissions. Among the analysed alternative agricultural practices, 'No-till' appears to be the one that provides a relatively inexpensive mitigation service. However, the benefits provided by this practice can be quickly lost if farmers return to ploughing and to using conventional practices. The use of relatively long-lasting contracts could be necessary that would greatly influence the implementation costs of a plan that incentivizes the adoption of such practice. The adoption of the 'Alternate Wet and Dry' (AWD) management practice does not suffer from this problem, as the benefits cannot be undone when dealing with a direct reduction in GHG emissions. AWD substantially reduces methane emissions from irrigated rice with a reduction in yields, which could be compensated with an environmental service payment.

Through the development of a new Computable General Equilibrium Model (CGE) model, a fourth major area for the project involved **preliminary modelling of the economy wide impacts of agricultural input subsidies linked to emission levels.** Initial work found that agricultural subsidies are worth about 2.5 per cent of GDP, with about one third being subsidies on inputs of fertilizer and electricity to agricultural industries and about two thirds being subsidies on production and sales of agricultural products. Agricultural subsidies were found to inflict a GDP dead-weight loss of about 0.20 percent, most of which is associated with subsidies on fertilizer and electricity.

Agricultural output was found to be about 2.3 percent greater with subsidies than without and they were found to increase output and exports of cotton textiles, edible oil, woollen textiles, khadi and apparel, but reduced output and exports of communication equipment, non-ferrous metals and computer services. About 20 percent of fertilizer output and 7 percent of electricity output depend on agricultural subsidies.

All of the current agricultural subsidies contribute positively to food security. The subsidies reduce food prices relative to the CPI by about 7 percent and increase food consumption by about 0.7 percent. However, food security and farm income goals could be achieved more efficiently by replacing input-based fertilizer and electricity subsidies with output-based production and sales subsidies. Under this scenario, model results indicate that real farm income would be increased by about 4 percent with no deterioration in the public sector budget, almost no effect on food security, and small increases in GDP and overall welfare.

This latest project also achieved outcomes that went beyond its initial aims and objectives. From a capacity building perspective, Victoria University (VU) worked closely with India's

National Council of Applied Economics (NCAER) to develop a new CGE model of the Indian Economy. The initial NCAER-VU Model was then used to assess the gains from agricultural subsidy reforms; however, it also represents a significant ongoing project legacy which provides exciting possibilities for NCAER to assess policy reform opportunities more broadly within the Indian economy. This collaborative partnership between NCAER and VU resulted in the two institutions entering into an MOU together focused on further model development, training in CGE modelling and broader model application.

Overall this series of projects has made a strong contribution to enhancing India's agricultural policy reform capability. A market based public policy reform framework has been established, reform priorities have been identified and the tools by which reform gains can be quantified have been developed. These contributions will play a lasting role in facilitating the open and transparent analysis and discussion of India's agricultural reform options. In so doing, they will help guide Indian agriculture on a pathway toward its natural comparative production advantages, sustainable growth and commensurate gains in poverty reduction.

3 Background

There is ongoing international concern that agriculture in many emerging economies remains subject to regulation that is impeding market led growth and thereby resulting in lost development opportunities and persistent rural poverty. Regulation of agriculture often remains focussed solely on achieving food self-sufficiency objectives, thus constraining access to the gains from international trade. Also at a time of growing concern about climate change, much of this regulation continues to encourage emissions intensive production systems.

This project and its predecessor projects therefore represent a focussed effort by Indian researchers and international collaborators to assist Indian policy makers modernise the regulatory framework that applies to Indian agriculture.

Key objectives of this 3 year ACIAR supported project were therefore to identify agricultural policy reforms that would increase sectoral efficiency, inter-sectoral linkages and reduce agricultural GHG emissions and to subsequently consider new programs targeted at the early exploitation of cost effective GHG abatement options within Indian agriculture.

Project collaborators included India's National Council of Applied Economic Research (NCAER), the NSW Department of Trade and Investment (DTI), India's Infrastructure Development and Finance Corporation (IDFC), Monash University, Victoria University, and the International Food Policy Research Institute (IFPRI).

This project is the latest in a series of projects focussed on agricultural policy reform in India. Previous projects included:

- ADP/2002/089 titled 'Agricultural Trade Liberalisation and Domestic Market Reforms in Indian Agriculture'; and
- ADP/2007/062 titled 'Facilitating Efficient Agricultural Markets in India: An Assessment of Competition and Regulatory Reform Requirements'.

Within this overall framework, an important issue addressed in the latest project was the extent to which broader policy reform in India's agricultural sector, relating to input and output price-subsidy policies, may contribute to national emissions reduction targets. However, the project was also seen as also offering a strategic opportunity to assist in refocusing farm-level assistance away from subsidies and toward service payments.

The first of the previous projects identified the need for significant domestic or 'behind the border' reforms if the gains from international and domestic market reform were to deliver on the government objectives of improved productivity, higher rural employment and incomes and enhanced food security.

The second project successfully established a contemporary 'market failure' based public policy framework with which 'behind the border' agricultural policy reforms could be identified and prioritised. Key regulatory impediments identified that are impeding competition and price transmission within India's agricultural supply chains included aspects of (i) input and output subsidies; (ii) regulated wholesale markets; and (iii) the activities of the Food Corporation of India.

The results from the second project were so well received that the Chief Economic Advisor to the Government of India at the time, Prof Kaushik Basu and senior Indian Government officials made a special request to the research team to undertake a study on the sharp price fluctuations of the Indian onion market. A report on the onion market showing the impact of poorly based regulatory interventions was subsequently prepared.

The current project was conceived as an extension of the previous work on policy reforms and built on that by strategically revisiting the issue of agricultural policy reforms by

quantitatively assessing the impacts of subsidy reform on both the conventionally measured economy-wide resource use efficiency gains, and the reductions in greenhouse gas emissions that would also be achieved as a result of changes in agricultural production patterns and practices.

Given the need for Indian agriculture to transition away from subsidy support and to consider new production and market opportunities, a further project element was to consider the potential viability of a carbon market whereby agriculture might become a provider of low cost carbon offsets to other emitting sectors of the Indian economy.

In considering these issues, key collaborator roles were:

- NCAER, Victoria University and Monash University building a new general equilibrium model of the Indian economy with which to quantify the gains from subsidy reform. This represented a major undertaking, but resulted in a significant lasting legacy that will enhance India's policy analysis capability for the foreseeable future.
- IFPRI similarly contributed a major enhancement in modelling capacity by working with the project team to add extensive further specification to their suite of IMPACT models which has now allowed potential emissions reductions from agriculture to be quantified.
- In terms of the work undertaken on a potential carbon offsets market, India's IDFC worked with DTI to undertake detailed analysis of the marginal GHG abatement cost currently facing India's large industrial point source emitters in order to identify the price below which agriculture would be required to provide offsets in order to make an offsets market viable.

The overall success of the project was reflected in the outcomes of the final Project Workshop in Delhi in April 2015, titled "**The Future of Indian Agriculture: Policy Options for Competitive, Inclusive and Sustainable Growth",** where the Secretary of the Ministry of Agriculture requested that further research be undertaken on agricultural subsidy reform at the state level, on other regulatory impediments to inter-state trade and on risk management options for the farm sector.

4 Objectives

Objective 1: Understand how national policy settings in India and Australia may have influenced agricultural emissions.

Activity 1.1 Review agricultural policies in India that may be encouraging high agricultural emissions.

Part 1 of Milestone 1 - Report describing agricultural policies, suggested reforms and linkages to emissions.

Activity 1.2 Qualitatively assess the timing and extent to which agricultural policy reforms may reduce emissions from the agricultural sector.

Part 2 of Milestone 1 - Report describing agricultural policies, suggested reforms and linkages to emissions.

Activity 1.3 A desktop review of policy settings influencing emissions of the Australian agricultural sector.

Part 3 of Milestone 1 - Report describing Australian policies.

Objective 2: Assess international GHG policy settings and the benefits that agricultural offsets could provide to energy and industry sectors in India.

Activity 2.1 Given India's commitment to GHG emission reduction targets, review developments in GHG policy settings in other countries.

Milestone 2 - Report describing alternative GHG policy settings to reduce emissions – an international survey.

Activity 2.2 Review available estimates of marginal abatement costs within the energy and industry sectors in order to establish the economy-wide importance of finding low cost abatement opportunities.

Milestone 3 - Report on marginal abatement costs within India's energy and industry sectors.

Objective 3: Evaluate the scope for cost effective emissions abatement within India's agricultural sector and the economy-wide impacts of an agricultural offsets policy.

Activity 3.1 Identify technologies and management systems that can deliver carbon sequestration and agricultural emissions reductions cost effectively.

Part 1 of Milestone 4 - Report outlining changed specifications.

Activity 3.2 Revise IMPACT with improved estimates for existing modelled technologies and management systems.

Part 2 of Milestone 4 - Report outlining changed specifications.

Activity 3.3 Broaden the coverage of IMPACT to include methane emissions from livestock and soil carbon sequestration potential.

Part 3 of Milestone 4 – Report outlining changed specifications.

Activity 3.4 Assessment of the scope of agricultural mitigation under alternative carbon prices, policies and investment scenarios.

Milestone 5 - Report on scope of mitigation in India's agricultural sector.

Activity 3.5 Undertake one or more regional case study(s) to provide more detailed assessment of the scope for abatement/sequestration under alternative policy settings.

Milestone 6 - Report containing the results of the case study(s).

Activity 3.6 Assessment of the economy-wide effects of reforming agricultural policy settings and the introduction of an agricultural offsets scheme on agricultural productivity, food security, rural incomes, employment, trade and emissions.

Milestone 7 - Report on reforms to be modelled, modelling approach and specification.

Milestone 8 - Report on economy-wide effects of reforming agricultural policy settings and the introduction of agricultural offsets.

Objective 4: Assess alternative policy designs and institutional arrangements that can efficiently deliver GHG mitigation by agricultural sectors in India and Australia.

Activity 4.1 Investigate alternative policy designs for the carbon offset scheme that can efficiently achieve abatement while meeting monitoring, reporting and verification demands.

Milestone 9 - Report describing the design of an agricultural offsets program.

Key considerations include issues of leakage, additionality and permanence, systems for reporting, monitoring and verification, constraints on small scale landholders and the merits of action-based versus outcome-based contracts. Experimental economics will be used to test alternative policy designs.

5 Methodology

This project builds directly on two related ACIAR projects:

- ADP/2007/062 '*Facilitating Efficient Agricultural Markets in India; An Assessment of Competition and Regulatory Reform Requirements; and*
- ADP/2002/089 '*Agricultural Trade Liberalisation and Domestic Market Reforms in Indian Agriculture'*.

Project ADP/2002/089 identified the need for 'behind the border' reforms to agricultural policy if India's farm sector is to enjoy the benefits from trade liberalisation and Project ADP/2007/062 identified a range of legislative and program interventions in Indian agriculture that are impeding price transmission in India's agricultural supply chains. They were found to include aspects of: (i) input and output production subsidies; (ii) regulated wholesale agricultural marketing arrangements; and (iii) the grain sourcing, storage and distribution activities of the Food Corporation of India.

The current project was therefore designed to provide a further opportunity to strengthen the case for agricultural policy reform by seeking to quantify the efficiency gains and emissions reduction benefits from the reform of agricultural subsidies, and then to assess the viability of a more contemporary form of agricultural policy intervention in the form of an agricultural carbon offset program.

As well as helping to address the contemporary policy challenge of national emissions reduction, the project therefore also offered a strategic opportunity to assist in refocussing farm-level assistance away from input and output subsidies and toward incentive payments which might supplement farm incomes and encourage less emission intensive farming practices.

The project was designed with the following four key objectives:

- Objective 1: Understand how national policy settings in India and Australia may be influencing agricultural emissions.
- Objective 2: Assess international GHG policy settings and the benefits that agricultural offsets could provide to energy and industry sectors in India.
- Objective 3: Evaluate the scope for cost effective emission abatement within India's agricultural sector and the economy-wide impacts of an agricultural offsets policy.
- Objective 4: Assess alternative policy designs and institutional arrangements that can efficiently deliver GHG mitigation by agricultural sectors in India and Australia.

Objective 1 was designed to familiarise the project team with key concepts associated with agricultural GHG emissions, such as the particular emissions associated with certain production practices and how government policy settings (i.e. production subsidies), may be inadvertently leading to increased emissions.

India's NCAER was strategically well placed to lead the review of Indian agricultural policy setting likely to be increasing GHG emissions, while the NSW Department of Trade and Investment was well placed to lead the review of Australian agricultural policy settings. Importantly, the Indian component of this work then set the scene for subsequently analysing agricultural subsidy reform in greater detail, as part of Objective 3.

An important concept emphasised at this stage of the project, that also underpins the overall project design, was an appreciation by the project team and other stakeholders that an efficient government strategy aimed at emissions reduction was likely to be one that first considered the reform of emissions 'increasing' agricultural policy settings, before

moving to positively reward emission reducing production practices through new government initiatives such as a carbon offset program.

Objective 2 then involved exposing the project team to the latest international developments in GHG policy, with emphasis on the treatment of agriculture. This work served to highlight the general international agreement that has emerged regarding (i) the difficulties associated with regulating agricultural emissions directly, but (ii) the growing interest in positioning agriculture to play a very positive role in reducing the cost of national emissions abatement efforts by becoming a provider of low cost abatement opportunities for other emitting sectors of an economy.

This research was led by India's Infrastructure Development and Finance Corporation given its strong interest in identifying low cost GHG compliance options for key infrastructure and service providers within the India's economy, such as the energy and industry sectors. This work helped to confirm that a number of countries have arrangements in place whereby large point source emitters are offsetting their emissions by investing either directly, or through intermediaries, in agricultural activities that abate or sequester carbon.

At this early stage of the project, IDFC were also tasked with reviewing India's existing renewable energy and energy efficiency programs to assess how they might be modified to accommodate an agricultural offsets program. To this point in the project the research methodology was therefore designed to:

- provide project collaborators with a shared understanding of agricultural GHG emissions and their linkages to agricultural policy;
- provide collaborators with a shared understanding of international efforts to consider the role of agriculture in emissions reduction; and
- identify how India might accommodate an agricultural offsets program within its existing energy policy framework.

Not only did this work build awareness and a shared understanding within the project team, but it also provided the basis to build a broader understanding of these issues among key stakeholders, such as Indian policy makers.

A further important element of project methodology was to hold an annual series of high-profile project workshops in India and Australia, where research finding could be presented and discussed and whereby Indian policy makers could be engaged and feel a sense of ownership in the project and its outcomes.

A Project Steering Committee comprised of eminent Indian academics and policy makers was also established to progressively consider the findings of research and to ensure that project direction was consistent with the interests of the Indian government. This advice proved invaluable, as reflected in advice in the final year of the project that, at this time, the Indian Government had a stronger interest in modelling state level subsidy reform, relative to modelling the impact of a carbon offset scheme.

While Objective 2 focussed on researching the 'demand side' of a potential carbon offsets market, Objective 3 focussed on research that investigated the 'supply-side' of a carbon market. In other words, the focus of the Objective 3 research was on agriculture and the potential for changed agricultural production practices that involved carbon abatement or sequestration. An important further element of this work was to establish the additional returns (or payments) that farmers would need in order to adopt those changed production practices.

The International Food Policy Institute (IFPRI) led this work given its widely acknowledged expertise in modelling international food production, supported by its suite of IMPACT models, and its extensive network of on-ground research staff in India. In order to undertake the country-wide analysis of Indian agriculture's carbon abatement and sequestration potential, IFPRI undertook extensive enhancements to its IMPACT models

in terms of updating key agricultural production parameters and deriving emissions estimates for a range of production activities.

Using the updated suite of IMPACT models, IFPRI in collaboration with project partners, was then able to conduct a country-wide assessment of Indian agriculture's emissions abatement and sequestration potential. This research was then refined by way of case studies in Punjab and Bihar which provided a more detailed assessment of particular faming practice changes and the associated incentive payments that would be required.

Having established that the broad demand and supply conditions exist that would potentially support a viable agricultural offsets market in India, the project methodology then sort to quantify the economy-wide benefits of (i) reforming agricultural subsidies; and (ii) adopting a carbon offsets program. These benefits would be in the form of Indian agriculture moving to a more sustainable pattern of agricultural production, and a lowered cost of India's national emissions abatement effort. As with any significant and sensitive policy reform proposals, this component of the project was not designed to produce prescriptive policy recommendations, but rather was designed to generate objective information about reform costs and benefits that would facilitate broader public discussion about this important issue, and in so doing, further the case for reform.

Methodologically, it was considered important that this quantitative research be led by NCAER using its CGE of the Indian economy in collaboration with Australian CGE modelling experts at Victoria and Monash Universities. Having NCAER lead this collaboration was considered more likely to achieve meaningful engagement with Indian policy-makers.

An unplanned project outcome, however, was a proposal by Victoria University (VU) (Peter Dixon and Maureen Rimmer) to work with NCAER (Rajesh Chadha) to build a completely new CGE model of the India economy. Ultimately this partnership evolved into an MOU between VU and NCAER to further develop NCAER's modelling and policy analysis capabilities.

Finally, further more detailed case study work lead by IFPRI regarding agricultural emissions abatement and sequestration potential in Punjab and Bihar was designed to 'dove-tail' with Objective 4, by helping to identify those regions where the NSW Department of Trade and Investment would undertake on-ground 'experimental economics' research to help answer the question of "what policy design and institutional arrangements might efficiently deliver GHG mitigation by India's agricultural sector". In other words, what would be the design features of an on-ground agricultural offsets program?

The work under Objective 4 aimed to investigate the types of contracts (commercial arrangements) farmers might be prepared to enter into in order to change farming practices for the purpose of abating or sequestering higher levels of carbon than they would otherwise find profitable. This work is necessary to underpin any future of on-ground carbon offset trial, where small groups of farmers were offered real financial payments to change production practices.

In summary, the project methodology as reflected in the project's four objectives, was therefore designed to enable a logical sequence of collaborative research to be undertaken that moved through:

- developing an understanding of GHG emissions and linkages to agricultural policy;
- demonstrating the 'in-principle' viability of an agricultural offset program;
- understanding how a carbon offset program might be accommodated within India's existing regime of renewable energy and energy efficiency programs;
- measuring the benefits of agricultural subsidy reform; and

- finally, an assessment of policy designs to underpin future carbon offset trials aimed at directly encouraging mitigation in agriculture.

It is important to note that the overall research methodology was consistent with the previously mentioned principle that, “an efficient government strategy aimed at emissions reduction should first consider the reform of emissions ‘increasing’ agricultural policy settings, before moving to positively rewarding emission reducing production practices through new government initiatives such as a carbon offset program”. This was achieved by maintaining a strong focus of agricultural subsidy reform as a way of not only increasing the broader efficiency of India’s agricultural sector, but also as the preferred initial strategy for reducing sectoral emissions.

This explains why emphasis was placed on modelling the benefits of subsidy reform at the expense of more quickly moving to more direct approaches like the implementation of an on-ground carbon offset program. Indeed previous work supported by ACIAR (CSE/2006/132 - “Policy Instruments to Address Air Pollution Issues in Agriculture – Implications for Happy Seeder Technology Adoption in India”) showed that changes in agricultural subsidies can have a positive influence on the gains from adoption of more sustainable production technologies that lower emissions. This ongoing emphasis on agricultural subsidy reform also proved to be consistent with the priorities of the Indian Government.

6 Achievements against activities and outputs/milestones

Objective 1: Understand how national policy settings in India and Australia may be influencing agricultural emissions.

no.	activity	outputs/ milestones	completion date	comments
1.1	Review agricultural policies in India that may be encouraging high agricultural emissions.	Part 1 of Milestone Report 1 describing agricultural policies, suggested reforms and linkages to emissions. NCAER & DTIRIS	2013	Completed (see Section 4).
1.2	Qualitatively assess the timing and extent to which agricultural policy reforms may reduce emissions from the agricultural sector.	Part 2 of Milestone Report 1 describing agricultural policies, suggested reforms and linkages to emissions. NCAER & DTIRIS	2013	Completed (see Section 4). Note that NCAER combined activities 1.1 and 1.2 into a single report.
1.3	A desktop review of policy settings influencing emissions of the Australian agricultural sector.	Part 3 of Milestone Report 1 describing Australian policies. NCAER & DTIRIS	2013	Completed (see Section 4).

PC = partner country, A = Australia

Objective 2: Assess international GHG policy settings and the benefits that agricultural offsets could provide to energy and industry sectors in India.

no.	activity	outputs/ milestones	completion date	comments
2.1	Given India's commitment to GHG emission reduction targets, review developments in GHG policy settings in other countries.	Milestone 2 Report describing alternative GHG policy settings to reduce emissions. IDFC & DTIRIS	2013	Completed (see Section 4).

2.2	Review available estimates of marginal abatement costs within the energy and industry sectors in order to establish the economy-wide importance of finding low cost abatement opportunities.	Milestone 3 Report on marginal abatement costs within the energy and industry Sectors. IDFC & DTIRIS	2014	Completed (see Section 4).

PC = partner country, A = Australia

Objective 3: Evaluate the scope for cost effective emission abatement within India's agricultural sector and the economy-wide impacts of an agricultural offsets policy.

no.	**activity**	**outputs/ milestones**	**completion date**	**comments**
3.1	Identify technologies and management systems that can deliver carbon sequestration and agricultural emissions reductions cost effectively.	Part 1 of Milestone 4 Report. IFPRI	2013	Completed.
3.2	Revise IMPACT with improved estimates for existing modelled technologies and management systems.	Part 2 of Milestone 4 Report. IFPRI	2013	Completed.
3.3	Broaden the coverage of IMPACT to include methane emissions from livestock and soil carbon sequestration potential.	Part 3 of Milestone 4 Report. IFPRI	2013	Not completed – data unavailable.
3.4	Assessment of the scope of agricultural mitigation under alternative carbon prices, policies and investment scenarios.	Milestone 5 Report on scope of mitigation in the agricultural sector. IFPRI	2014	Completed. Note that IFPRI combined activities 3.1-3.4 into a single report.

3.5	Undertake one or more regional case study(s) to provide more detailed assessment of the scope for abatement/sequestration under alternative policy settings.	Milestone 6 Report containing the results of the case study(s). IFPRI	2014	Case study results for Punjab and Bihar presented at final project workshop in Delhi in 2015. Report write-up being finalised and expected by end September 2015.
3.6	Assessment of the economy-wide effects of reforming agricultural policy settings and the introduction of an agricultural offsets scheme on agricultural productivity, food security, rural incomes, employment, trade and emissions.	Milestone 7 Report on reforms to be modelled, modelling approach and specification. Milestone 8 Report on economy-wide effects of reforming agricultural policy settings and introduction of agricultural offsets. NCAER, Victoria University, Monash University, IFPRI	2015	Given opportunity and desire of NCAER and VU to create a new CGE model of the Indian economy, more resources were devoted to model construction than originally planned. Preliminary analysis of subsidy reform completed. Analysis of gains from an agricultural offset scheme will be completed in second half of 2015. The focus on subsidy reform emerged as being of greater interest to the new Indian government, relative to the modelling of a carbon offset program.

PC = partner country, A = Australia

Objective 4: Assess alternative policy designs and institutional arrangements that can efficiently deliver GHG mitigation by agricultural sectors in India and Australia.

no.	activity	outputs/ milestones	completion date	comments
4.1	Investigate alternative policy designs for the carbon offset scheme that can efficiently achieve abatement while meeting monitoring, reporting and verification demands. Key considerations include issues of leakage, additionality and permanence, systems for reporting, monitoring and verification, constraints on small scale landholders and the merits of action-based versus outcome-based contracts. Experimental economics will be used to test alternative policy designs.	Milestone 9 Report describing policy design. DTIRIS & IFPRI	2015	Preliminary work on contract design commenced. Approval granted to take this component of the project forward into 2015-16 as a separate, small, ACIAR project.

PC = partner country, A = Australia

7 Key results and discussion

Objective 1: Understand how national policy settings in India and Australia may have influenced agricultural emissions

Milestone 1 Reports relating to this objective include:

1. GHG Emissions: Indian Agricultural Policy Settings (lead, NCAER).

2. A Review of Policy Settings Influencing Emissions of the Australian Agricultural Sector (lead, NSW Department of Trade & Investment).

The first report addressed Activity 1.1 (Review agricultural policies in India that may be encouraging high agricultural emissions) and Activity 1.2 (Qualitatively assess the timing and extent to which agricultural policy reforms may reduce emissions from the agricultural sector).

This report, completed in 2013 and updated in 2015, enabled the project team to gain a shared, early stage understanding of agricultural GHG emissions and how agricultural policy settings can inadvertently increase emissions. The report on India also helped to identify those agricultural policy reforms that would subsequently be evaluated within the economy-wide CGE modelling framework.

The second report addressed Activity 1.3 (a desktop review of policy settings influencing the emissions of the Australian agricultural sector). It summarises Australian agricultural policy settings likely to be promoting sectoral emissions. It also provides a 'market failure' based framework which was used to assess the efficiency of policy settings. Where agricultural policies were found not to be addressing an accepted form of market failure, they were considered likely to be encouraging higher and questionable levels of GHG emissions. This policy framework remains relevant to any current assessment of international agricultural policy reform priorities.

The agricultural policy settings in Australia stand in some contrast to policy settings in India. This is not to suggest that Australia's policy settings represent a model that India should aim to replicate even in the longer term. The differences do suggest, however, that there should be a very different focus when it comes to achieving mitigation in the agricultural sectors of each country.

Other supplementary reports completed for Milestone 1 include:

3. Capturing the Potential for Greenhouse Gas Offsets in Indian Agriculture, World Bank Workshop on Assessing Environmental Challenges (NCAER); and

4. Review of Policy and Legal Frameworks Impacting GHG Policy Settings in India (lead, IDFC).

The first of these reports by NCAER was a conference paper that provided an important opportunity to discuss the project and the issue of agricultural policy linkages to GHG emissions at an international forum.

The second report led by IDFC and completed in 2013, provides detailed information on India's GHG reduction targets and its renewable energy and energy efficiency policy settings. Of key interest to the project team was how these arrangements might accommodate an agricultural offsets program, and so allow India's large point-source GHG emitters in the energy, cement and steel sectors to potentially access low cost, carbon abatement from India's agricultural sector.

To address this issue, IDFC worked closely with NSW DTI to consider possible modifications to India's existing regulatory framework applying to renewable energy and energy efficiency. They also considered how some of India's existing statutory funds could be broadened in their purchase options to include agricultural offsets.

In terms of India's regulatory framework that is designed to encourage renewable energy and energy efficiency, this collaborative research effort found some of the major initiatives as being:

(i) Renewable Purchase Obligations (RPOs);

(ii) Renewable Energy Certificates (RECs);

(iii) Preferential tariffs for renewable energy resources; and

(iv) Industrial Energy Consumption Benchmarks.

It was found that while India does not have GHG specific regulation, the existing legislative framework for the regulation of emissions into the atmosphere under the *Environment Protection Act* and the *Air Act,* including the process for Environmental Clearances under the EPA, appear to provide some policy and regulatory space for GHG regulation in India.

It was found that the direct regulatory powers under which GHG emissions could be controlled are as follows:

- The Environment Protection Act empowers the Central Government to take steps to abate environmental pollution.
- The Central Government can specify GHG standards under the Environment (Protection) Act and can establish a nation-wide program for the prevention, control and abatement of environmental pollution, including a mandatory system for regulating GHG emissions.
- The Air Act empowers the Central Pollution Control Board to advise the Central Government on control of air pollution, and to plan and execute a nation-wide program for the abatement of air pollution. Similarly, the State Pollution Control Boards can also plan and implement comprehensive programs for abatement of air pollution. Thus, the Central or State Pollution Control Boards could use their powers under the Air Act to implement mandatory GHG reduction programs.
- The National Ambient Air Quality Standards notified by the Central Pollution Control Board under the Air Act already specify emission standards for identified pollutants. This list of identified pollutants could be expanded to include GHG emissions.
- The State Boards, while assessing applications for setting up or operating industrial plants, have the power to impose any condition as a requirement for the grant of consent. The Act also provides that no person operating any industrial plant, in any air pollution control area, shall discharge the emission of any air pollutant in excess of the standards laid down by the State Board. The Boards, while exercising their powers and performing their functions, also have the power to issue any binding directions to any person, officer or authority.
- While granting consent to operate under the Air Act, State Pollution Control Boards could consider mandating the offsetting of GHG emissions as a condition. In this context, it is useful to note of the practice in the State of Connecticut, where the authority granting approval for construction of a new air contaminant source has the power to require, as an approval condition, the planting of trees or turf grass to offset carbon dioxide emitted into the atmosphere from the air contaminant source.

It was also noted that with respect to environmental clearances, that the Indian government has initiated steps to include corporate environment responsibility as a part of the process of obtaining and maintaining environmental clearances. Hence, there is potential to introduce an agricultural offset mechanism as a further option in meeting those corporate responsibility requirements by mandating conditions for certain types of climate-friendly agricultural activities.

In terms of market based mechanisms, IDFC found that there are currently two main market-based schemes in India which have linkages with climate change related obligations: the Renewable Energy Certificate (REC) scheme and the Energy Efficiency Certificates (ESCerts). RECs can be purchased by electricity distribution companies that fall short of their Renewable Purchase Obligations. Alternatively, under the framework for energy efficiency, an obligation to undertake energy saving measures and obtaining ESCerts is currently placed on specified Designated Consumers (DCs).

Research partners found, however, that there was no provision for fungibility in regard to RECs and ESCerts and that for these market-based instruments to work efficiently, a legal and policy framework is needed that would allow energy users and hence GHG emitters to purchase or invest in the least cost GHG emissions reducing options. These could for example be made more flexible to include either renewable energy, technology upgrades or emissions reductions in the form of agricultural offsets.

Regarding the use of existing statutory funds for purchasing agricultural offsets, IDFC and NSW DTI identified the National Clean Energy Fund (NCEF) and the Compensatory Afforestation Fund (CAF) as two funds, that have been created by the Indian government for the purpose of funding the environmental obligations of project developers that could be used to purchase environmental services from agriculture including emissions reduction. If these funds were extended in this way, it would further serve to incentivize new research into carbon abatement and sequestration.

IDFC and NSW DTI further highlighted how the broad structure and purpose of the NCEF in India is comparable with the Portuguese Carbon Fund (PCF) established by the Government of Portugal in 2006. The PCF has been instrumental in initiating national projects relating to treatment of industrial gases and on biodiverse pastures, also known as “Terra Prima, which is a carbon sequestration project focusing on sowing bio-diverse pastures. The PCF is similar to the NCEF in India, being a national level fund credited with charges levied on users of conventional sources of energy.

Objective 2: Assess international GHG policy settings and the benefits that agricultural offsets could provide to energy and industry sectors in India

The following **Milestone 2** and **Milestone 3** reports addressed this objective:

1. Review of Developments in Greenhouse Gas Policy (lead, IDFC); and
2. The Marginal Abatement Costs of India’s Thermal Power, Cement and Steel Sectors (lead, IDFC).

These reports deliver on Activity 2.1 (Review developments In GHG policy settings in other countries) and Activity 2.2 (Review available estimates of marginal abatement costs within the energy and industry sectors in order to establish the economy-wide importance of finding low costs abatement opportunities).

The first report, completed in 2013, delivered on Milestone 2 and aimed to increase awareness among the project team of international efforts to address agricultural GHG emissions. It contains a survey of international GHG policy efforts, which also helped to highlight the timeliness of all countries moving to consider the role of agriculture in their national emissions abatement efforts.

The second report, completed in 2014, delivered on Milestone 3.. This research established broad estimates of the marginal GHG abatement costs facing India’s large point-source emitters. Importantly, it enabled comparison with the cost of GHG abatement and sequestration in agriculture.

The important project research outcome achieved was therefore to demonstrate (in conjunction with the Objective 3 report lead by IFPRI) that the marginal abatement costs facing India’s energy and industry sectors, while varying widely depending on the particular technology in question, was in many cases much higher than the cost at which GHGs can be abated or sequestered in agriculture.

For example, in considering the marginal GHG abatement costs facing India's large point source emitters, IDFC and NSW DTI set an upper limit on feasible mitigation technologies available to the energy and industry sectors at INR5000 per tonne CO2e (or approximately $75US) given that Solar Renewable Energy Certificates were being purchased by industry as a mitigation option at that price. Hence, the project established *prima facie* conditions suggestive of positive potential for the establishment of a viable agricultural offsets market in India that could significantly lower the cost of India's national abatement effort. These results confirm the basic proposition of the value of agricultural offsets as shown diagrammatically below.

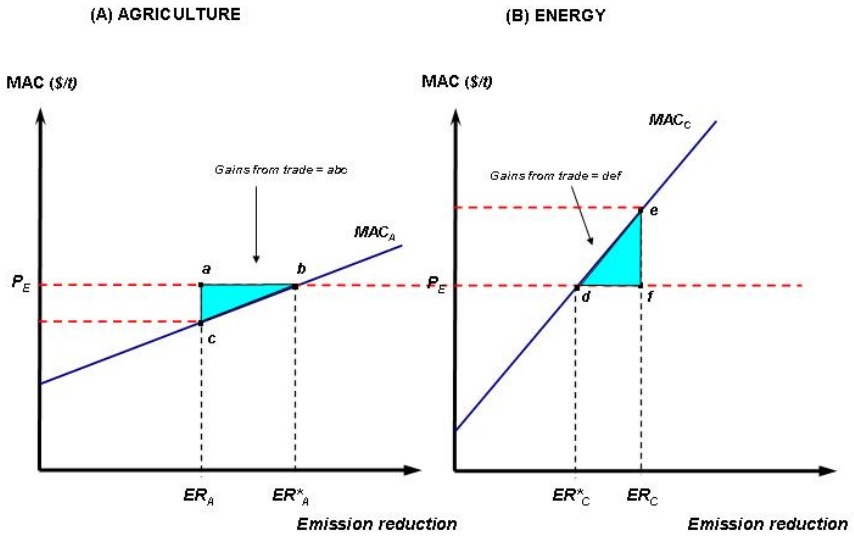

Figure 1: The value of agricultural offsets

Objective 3: Evaluate the scope for cost effective emissions abatement within India's agricultural sector and the economy-wide impacts of an agricultural offsets policy.

Milestone 4 and 5 (IFPRI)"Assessment of the scope for greenhouse gas mitigation in India's agricultural sector" relates to the following project activities:

- Activity 3.1 - identify technologies and management systems that can deliver carbon sequestration and agricultural emissions reductions cost effectively.
- Activity 3.2 - revise IMPACT with improved estimates for existing modelling technologies and management systems.
- Activity 3.3 - broaden the coverage of IMPACT to include methane emissions from livestock and soil carbon sequestration potential.
- Activity 3.4 - assess the scope of agricultural mitigation under alternative carbon prices, policies and investment scenarios.

This is a further important project report given it is one if the first research efforts that comprehensively investigates the GHG abatement and sequestration potential of Indian agriculture. For the purpose of the project, a new and exciting research finding was the existence of significant low cost abatement and sequestration opportunities within Indian agriculture, although those opportunities exhibit wide regional variation. As stated in this project research report:

> *"Our findings are strongly suggestive of a significant potential for low-cost mitigation in agriculture. This is true both when using instruments that incentivize the adoption agricultural practices with lower GHG emission profiles and when using instruments that dis-incentivize groundwater pumping. It is however clear*

that policies should play particular attention to target areas and practices that are best suited to deliver the mitigation service since results indicate a great variance within and across states".

Some particularly important results from this project research are contained in the following table which indicate that for three levels of a potential government program budget, the cost per ton of CO_2e abated is small and well under US$1 per ton.

It can also be seen from the table that the economic potential for climate change mitigation is significant, some 45 million tons of CO_2eq, which represents about 13 percent of the annual GHG emissions from agriculture (the figure following the table provides a geographic representation of where the changed production patterns are likely to be viable).

Table 1: Effects of alternative budget allocation to mitigation efforts in food-crop production

	Total Implementation Cost					
	Per hectare compensation			**Per ton of CO_2eq compensation**		
	10 Million US$ yr^{-1}	20 Million US$ yr^{-1}	50 Million US$ yr^{-1}	10 Million US$ yr^{-1}	20 Million US$ yr^{-1}	50 Million US$ yr^{-1}
Total GWP reduction ($TgCO_2eq\ yr^{-1}$)	45.2	46.1	48.0	45.6	46.4	48.8
Implicit price per Mg carbon sequestered (US$ $MgCO_2eq^{-1}\ yr^{-1}$)	0.22	0.43	1.41	0.22	0.43	1.02
Total Area Converted to Alternative Practice (Million ha)	11.9	12.2	13.2	11.0	12.0	12.7

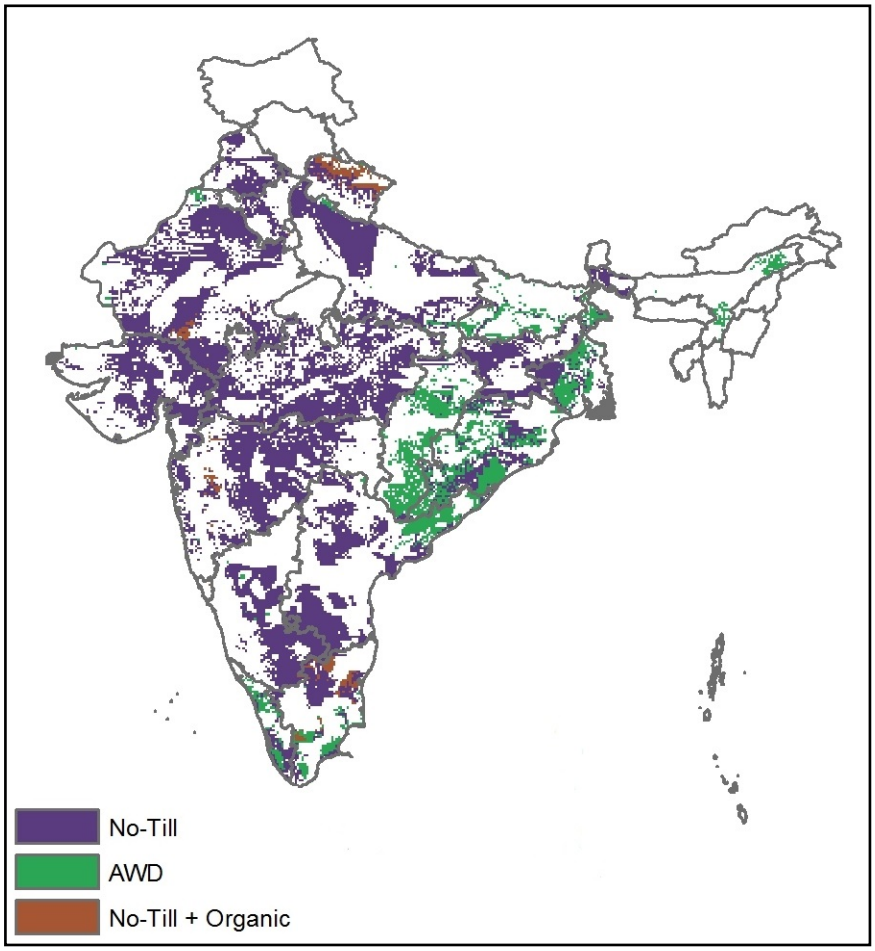

Figure 2: Adoption of mitigation practices with the UD$ 10 million budget

The project team also researched how the type of farmer payment might influence farmer adoption, and looked at a per hectare payment in exchange for changes in farm practices, versus a more direct payment for the actual amounts of CO_2e mitigated.

They found (see the following table) that for a yearly payment of US$2 per hectare, around 12 million hectares transition to alternative practices for a cumulative yearly reduction in global warming potential (GWP) of about 46 million tons of CO_2eq. With required expenditures of about 25 million US$ per year, this equated to a cost per ton of CO_2eq abated of US$0.54.

The effects of an equivalent payment per ton of CO_2e abated generated similar results and overall the findings were found to reinforce the idea that there is a core amount of land with high mitigation potential, achievable at a very low cost.

Researchers then compared these GHG mitigation potentials relating to food-crop production with the potential that might relate to changed irrigation practices and changes in the price of diesel and electricity.

Table 2: Simulation of per hectare and per ton of compensation

	Type of Compensation	
	US$2 $ha^{-1}yr^{-1}$	US$0.54 $MgCO2eq\ ha^{-1}yr^{-1}$
Total GWP reduction ($TgCO_2eq\ yr^{-1}$)	46.6	46.8
Total Cost (Million US$ yr^{-1})	24.8	25.1
Implicit price per Mg carbon sequestered (US$ $MgCO_2eq^{-1}\ yr^{-1}$)	0.54	0.54
Total Area Converted to Alternative Practice (Million ha)	12.4	12.1

An important result, as reported in the following table, was that a 100 percent increase in the price of diesel reduces total water use by less than 1 percent and CO_2e emissions by slightly more than 1 percent. However, a 100 percent increase in the electricity price reduces water use by more than 8 percent and CO_2e emissions by 14 percent. They also found that the effect of these price increases on crop production was small.

These findings are important because they indicate that reductions in electricity subsidies can trigger reductions in CO_2e emissions, improve energy and water use efficiency whilst leaving crop production basically unchanged. In this way, reducing existing electricity subsidies has wider appeal of providing multiple environmental benefits without negatively impacting on agricultural production. From an economic efficiency perspective it is also preferable to reform existing policy settings that can induce substantive change prior to considering any specific measures or programs aimed at reducing emissions in agriculture.

Table 3: The effects on groundwater pumping and GHG emissions of energy price increases

	100 percent increase in diesel price		100 percent increase in electricity price	
	Change in total water use (percent)	Change in CO_2eq, (percent)	Change in total water use (percent)	Change in CO_2eq, (percent)
2010	-0.77	-1.11	-8.16	-14.00
2020	-0.78	-1.08	-8.18	-13.75
2030	-0.74	-1.06	-8.12	-13.49
2040	-0.73	-1.03	-8.11	-13.30
2050	-0.73	-1.05	-8.10	-13.44

Important key concluding points from the research team were that:

- There are significant opportunities for cost-effective mitigation of GHGs in Indian agriculture. These opportunities lay both in agricultural management practices alternative to the status quo, and in a reduced use of irrigation pumps. Reductions in subsidies to rural electric use for agriculture would discourage the use of electricity for extraction of groundwater from deep aquifers with a consequent reduction in emissions.
- Among the analysed alternative agricultural practices, 'No-till' appears to be the one that provides a relatively inexpensive mitigation service. However, the benefits provided by this practice can be quickly lost if farmers return to ploughing and to using conventional practices. The use of relatively long-lasting contracts could be necessary that would greatly influence the implementation costs of a plan that incentivizes the adoption of such practice.
- The adoption of the 'Alternate Wet and Dry' (AWD) management practice does not suffer from this problem, as the benefits cannot be undone when dealing with a direct reduction in GHG emissions. AWD substantially reduces methane emissions from irrigated rice with a reduction in yields, which could be compensated with an environmental service payment.
- The low mitigation costs, in terms of US$ per ton of CO_2e indicate that there is significant potential for these payments to fund mitigation activities in agriculture. Prices in the range of US$0.2 – 0.5 per ton of CO_2e strongly suggest that these activities can compete with mitigation efforts in other economic sectors.
- Furthermore, although not accounted for in this research, accumulation of soil organic carbon increases sustainable agricultural production and the resilience of production system to climate change
- Aggregated values hide the complexity present in mitigation potential, both technical and economic, and can lead to erroneous mitigation strategies and policy recommendations. Mitigation strategies and policies must carefully consider this important aspect.

Importantly, the research also revealed significant negative marginal abatement costs, i.e. the existence of already available agricultural production practices with less emissions that are at least as profitable as currently applied practices.

These research findings now set the scene for a further program or research and extension aimed at refining regional mitigation opportunities, and shedding light on possible impediments to the adoption of existing low emissions farming systems.

The **Milestone 6** Report delivered on Activity 3.5 (Undertake one or more regional case studies to provide a more detailed assessment of the scope for abatement/sequestration under alternative policy settings). The findings of the Punjab and Bihar case study analyses were presented at the final Project Workshop in Delhi in April 2015. IFPRI repeated the country level analysis for the states of Bihar and Punjab based on new data (second generation Village Level Studies) and recalibrated the effects of adoption of mitigation practices. Results of this downscaled analysis support the findings of the country-wide analysis confirming that there is a high potential for cost effective reduction of emissions in land allocated to crop production. The state-wide analysis found an average price of $US0.6 and $US3.1 per abated ton of CO2e for the states of Punjab and Bihar, respectively. Local conditions influence the cost of reducing emissions and more opportunities for mitigation were found in Punjab relative to the State of Bihar.

To further increase the level of confidence in these results, IFPRI performed an evaluation basing our analysis on household data for the state of Bihar. Form the household survey

fifty farmers were selected that produce both wheat and rice and used the available information on yields, farm prices and cost of production, to compute the costs of abating one ton of CO2e given local conditions. There was an even split between No-Till and AWD in terms of best practice while the combination of No-Till and Organic continues to appear a less appealing option in terms of economically efficient practices.

In overall terms, abatement costs were found to vary significantly for each practice according to the farm location and characteristics. The values were consistent with the figures found in the country- and state-wide analyses. There were instances in which the No-till practice appears superior to the current farming practice (zero abatement costs). This indicates that even when we use household level data we are not including the full cost of adoption of an alternative practice. These additional costs are likely related to learning and additional risk that a farmer has to bear in order to use the new technology. The AWD practice seems to offer, on average, ample opportunities for lowering emissions at a low costs.

There is a vast literature about the diffusion of innovations that is worth considering in the context of proposed mitigation practices. The literature identifies five key attributes of an innovation that influence its rate of adoption including: relative advantage; compatibility; complexity; trialability and observability. How mitigation practices rate on some of these factors is of key interest and will be partly addressed through planned experimental economics work in Bihar which is now included as a separate small research activity.

The **Milestones 7 and 8** report, a collaboration by NCAER, Victoria University, Monash University and IFPRI, titled "*A CGE Model for India with an Application on the Effects of Eliminating Agricultural Subsidies",* delivers on Activity 3.6 (Assess the economy-wide effects of reforming agricultural policy settings and the introduction of an agricultural offset scheme on agricultural productivity, food security, rural incomes, employment, trade and emissions).

This key component of the project was originally intended to be completed by NCAER using their CGE model of the Indian economy in collaboration with Professors Peter Dixon and Sisira Jayasuriya. However, following a workshop in 2013, it became clear that ideally a more comprehensive and updated CGE model of India with greater disaggregation of the agricultural sector would be desirable.

An unplanned but important project outcome was therefore Professor Peter Dixon offered to help the NCAER research team build a new CGE model of the Indian economy with the necessary features incorporating the latest data and up to date software. The new model could be used not only to assess the impact of agricultural subsidy reform on resource use efficiency and emissions in this project, but would also provide substantial benefits for Indian policy research well beyond this project, by strengthening the analytical capacity and skills of the Indian collaborators.

Preliminary CGE economy-wide modelling results generated by the NCAER/VU team were presented by Professor Peter Dixon and Dr Rajesh Chadha (NCAER) at the 2014 project workshop in Delhi, with further results presented at the 2015 Delhi Workshop. Key, early stage indicative findings, to be refined and appropriately modified in subsequent work, were that:

(i) Agricultural subsidies are worth about 2.5 per cent of GDP with about one third being subsidies on inputs of fertilizer and electricity to agricultural industries and about two thirds being subsidies on production and sales of agricultural products.

(ii) Agricultural subsidies were found to inflict a GDP dead-weight loss of about 0.20 percent, most of which is associated with subsidies on fertilizer and electricity. The percentage loss in economic welfare measured by foregone consumption is about 0.24 percent.

(iii) Agricultural output was found to be about 2.3 percent greater with subsidies than without and they were found to increase output and exports of cotton textiles, edible oil, woollen textiles, khadi and apparel, but reduced output and exports of communication equipment, non-ferrous metals and computer services.

(iv) About 20 percent of fertilizer output and 7 percent of electricity output depend on agricultural subsidies.

(v) Fertilizer and electricity subsidies do not contribute to the objective of supporting farm income. By inducing substitution against factors that contribute to farm income (agricultural land, and labour & capital used on farms), fertilizer and electricity subsidies reduce real farm income by about 2 percent. By contrast, production and sales subsidies on agricultural products boost real farm income by about 5 percent.

(vi) All of the current agricultural subsidies contribute positively to food security. The subsidies reduce food prices relative to the CPI by about 7 percent and increase food consumption by about 0.7 percent.

(vii) However, the reforms to the regime of subsidies to fertilizer can help achieve food security and farm income goals more efficiently, because if government provision of fertilizer and electricity subsidies to the agricultural sector were phased out and replaced with additional provision of agricultural production and sales subsidies, then real farm income would be increased by about 4 percent with no deterioration in the public sector budget, almost no effect on food security, and small increases in GDP and overall welfare.

Objective 4: Assess alternative policy designs and institutional arrangements that can efficiently deliver GHG mitigation by agricultural sectors in India and Australia.

A **Milestone 9** report, led by the NSW DTI, was designed to address Activity 4.1 (Investigate alternative policy designs for a market offset scheme that can efficiently achieve abatement while meeting monitoring, reporting and verification demands).

Aspects of contract design have been investigated and approval has been granted to take this component of the project forward into 2015-16 as a separate, small, ACIAR project. An important focus for this research will involve working with other researchers and advisers to explore efficient contract designs for carbon offsets and to enhance the capacity of local researchers to design and implement market based instruments in agriculture in the future.

Overall Assessment

The project has achieved most of its major objectives and is well on the way to completing the others. The main findings are that:

- The marginal abatement cost analyses, and the IFPRI lead crop-modelling and simulations, taken together, demonstrate the significant potential for significant mitigation in India's agricultural sector. There are potential cropping alternatives that offer low cost emissions reductions.
- There is a range of ways by which an agricultural offset program could be incorporated into India's existing energy policy frameworks in order to reduce the cost of India's overall abatement challenge.
- The current regime of large subsidies on fertilizer and electricity are clearly a wasteful and inefficient way to achieve the key national goals of food security and farmer welfare. Even the limited CGE modelling results available so far show the

significant scope for agricultural price-subsidy reforms to achieve food security and higher farmer welfare without increasing the already very high fiscal burden. It also reduces overuse of these inputs, which are known to have negative environmental effects.

- Once the emissions outcomes of changes in production patterns in the agricultural sector are incorporated into the CGE model, it will be possible to quantify the extent of environmental benefits by way of reduced fertilizer and electricity usage, and reduced GHG emissions.

In addition to these direct project research outcomes, a widely acknowledged project achievement has been a consolidation and deepening of the research collaboration between Australian researchers (that now includes the COPS team at Victoria University) and Indian researchers at NCAER and, through NCAER, also in other Indian research institutions.

NCAER has been working in close interaction and collaboration with senior officials and representatives from various branches of the Indian government, major industry bodies and international agencies. The project has helped build strong, enduring links with key stakeholders and policy makers. A significant achievement, for example, has been the active involvement of Prof Arvind Panagariya (currently heading the Niti Ayog with Cabinet Minister rank) and Dr Ramesh Chand (Deputy Director, ICAR) in this and previous projects as members of the Project Steering Committees, and the involvement of leading private sector institutions.

The project has also led to substantial capacity building in analytical techniques, modelling capabilities and policy analysis skills – activities that will continue with the MOU between VU and NCAER, a direct outcome of the project.

A particularly feature of this and previous projects is that they were strongly demand-driven, being developed in response to policy priorities identified by Indian researchers and government, rather than being based on academic research perspectives.

The modalities of the research processes were driven primarily by the aim of achieving policy relevant outcomes through an interactive process of engagement with the relevant key stakeholders, rather than by narrow academic publication goals. As a result, the project has developed an established channels of communication with India's policy makers that now enable stakeholders to feel a sense of ownership in the policy research process, which is critically important for the acceptance and implementation of policy recommendations.

This engagement with the Indian Government and industry, which has enabled the research team to build up (i) in-depth knowledge of the policy issues and institutional realities, (ii) channels of communications, and (iii) close relationships, has now laid the foundation for undertaking further policy reform analysis of direct interest to the new Government that has signaled its intention to undertake major reforms.

In particular, there are opportunities to use the analytical and modelling capacity built by this project, including the newly developed CGE model of the Indian economy, to work even more closely with the Indian Government to address a range of high priority policy issues. The importance of such further work, involving the refinement and extension of the current models, is further highlighted by emerging developments in agriculture in global markets. In the absence of necessary agricultural reforms, India will not be well placed to exploit these opportunities.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The impact of the project on the scientific data base has been significant. New scientific information has been generated on:

- Opportunities for cost-effective mitigation of GHGs in Indian agriculture reflecting important biophysical differences across India. These opportunities lay both in agricultural management practices alternative to the status quo, and in a reduced use of irrigation pumps;
- The extent to which subsidies to rural electricity use for agriculture encourage emissions;
- GHG emissions and their linkages to agricultural policy and the payments required by Indian farmers to offer GHG abatement and sequestration services;
- Opportunities for India to incorporate an agricultural offsets initiative within its current suite of renewable energy and energy efficiency programs; and
- The likely feasibility of an agricultural offsets scheme based on new information on the marginal abatement costs facing India's large point source GHG emitters.

Importantly, the project has enabled (albeit preliminary) numbers to be attached to the costs of India's agricultural subsidy schemes which has provided a much stronger basis for thinking about the case for such schemes and for market liberalizations.

Similarly, the quantification of the emissions abatement potential of Indian agriculture had laid the groundwork for closer examination of this potential. The negative marginal abatement costs revealed for certain emissions reducing farm practices have also indicated a need to further investigate impediments to their adoption, before progressing with an offsets program.

The new scientific information generated by the project represents a strong contribution to the current dialogue in India about agricultural policy reform. Importantly, the timing of this new policy research has aligned with the election of the new Indian Government and its first term reform priorities. It follows that in 5 years' time this research will have encouraged significant additional strategic policy research that will be strongly supported by NCAER's enhanced CGE modelling capacity and it's MOU with Victoria University.

With growing international concerns about climate change and GHG emissions, it can be expected that the project's initial work on Indian agriculture's carbon mitigation and sequestration potential will be subject to further, close examination, and over the next 5 years will provide strong strategic direction to research and extension priorities.

8.2 Capacity impacts – now and in 5 years

This is the third in a series of India projects on related themes, and so important links have been developed between a geographically diverse group of agricultural policy researchers in India, Australia and the United States.

The development of linkages between policy researchers has been significant and the modelling technology transfer has been important. For example, CGE model-building capability has been enhanced and gains delivered to all project participants. It takes time to develop such capabilities, but once developed, this capacity lays the groundwork for important policy contributions with economic benefits. The CGE modelling of agricultural subsidy reform has not been undertaken previously, and the initial preliminary results

derived will act as a catalyst for further, more detailed analysis which will strongly support more informed public discussion about these reforms.

It is significant that this project has approached the issue of sensitive policy reforms by seeking to develop key stakeholder relationships and facilitating more informed debate. This is considered to be a more effective approach than proffering prescriptive academic policy recommendations that can have little connection with the circumstances and issues facing policy makers and government.

The project was also structured to achieve the broader capability development of policy makers in considering the gains from reform through a series of annual, high-profile workshops in New Delhi where Indian policy makers attended and participated in discussing project findings and future research directions.

Of great significance is that the relationship between Indian and Australia researchers has been deepened, such that Australia's relationship with India's National Council of Applied Economics is one characterised by very high levels of trust and confidence, particularly regarding the nature and direction of agricultural policy research and agricultural policy advice. This relationship now represents a valuable asset to support further agricultural policy reform research initiatives that has resonance with the Indian Government.

Capacity building in CGE modelling has been a major achievement from the project. With Professor Peter Dixon agreeing to work with Dr Rajesh Chadha and his staff from NCAER to build a new CGE model of the Indian economy, a significant capacity transfer to Indian researchers has and will continue to occur.

This CGE modelling and associated policy evaluation capacity transfer will be ongoing with the entering into of an MOU between NCAER and VU to further build NCAER's capacity over the next five years. This capacity transfer will see NCAER being very well placed to undertake broader appraisal of policy reforms throughout the Indian economy at a time when the Indian Government is keen to pursue a significant reform agenda.

IFPRI made significant progress in the development of a modelling framework that combines and reconciles economic and biophysical models to provide an estimations of changes in GHG emissions, carbon stock, and economic effects of the adoption of mitigation practices. Mitigation estimates are now based on highly disaggregated information from data capable to represent the biophysical processes responsible for GHG emissions. This will support future work mitigation work undertaken by IFPRI in both India and other countries in South Asia and enhance local research.

8.3 Community impacts – now and in 5 years

The project and its predecessor projects have impacted on core market liberalisation policies that lie at the heart of India's current agricultural policy settings. The market based reform proposals and approach that arise from the project are consistent with the approach and underlying rationale applied to agricultural policy reform in developed countries, such as Australia.

While this is appropriate, in the Indian context, it is necessarily associated with major economic, environmental and social impacts on much of India's population as a result of changed agricultural production patterns and changes in incomes and income distribution.

8.3.1 Economic impacts

The policy reform directions that lie at the heart of the project include the reform of agricultural subsidies and the positioning of agriculture as a sector that can contribute positively to India's GHG mitigation targets (emission intensity or absolute emissions). The reform of subsidies will necessarily be associated with parallel reforms focussed on more efficient means of meeting the social welfare needs of the Indian community. This project, building on previous projects, has contributed significantly to the weight of pro-reform

research that is starting to tilt Indian agricultural policies towards efficiency enhancing reforms that can help release scarce funds for urgent high priority investments while maintaining strategic targets for farmer incomes, food security and environmental objectives.

Already the new Indian government is moving to consider more direct systems of welfare payments. It follows that the decoupling of welfare policy from industry policy will enable agriculture to be more directly exposed to market prices, opening the way for new growth and development opportunities. The economic impacts of such reforms are potentially significant and are in the form of higher farm incomes for those farmers who can adjust their production patterns in a manner consistent with India's emerging comparative production advantages.

The reform of agricultural subsidies will also have significant, positive, budgetary impacts for the Indian government, with funds potentially able to be redirected to investments with higher public value, such as the provision of rural infrastructure. More efficient price transmission in agricultural supply chains will also incentivize private investment leading to strong second-round impacts that will further enhance agricultural growth, productivity and food security.

The possibility of positioning agriculture as a provider of carbon offsets has a number of potentially significant economic impacts. First, the sourcing by India's large point source emitters of low cost carbon offsets from agriculture has the potential to lower the overall national cost of India meeting its GHG reduction targets. Second, the purchase of agricultural offsets could provide significant supplementary income to Indian farmers.

The project finding that agriculture could offer India's energy and industry sectors low cost GHG mitigation of at least 46 million tons of CO_2eq at around US$ 0.54 per tonne, translates potentially into huge industry savings in meeting their emission reduction commitments, and represents a significant supplement to farm incomes. Such payments would also assist agriculture move to production patterns that are more economically sustainable in the longer term.

8.3.2 Social impacts

Improved social outcomes for India's farm families, such as improved education and health services, can only be attained by sectoral growth, improved incomes and improved public sector investments. However, for the 60 percent of India's population that depend on agriculture, rural poverty remains high and largely unchanged.

This situation is underpinned by an agricultural sector that is slow to adjust to emerging markets and growth opportunities. It remains largely subsistence based and is insulated from these opportunities by outdated policy settings, such as production subsidies and agricultural marketing arrangements that impede price transmission in agricultural supply chains.

The case for reforming of these policy impediments to more efficient patterns of private and public investment is compelling. The social impacts of the current project and its predecessor projects, given their contribution to this market liberalisation process, are therefore high, with that impact being realised progressively over the medium term.

Climate change poses a significant risk to Indian agriculture and therefore to the social well-being of much of India's population. The project has directly assisted Indian policy makers to reconsider the role of agriculture in helping to address this challenge.

As a direct result of this research collaboration, policy makers and researchers have become far more aware of the nature and causes of GHG emissions from agriculture, of the various forms of government intervention that are exacerbating agriculture's GHG emissions profile and of there being potential impediments to the adoption of alternative, profitable, but lower emissions production practices.

These contributions and findings have strongly assisted in paving the way for further and deeper consideration of the ways in which Indian agriculture can contribute to the global warming challenge, while at the same time helping to put the sector on a more economically and environmentally sustainable path to growth and commensurate reductions in rural poverty.

8.3.3 Environmental impacts

Agricultural subsidies are widely acknowledged as providing incentives for practices, such as excessive fertiliser use and groundwater pumping, which are in turn linked to significant environmental degradation in the form of soil salinity and waterlogging, unbalanced nutrient levels, steeply falling water tables and water quality problems.

In addition to these direct environmental impacts, agricultural subsidies are also promoting emissions intensive cropping practices, such as flood irrigated rice and wheat production, which contribute to climate change.

The project has provided clear insights into the linkages between agricultural policy and the over-exploitation of India's natural resources. Nevertheless, it has highlighted that there are a range of very positive strategies that can and should be pursued in regard to increasing the production efficiency of Indian agriculture. For example, there appear to be very worthwhile gains from:

- more effective extension efforts (to address information failures) focussed on changing production patterns to lower emissions, yet equally profitable, production systems;
- considering the further 'directional change' in agricultural production systems that might be associated by a transitional program of subsidy reform and the progressive change in production incentives that would provide; and
- ensuring that agricultural production research and extension is re-positioned to reduce the adjustment costs that might be associated with a shift to less subsidised and emissions intensive agricultural practices.

8.4 Communication and dissemination activities

Strategic communication activities have been undertaken continuously throughout the term of the project. All research findings relating to each of the project objectives have been presented at high-profile workshops in Delhi, organised by the National Council of Applied Economics and attended by Indian policy makers and academics, as well as in a number of other fora.

Throughout the three year term of the project, major two-day workshops were held in 2013, 2014 and 2015. The program of each of these workshops included eminent speakers from the Indian government, from India's various agricultural policy and advisory bodies and from internationally recognised academics with backgrounds in key topics such as food security, climate change policy and agricultural policy reform. Workshop presentations and discussions were further disseminated by the NCAER through the further development of policy papers, through advice provided to Indian government agencies and through its website.

Similarly, the IDFC Foundation was a key disseminator of the project's research and associated findings within the Indian Government.

A further key mechanism by which project findings were disseminated was through the Project Advisory Committee which was comprised of key Indian Government representatives including:

- The National Centre for Agricultural Economics;

- The Joint Secretary, Ministry of Environment and Forests;
- The Joint Secretary, Department of Agriculture and Cooperation, Ministry of Agriculture; and
- The joint Secretary, Department of Industry Policy and Promotion.

9 Conclusions and recommendations

9.1 Conclusions

As outlined in Section 6, key project findings, by way of the marginal abatement cost analyses and crop-modelling and simulations, demonstrated the potential for significant mitigation in India's agricultural sector.

The project analysis and findings also confirmed that an agricultural offsets scheme could, in principle be accommodated within India's existing renewable energy and energy efficiency policy framework. There are also existing statutory funds such as the National Clean Energy Fund and the Compensatory Afforestation Fund that could be vehicles for the direct purchase of carbon abatement and sequestration services from the agricultural sector.

The research on carbon emissions associated with alternative cropping systems strongly confirmed the existence of significant carbon abatement potential linked to changed agricultural practices, such as 'No-till' and 'Alternative wetting and drying' cropping practices. That potential was estimated to be around 45 million tons of CO_2e, which represents about 13 percent of the annual GHG emissions from agriculture. The research highlighted, however, that this potential is variable across regions and thus requires careful design of policy mechanisms.

It was also found that a lack of up-take of certain carbon mitigating farm practices in certain regions that were at least as profitable as currently practices, indicating the possible existence of impediments to adoption.

While the above-mentioned findings point to the potential viability of an agricultural offset scheme in India, project collaborators were nevertheless mindful of a sequenced approach needing to underpin strategy aimed enhancing the efficiency of Indian agriculture and its role in GHG emissions abatement. It was concluded that:

- first in that sequence, is the need to reform outdated agricultural policies, such as production subsidies. This would not only enhance the efficiency of resources use in agriculture, but would also reduce the sectors emissions profile;
- second in that sequence, is the need to promote less intensive GHG production practices by addressing impediments to their adoption, some of which may simply be a lack of information (extension) available to the farm sector; and
- third in the sequence, is the possibility of positive intervention by government in the form of a carbon offsets program.

The CGE modelling that was undertaken has confirmed the inefficiency of agricultural subsidies. This modelling capability, developed with India's NCAER, provides a solid platform to consider future policy reform opportunities by providing evidence about the benefits of change. Having clearly enunciated the reform issues and developed the analytical tools, a logical next step is to ensure that this investment now translates into an evaluative framework focussed on subsidy reform at the state level.It was made clear at the final project workshop that a policy framework that promotes a form of competitive federalism is now essential, if the necessary agricultural policy reforms are to be achieved.

9.2 Recommendations

Given the need for international food security and poverty reduction to be supported by agricultural policy settings based on comparative production advantage, rather than on self-sufficiency principles, this project and its predecessor projects represent a major

commitment by ACIAR to assisting in the modernisation of India's agricultural policy settings.

This research has specifically shown there is significant scope for agricultural offsets through increased adoption of less carbon intensive farm production systems. Developing and exploiting this aspect of India's natural comparative advantage could be an important public policy focus over the medium term.

This research has also quantified the benefits from reforming India's agricultural subsidies, with benefits in the form of changed and more efficient production patterns and reductions in agriculture's greenhouse gas (GHG) emissions. Importantly, this work has significantly contributed to opening a high-level policy dialogue around how a subsidy reform pathway might be structured.

There are good opportunities for this progress to be built upon by the Indian government and state-based policy makers to address specific reform initiatives to enhance the long term sustainability and economic prosperity of the agricultural sector ahead. . The Ministry of Agriculture has expressed support to establish an analytical framework capable of assessing the relative interstate gains associated with agricultural subsidy reform.

In respect to agricultural mitigation more specifically, additional research could be undertaken to further refine the GHG mitigation potential of Indian agriculture and to identify the nature of possible impediments to the adoption of already profitable, less emissions intensive, farm practices. It's worth re-iterating that many agricultural practices that reduce emissions (eg. water saving practices, more efficient fertiliser use, adoption of improved cultivars, better cattle feeds etc) also improve agricultural sector productivity and sustainability more generally. Importantly, this suggests that enhancing climate mitigation in agriculture can complement rather than compete with other national development plans.

There are opportunities to further consider the issue of food security and invest in additional policy research to demonstrate the food security gains that can be achieved through appropriate agricultural policy reform. For example, both the NCAE–VU CGE model of the Indian economy, and the IFPRI IMPACT models, as modified in this project, could be used to demonstrate the food production and trade consequences of reform.

Note that these recommendations are strongly supported by an Independent Review of the project which noted that:

- Valuable insights on possible future work on the role of market liberalization in Indian agriculture were outline in a keynote address by Mr. Siraj Hussain, Secretary Department of Agriculture and Cooperation (at the final project Workshop). These remarks were valuable since many of the issues suggested are related to the issues of subsidy reform that this project addressed.
- This report is worth reading in full but the 4 main areas Mr. Hussain focused on were: (i) The fragmentation of Indian agriculture into excessively small holdings and the need to attract participants from this sector into better rewarded opportunities elsewhere in the economy; (ii) The mitigation of risk – including climatic and land degradation risk – by means of insurance and credit market reforms as well as agricultural diversification policies; and (iii) Achieving balanced growth across the various states of India by increasing economic integration and delivering appropriate infrastructure.
- With the exception of the risk issue, these are all concerns that can be addressed using the types of analytical frameworks employed in the present study and are a natural extension of the pre-existing work. On the risk issue there is a report forthcoming by ABARE in Australia that might be of interest to Indian researchers and policy-makers and which could provide the basis for further work. The core need is to build on the recognition that farmers have various ways of addressing risks to develop a policy-relevant crop insurance model and to relate this model to market liberalization initiatives in agriculture.

10 References

10.1 List of publications produced by project

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