Australian Government
Australian Centre for International Agricultural Research

Final report

Small research and development activity

SRA	**Happy Seeder policy linkage scoping study**
date published	December 2006
prepared by	Phillip Pagan Policy Economist Industry Analysis Branch NSW Department of Primary Industries Dr Rajinder Pal Singh Research Economist Systems Research Branch NSW Department of Primary Industries
approved by	Dr Jeff Davis
project number	PLIA/2006/180
ISBN	978 1 921434 06 8
published by	ACIAR GPO Box 1571 Canberra ACT 2601 Australia

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Acknowledgements

The authors wish to acknowledge the contribution of all those who have assisted with the development and completion of this study.

In developing the project, the authors thank Jeff Davis and Christian Roth (ACIAR) and Don Vernon and John Mullen (NSW DPI) for initiating the project and providing the opportunity for us to be involved.

We also thank Kim Regan, Di Williams, Graham Denney and Penny Wheeler (NSW DPI) for their help with our travel arrangements, external funding contract arrangements, and for providing editorial assistance.

The support for this project from the ACIAR South Asia office in New Delhi (Kuhu Chatterjee, Simrat Labana and Frank Wilson) has been excellent, especially in meticulously organising our itinerary and providing transport in Delhi and Chandigarh. Sincere thanks must also be expressed for the input and organisational support provided by H.S. Sidhu and Yadvinder Singh (PAU).

Finally, the generous provision of time, ideas and hospitality by the many organisations and individuals that we interacted with in India in early September has been crucial to the successful completion of this study. The contributions made by these organisations and individuals have been greatly appreciated.

Table of Contents

Figures

Tables

Executive Summary

A recent ACIAR technical project (SMCN/2000/089 ‘Permanent beds for irrigated rice-wheat and alternative cropping systems in north-west India and south-east Australia’), has resulted in the development of agricultural machinery (The Happy Seeder) which could contribute significantly to improved sustainability of irrigated cropping in northern India. However, existing policy settings (and/or the way they are practically interpreted and implemented) may constrain the adoption of this technology.

Consequently, ACIAR commissioned this scoping study to assess the range and scale of policy related issues relevant to the adoption of The Happy Seeder, with a view to developing an ACIAR policy linkage project to overcome them if significant constraints were identified.

Lack of suitable machinery is a major constraint to direct drilling into heavy combine harvested rice residues. Consequently, rice stubble burning is widely practised in the mechanised rice-wheat systems of south Asia, as it is a rapid and cheap option, and allows for quick turn around between crops. As well as loss of organic matter and nutrients, rice stubble burning is causing very serious and widespread air pollution in the north-west Indo-Gangetic Plains of India, particularly in Punjab. The Happy Seeder technology, which combines mulching and direct drilling functions is capable of making a significant contribution to sustainability and air quality issues, and could generate substantial economic benefits in India. These benefits arise from agricultural production, resource management, environmental, human health and animal health improvements. The extent and rate of adoption of this technology is, however, critical to the realisation of these benefits.

The scoping study included meeting with a variety of national and state government policy makers in India, so as to assess the range and scale of policy barriers to the adoption of the Happy Seeder technology. Meetings were also held with additional technical experts and environmental policy groups and agencies that may collaborate in any future policy linkage project. The scoping study coincided with the final review workshop of ACIAR Project SMCN/2000/089, which facilitated additional interaction with relevant stakeholders.

The scoping study identified a range of potential constraints to the adoption of the technology. These could be usefully addressed through a policy linkage project focussing on:

- evaluating the financial viability of the Happy Seeder technology to farmers;
- evaluating the benefits of the technology to the community more generally;
- assessing alternative potential policy instruments which could be used to enhance adoption; and
- reviewing intellectual property protection options for the Happy Seeder technology.

In addition, potential collaborators within India have been identified who hold the necessary technical and policy analysis skills, and policy process linkages required for successful completion of the proposed policy linkages project.

1 INTRODUCTION

1.1 Background to the scoping study

A recent ACIAR technical project (SMCN/2000/089 ‘Permanent beds for irrigated rice-wheat and alternative cropping systems in north-west India and south-east Australia’), has resulted in the development of conservation farming machinery (the Happy Seeder) which could contribute significantly to improved sustainability of irrigated cropping in northern India. However, existing policy settings (and/or the way they are practically interpreted and implemented) may constrain the adoption of this technology.

ACIAR recognises the potential importance of policy settings in influencing the effectiveness and impact of technical research projects. Consequently, ACIAR commissioned this scoping study to assess the range and scale of policy related issues relevant to the adoption of the Happy Seeder, and to propose potential directions for an ACIAR policy linkage project to address significant policy impediments, if required.

Lack of suitable machinery is a major constraint to direct drilling into heavy stubbles, and in particular to direct drilling of wheat into combine harvested rice residues. Rice stubble burning is widely practised in the mechanised rice-wheat systems of south Asia and Australia, as it is a rapid and cheap option, and allows for quick turn around between crops (Humphreys et al., 2006). As well as loss of organic matter and nutrients, rice stubble burning is causing very serious and widespread air pollution in the north-west Indo-Gangetic Plains of India, particularly in Punjab where rice-wheat systems predominate. The Happy Seeder, which combines stubble mulching and seed drilling functions into the one machine, is an innovative approach and is technology that can effectively operate in cropping systems with heavy stubbles.

High levels of adoption of this technology will produce significant benefits in increasing the profitability and sustainability of farming systems and from reducing the health related costs of particulate air pollution which currently arise from stubble burning. National and State Governments in India are increasingly concerned about the negative impacts of stubble burning, and regulatory arrangements have been implemented to lower the incidence of it. Currently, there are low levels of enforcement of these regulations because of a lack of management alternatives to stubble burning for irrigators. The Happy Seeder technology provides such an alternative.

1.2 Objectives of the scoping study

The terms of reference for the scoping study include the following objectives.

Objective 1: Finalise the financial analyses of the Happy Seeder technology and the wider ‘Permanent beds for irrigated rice-wheat and alternative cropping systems in north-west India and south-east Australia’ project and present these results at the project workshop and review during September 5-8, 2006 in India.

Objective 2: Visit policy groups in India who develop and implement environmental policies associated with burning stubble and review the current policy/economic environment and its implications for adoption of the Happy Seeder technology.

Objective 3: Advise if a small policy linkage/economic analysis project is required to complement any proposed technical projects which come out of the Workshop/Review.

Objective 4: Identify key personnel involved in policy formulation and decision-making relevant to the issues raised in the scoping study and suggest people to engage with and involve in a policy linkage project to maximise the probability of improving the policy environment and maximising adoption of the Happy Seeder technology.

1.3 Technical development of the Happy Seeder

As indicated above, the Happy Seeder technology was developed as a component of a broader ACIAR technical project on the use of permanent beds in irrigated cropping systems in north-west India and south-east Australia. This sub-section summarises the evolution of the technology, as outlined in Humphreys et al. (2006).

First generation- Happy Seeder

The original Happy Seeder was conceived and built by John Blackwell of CSIRO Griffith in collaboration with research engineers at Punjab Agricultural University (PAU), in July 2001. The machine consisted of a standard Indian seed drill with inverted T-boots attached by three point linkage behind a forage harvester with a modified chute. This early version of the Happy Seeder was then improved by incorporating independent PTO driven hydraulics on the forage harvester, enabling it to be used with any tractor in India, as most tractors in India do not have remote hydraulics. This was also done for all subsequent versions of the Happy Seeder.

Tests of the first Happy Seeder sowing wheat into approximately 6 t/ha of rice stubble were very encouraging, however, in some situations establishment was poor due to poor seed/soil contact and uneven distribution of straw.

Figure 1. Happy Seeder

Source: Humphreys et al. 2006

Second generation – Combo+ Happy Seeder

The main improvements to the Combo+ Happy Seeder version included:

- combining the forage harvester and seed drill into a single, compact, light weight (540kg), 2 metre wide machine which can be easily mounted on a three point linkage
- reducing the cutting width to 7cm in front of each sowing tyne (20cm spacings). This reduced the load of mulch produced as well as the tractor power requirements for use of the Happy Seeder.
- adding a narrow strip tillage assembly in front of the sowing tynes, which improves seed/soil contact on the sandy loam and loam soils in Punjab.

Figure 2. Combo+ Happy Seeder

Source: Humphreys et al. 2006

Extensive trials have been undertaken sowing wheat into up to 9t/ha of rice stubble in Punjab. Other trials have also been undertaken in other parts of India, Pakistan, and Australia. In Australia, trial results of the Happy Seeder technology have continued to be hampered by its poor ability to handle the very high stubble loads that often occur in Australian rice crops (up to 14t/ha). The results of the India and Pakistan based trials however, have been very encouraging, with comparable or higher yields being achieved than under conventional cultivation and direct drilling, both of which require stubble burning. In addition, the technology has potential application in a range of other cropping systems such as the establishment of mungbeans in wheat residues. Residual problems with the technology included restricted straw flow through the chute and clumpy distribution when the straw is moist, impeded establishment from the straw being deposited over the sowing lines, and gaps and overlapping of the area sown due to difficulties for the operator in visually identifying the sowing lines.

Third generation – Turbo Happy Seeder

The Turbo Happy Seeder, developed by Dasmesh Mechanical Works in collaboration with the Punjab Agricultural University (PAU), eliminates the chute, greatly reduces the amount of dust generated, and leaves sowing lines more exposed and visible, thus overcoming most of the difficulties with the earlier Happy Seeder models.

Initial trials of the Turbo Happy Seeder in 2005/06 sowing wheat into rice stubble in Punjab have indicated that it is a significant improvement on the Combo^{+} Happy Seeder. However, it has not yet undergone full evaluation. Seedling establishment in the trials using the Turbo Happy Seeder was very successful, but the crops did not perform to expectations. The researchers believe that this was due to poor management by the landowners (largely absentee or engaged in other businesses) after sowing. The Turbo needs to be tested in a range of conditions (stubble load, moisture, soil) and compared the Combo+ Happy Seeder in terms of stubble handling performance, power requirements, and crop performance.

Figure 3. Turbo Happy Seeder

Source: Humphreys et al. 2006

In summary, the Happy Seeder technology has now been developed to an advanced level, and has proven itself in terms of its suitability in handling a wide range of common soil and stubble conditions across rice-wheat production systems on the north-west Indo-Gangetic Plains of India, while producing equivalent or superior yield results to conventional approaches. The benefits of the Happy Seeder technology relative to a range of alternative stubble incorporation and stubble burning options include: significant fuel savings; faster turn-around between crops; increased opportunities for double cropping; improved soil properties; lower air pollution; higher moisture retention resulting in lower irrigation applications; and more effective weed suppression resulting in lower herbicide applications.

While some residual engineering and agronomic issues deserve continuing attention, the remaining uncertainties about the applicability of this technology centre on: the financial viability of the technology for individual farmers in a range of circumstances; other social or institutional constraints to the adoption of the technology; and on determining the most appropriate and efficient way of facilitating adoption.

2 THE HAPPY SEEDER TECHNOLOGY AND ITS COMMERCIAL POTENTIAL

2.1 Background

Initial financial and economic assessment of the on-farm adoption of the Combo Happy Seeder technology for rice-wheat farming systems in Punjab State has been undertaken by Singh et al. (2006), and were presented at the final workshop for ACIAR Project SMCN/2000/089 held at Punjab Agricultural University (PAU), Ludhiana, India, during 5-8 September 2006. The results of the financial evaluations are summarised in this section. These results will be published in full in the workshop proceedings.

In Punjab, rice-wheat cropping is the predominant and most profitable farming system and accounts for more than 60% of the total net sown area of the state (Government of Punjab, 2005). Timeliness of different field operations for both rice and wheat is a key element in fitting both crops in a year and achieving high yields. More than 90 percent of the rice grown in Punjab is harvested using combine harvesters leaving heavy loads of rice stubble in the fields. A major problem in this rice-wheat system has been in managing the heavy rice stubble (more than six tonnes/ha, Gajri, et al., 2002) in a way that allows wheat planting within the short period of time available. Due to a lack of suitable machinery to direct drill into heavy stubbles, burning of rice stubbles is widely practised.

While the Happy Seeder approach to stubble management and direct drilling of wheat may have significant financial, social and environmental benefits, its adoption on-farm involves significant initial capital investment, replacement and maintenance costs.

2.2 Approach

The main objectives of the initial financial assessment of the Happy Seeder technology were to: measure the potential on and off farm benefits from the current Combo model of the Happy Seeder technology to farmers; estimate the costs involved in adoption of the technology; and to identify constraints in the adoption of the technology. The initial evaluation has also identified some of the potential social and environment benefits associated with the Happy Seeder technology.

The methodology used to undertake the financial analysis involved a partial budgeting approach in which the additional and foregone annual costs and benefits of an option were compared. The analysis was principally carried out from a financial perspective. However, in addition, the economic benefits from improved water use efficiency that are achieved through reductions in electricity and other water pumping costs were estimated, to indicate the significance of some of the external benefits of the Happy Seeder technology. These economic values for pumping costs and electricity savings are included in the evaluations and presented as economic analysis results, but it is important to recognise that these do not represent full economic evaluation of the technology.

The criterion used in assessing the financial merit of converting to the Happy Seeder technology is the Net Present Value (NVP) of the proposal measured over a 20 year period.

2.3 Alternative management practices

The Happy Seeder combines the stubble mulching and seed drilling operations into the one machine. It chops the straw into mulch, undertakes limited row tillage, sows the seed and applies fertiliser in a single operation. The Happy Seeder technique eliminates the need for burning. The analysis evaluated the performance of this technology in comparison to current approaches to managing rice stubbles and sowing wheat after rice in Punjab. These current approaches are:

1. Burning of rice stubble residues and conventional sowing of wheat

This approach is followed on around 70% of the area sown to wheat after rice. After burning rice stubbles, the seedbed for sowing wheat is prepared with at least 2 workings using a disc plough, 2 tillage operations using a tyned cultivator, and 1 planking (levelling) (Singh, et al. 2006). Wheat is then sown using a conventional seed and fertiliser drill.

2. Burning of rice stubble residues and zero till sowing of wheat

Less than 10% of the total area sown to wheat follows this approach. It involves using zero tillage machinery to direct drill wheat seed and fertiliser after the burning of rice stubble residues.

3. Incorporation of rice stubble residues and conventional sowing of wheat

On less than 20% of the area sown to wheat in Punjab, rice stubbles are incorporated by cultivating. The field is then irrigated prior to sowing wheat with a conventional seed and fertiliser drill.

Full evaluations were undertaken of the Happy Seeder technology in comparison to the first two of these current approaches. Only partial evaluation of the performance of the Happy Seeder technology in comparison to the third (stubble incorporation) approach was possible, due to unavailability of sufficient technical data.

2.4 Cost differences between the alternative management practices

Based on the information provided by research staff involved in the development and trialling of the Happy Seeder technology, the potential net benefits from the use of the Happy Seeder were calculated. These net benefits arise though the reduction in field preparation and wheat sowing costs, reductions in the water, electricity, labour, fertiliser and herbicide input costs, and from improved chances of growing a short duration crop immediately after the wheat harvest.

The evaluations assumed contract rates for the hiring of machinery for farming operations required under each of the management practices outlined above. Information on the total custom hiring charges for both the tractor and other machinery for different agricultural operations (managing stubbles and seedbed preparation for sowing wheat after rice) are outlined in Table 1.

Table 1. Total costs of managing stubble and sowing wheat after rice in Punjab

Managing stubble/ sowing wheat	Cost (Rs/ha)
Stubble mulching Happy Seeder	2160
Stubble burnt, conventional tillage	3500
Stubble burnt, zero tillage	1690
Stubble incorporated, conventional tillage	4250

Additional input cost savings of the Happy Seeder in comparison to the alternative conventional approaches to managing rice stubble residues and sowing wheat are outlined in Table 2.

Table 2. Saving of operating and input costs from the use of the Happy Seeder

Operation / input use	Financial savings (Rs/ha)	Economic savings (Rs/ha)
Saving from operating cost of tubewells	Rs.28	Rs.73[a]
Saving from electricity used	Rs.0	Rs.595[b]
Labour saved	Rs. 238	
Reduction in fertiliser cost After 2 years After 5 years	 Rs.133 Rs.200	
Reduction in herbicide costs	Rs.875	

Notes:
a. The savings in tubewell operating costs arise from differences in the annualised capital, repair and maintenance costs of centrifugal versus submersible groundwater pumps. The centrifugal and submersible pump costs are assumed to represent financial and economic values (respectively), if adoption of the Happy Seeder prevents the decline of groundwater levels.
b. The difference in financial and economic values of electricity savings is caused by the subsidy on electricity to agriculture. While farmers pay infrastructure related costs for electricity connection, they face a zero tariff on electricity use.
c. Fertiliser cost savings only reflect savings in producing the wheat crop. Information was not available on potential fertiliser savings for subsequent rice crops in the rotation.

In addition to the above cost differences, it is expected that higher crop yield benefits will arise in the longer term from use of the Happy Seeder. However, data was not available to allow valuation of these effects within the initial financial evaluations.

2.4 Results

The value of total annual financial benefits from the use of the Happy Seeder over the stubble burnt/ conventional tillage option and the stubble burnt/ zero tillage option were estimated taking into account the benefits from reduced input costs and machinery operation costs. The total value of net annual financial benefits from the use of the Happy Seeder over the stubble burnt/ conventional tillage option was Rs.2495 per ha, and Rs.635 per ha over the stubble burnt/ zero tillage option.

When the economic value of improved water use efficiency through reductions in the costs involved in pumping out water and lower use of electricity in agriculture was included, the total value of net annual economic benefits from the use of the Happy Seeder over the stubble burnt/ conventional tillage option was Rs.3238 per ha, and Rs.1425 per ha over the stubble burnt/ zero tillage option. While these economic values account for only two of the externalities involved in these production systems, it demonstrates the significant difference between the value of the Happy Seeder from the point of view of individual farmers, in comparison to the value of the Happy Seeder technology from the point of view of the broader community.

The results of the benefit cost analysis of the alternatives, undertaken for a 20 year project period, are presented in Table 3.

Table 3. Results of the benefit cost analysis of the adoption of the Happy Seeder

Alternative option	PV of Happy Seeder benefits over alternative options	
	Financial (Rs/ha)	**Economic (Rs/ha)**
Stubble burnt, conventional tillage	32,750	42,500
Stubble burnt, zero tillage	10,150	20,000

The results of the financial analysis of adoption of the Happy Seeder indicate that the present value of total financial benefits from adoption of the Happy Seeder in comparison to stubble burnt/ zero tillage wheat are Rs.10,150 higher, and Rs.32,750 higher than the stubble burnt/ conventional tillage option. When economic values are incorporated for the water use efficiency related cost savings, the benefits of the Happy Seeder increase to Rs.20,000 and Rs.42,500 per ha over these other options respectively. The total value of the benefits would be significantly higher than these values for farmers who are able to also grow a short duration crop (such as mungbean) following the wheat crop.

These initial evaluations of the Happy Seeder technology were undertaken under significant time and information constraints, which limited the comprehensiveness of the evaluations. Nevertheless, the financial evaluations of the Happy Seeder technology indicate that the technology is financially viable for farmers (under assumptions of average farm size and custom hiring of the Happy Seeder), and is more profitable than conventional alternatives. In addition the evaluations indicate the significant potential additional value of the externalities associated with the Happy Seeder technology. A range of options for refining the evaluations have subsequently been proposed, and these are outlined in section 6 of the report.

3 THE BROADER POLICY ENVIRONMENT AND ADOPTION OF THE HAPPY SEEDER

The following two sections of the report identify and discuss issues arising from the current policy environment within which the Happy Seeder technology must be implemented, as well as aspects of the Happy Seeder technology itself which either present policy challenges, or would benefit from stronger linkages between policy makers and the technology implementers.

These issues were largely identified during meetings and interactions with a range of stakeholders in India during the period 2-9 September 2006. ACIAR representatives were present at many of these meetings. This included Dr Christian Roth at meetings with State based representatives in Chandigarh and at the PAU workshop, and Dr Kuhu Chatterjee at some of the nationally focussed policy maker meetings in New Delhi. ACIAR staff from the South Asia office in New Delhi were integrally involved in organising a large proportion of these meetings. Contact details of many of the key stakeholders who were consulted during the scoping study are contained in section 8 of the report.

3.1 State level focus on stubble burning as an air pollution issue

Stubble burning as a source of air pollution is generally not regarded as a national policy issue. Addressing these impacts is commonly regarded as being of state significance and a state responsibility, because it is at the local level that its effects are most acutely and immediately felt. Although burning of rice stubbles is not considered to be a national level issue, it is a serious problem in Punjab where more than 17 million tonnes of rice stubbles are burnt each year within 20 to 25 days of the rice harvesting period. This causes serious problems for soil health, human health, animal health, adjacent crops and remnant vegetation (which are important biodiversity havens), creates major traffic hazards, as well as releasing significant volumes of GHG’s into the atmosphere.

Stubble burning and air pollution issues are a larger problem in Punjab because of the more intensive agricultural systems present in that State. In most other rice-wheat areas of India rice stubbles are used as feed for dairy animals kept on each farm. In those areas the rice is generally harvested manually, leaving lighter loads of 2-4 tonnes/ha of rice stubbles in the field. Consequently, farmers can cultivate and sow wheat conventionally, or direct drill wheat into these remaining stubbles, without significant difficulty.

In Punjab, more than 90% of the rice is harvested using combine harvesters, leaving very heavy loads of up to 9 tonnes/ha of rice stubbles in the fields. These stubble loads cannot be efficiently managed with existing machinery. While Punjab farmers also commonly keep dairy animals, they satisfy their feed requirements with the more nutritious and digestible wheat and basmati rice straw, and do not utilise straw from the long grain rice varieties that comprise the bulk of the residue load.

This perception of stubble burning being a state based issue rather than a national issue is also borne out by the emphasis of national environmental NGO organisations such as The Energy Research Institute (TERI), which is focusing more on pollution issues relating to domestic cooking and transport pollution, because they see these as having broader national applicability.

3.2 Labour availability

The Indian Government has recently introduced policies which will provide guarantees of minimum levels of employment of up-to 100 days a year to people within their State of origin. Along with other transformations occurring in the Indian economy, this will significantly reduce the flow of itinerant migrant workers who previously provided a ready, low cost workforce for Punjab farmers. This tightening labour supply has implications for adoption of the Happy Seeder:

- While use of the Happy Seeder technology is less labour intensive than alternative rice stubble incorporation or removal practices, it is more labour intensive than alternatives such as rice stubble burning in combination with zero till. This is particularly the case while harvest straw needs to be dispersed manually before sowing with the Happy Seeder; and
- In neighbouring states such as Haryana and Uttar Pradesh, where the rice stubbles are commonly removed and used as low cost and low nutrition stock feed, the increasing scarcity and cost of labour will reduce the financial viability of this rice stubble removal activity. Hence, there may be increased need for Happy Seeder type technology in these areas as well in order to prevent the burning of rice stubbles before sowing wheat.

3.3 Electricity and groundwater inputs to irrigated agriculture

While government intervention in agricultural input and output markets significantly masks true economic prices for most inputs and outputs, brief specific consideration of electricity and groundwater inputs is warranted. The initial financial evaluations by Singh et al. (2006), reported in section 2 of this report, have already indicated the importance of these factors in the evaluation of the Happy Seeder technology.

Both electricity and groundwater are significant, but (financially) free inputs into irrigated agricultural production systems. Groundwater access is unregulated, and while farmers incur the significant capital costs of installing tubewells, there is subsequently no ongoing access or unit pricing of the water resources used. Similarly, farmers must pay significant capital costs in connecting the electricity supply to their tubewell pumps, but there is subsequently no ongoing access or unit pricing of the electricity consumed.

In addition to the inefficient use of these resources, the supply of both of these resources is in a precarious situation. Demand for electricity is significantly higher than supply capacity (and demand is growing quickly), and groundwater levels are falling at a rate of approximately 1 metre per year in some parts of Punjab. The consequences of this situation are that all sectors of the economy (domestic, business and industry) suffer from a highly unreliable electricity supply, and at some point in the relatively near future, groundwater will cease to be available - a devastating proposition for irrigated agriculture.

Policy reform in this area is inevitable, as the current drawdown of groundwater resources is unsustainable. Currently, the situation is viewed by many as intractable because of the perceived political infeasibility of imposing costs on farmers for use of these resources. However, while perhaps second best, relatively simple policy instruments can be implemented which guarantee that no farmer will bear any additional costs, but which provide the incentive for farmers to manage these resources in a more efficient and sustainable way, and consequently deliver substantial savings to government and the community. Policy instruments such as credit/rebate schemes which credit farmers with the average cost of their current or historical use of a resource (for example of the electricity used to pump groundwater), but which charge them on the basis of their marginal use, should be trialled as a means of making progress on these critical resource use issues.

While the potential reform of policy regarding management of these resources is of immense importance in its own right, the specific relevance of these issues for adoption of the Happy Seeder technology stems from the potential effect that such (inevitable) reforms may have on irrigated rice-wheat production systems in Punjab. As the costs of these resource inputs begin to be internalised by farmers, the relative profitability of (water input intensive) rice production in comparison to other potential crop and rotation choices will change. This has implications for the Happy Seeder in terms of a possible reduction in the need for its current primary purpose (sowing wheat into rice stubble), but also increases the potential need for the Happy Seeder to be flexible in its ability to efficiently sow alternative crops into other types of heavy stubble loads.

3.4 Land law

National Indian land policy and State based legislation (*Punjab Land Reforms Act 1972*) continue to restrict ownership of land to 7 hectares per person in Punjab (for the most productive land). While both corporate and family farming interests find ways of complying with these regulations while operating farm production units of significantly greater size, this continuing restriction is worth noting in the context of the economics of private ownership of the Happy Seeder. Farm size remains less than 4 ha for more than 70% of operational holdings (Government of Punjab, 2005). Farm size affects the financial viability of individual farmers owning and using the Happy Seeder on their farm, in comparison to contractor and cooperative based approaches to making the technology available.

3.5 Agricultural training and extension capacity

There is an extensive established agricultural extension and training network operating in Punjab which can be utilised to support extension efforts to enhance adoption of the Happy Seeder technology. Punjab is comprised of 17 Districts, 46 Subdivisions and 141 Development Blocks. Each Development Block includes about 100 villages, has a State Agricultural Officer, and there is one state government extension person for approximately every 10 villages (total of 12,238 villages).

Punjab Agricultural University (PAU) also has extension offices at District headquarters, and publishes a number of extension publications, including *Progressive Farming* and *Changi Kheti* which are highly regarded by farmers.

Each district has one KVK (Krishi Vigyan Kendran “Agricultural Science Centre”), as do all of India’s approximately 530 districts. The main purpose of the KVKs is extension of technology (training, on-farm demonstrations, field days etc). In addition, The Rice-Wheat Consortium operates over the entire rice-wheat region of South Asia, and its major function is promotion of “resource conserving technologies”. Consequently, adoption of the Happy Seeder technology is unlikely to be hindered by information failures in the extension process, as there are adequate pathways for the provision of practical extension and training activities with farmers.

3.6 Banking and credit services

Lack of credit availability is unlikely to be a widespread barrier to adoption of the Happy Seeder. The high market value of agricultural land has resulted in reasonably high levels of credit availability for irrigated rice-wheat system farmers in Punjab. In fact, views were expressed by some stakeholders during the scoping study that credit is provided too readily to farmers and that some financial institutions have recently been paying insufficient attention to the underlying financial viability of the investments for which credit was being sought. As a result, while the land value provides financial institutions with sufficient security against loans, there is an increasing rate of loan repayment default and forced sale of farms (with consequent social implications). Credit provision arrangements for the Happy Seeder need to account for these potential effects. This is further discussed in section 4.12 below.

4 POTENTIAL CONSTRAINTS TO THE ADOPTION OF THE HAPPY SEEDER

This section of the report discusses specific aspects of the Happy Seeder technology and how policy related actions may either be necessary or would facilitate adoption. These include technical and physical issues as well as financial, social, and institutional aspects of and linkages to the Happy Seeder.

4.1 Engineering design issues

At the final workshop for ACIAR project SMCN/2000/089, a session was held to identify and discuss technical constraints and issues with the current engineering design of the Happy Seeder, and to suggest potential approaches to addressing these design issues. The session proposed the following as key issues to be addressed:

- Development of a lightweight Happy Seeder which can be used with the 35 HP tractors that are more common on small – medium sized Punjab farms;
- Increasing the capacity of the Happy Seeder for use in planting a wider range of crops into a wider range of residues, so as to increase the potential annual utilisation of the machine;
- Undertaking a comparative evaluation of the Turbo Happy Seeder on medium and heavy soils; and
- Development of a straw manager and spreader for combine harvesters, so as to eliminate the need for manual spreading of straw prior to sowing with the Happy Seeder.

4.2 Agronomic issues

The final workshop also incorporated a focus on agronomic constraints and issues with the use of the Happy Seeder, and proposed the following as key issues to be addressed in supporting the wider adoption of the technology:

- Determining the effect of straw mulch on soil moisture conservation and irrigation needs of wheat sown with the Happy Seeder;
- Refining appropriate nitrogen management strategies for wheat grown under mulched conditions; and
- Evaluation of the Happy Seeder for straw management in wheat on raised beds in an annual rice-wheat system.

4.3 Financial viability of technology

As discussed in section 2 of this report, the initial financial evaluations of the Happy Seeder technology indicate that the technology is financially viable for farmers, and is more profitable than conventional alternatives. However, these evaluations were restricted due to the availability of time and data, and were only undertaken under assumptions of contract provision of Happy Seeder sowing services for an “average” farm. Consequently, the implications of uncertainty for some of the key variables in the analyses have not been able to be adequately investigated, and investigations for a range of farm circumstances have not yet been undertaken. Given the expected sensitivity of the financial viability of the technology to these factors, firm conclusions about financial viability cannot yet be made.

4.4 Distorted price signals

Key features of the Happy Seeder technology are its capacity to substantially reduce the input requirements of a rice-wheat production system and its capacity to reduce adverse side-effects of the production system (especially air pollution from rice stubble burning).

However, prevailing institutional arrangements surrounding the rice-wheat production systems of Punjab mean that many of the financial benefits of adopting the Happy Seeder technology are not received by the adopting farmers (or put differently, the current costs of following conventional farming practices are not financially borne by those farmers). Consequently, the financial incentive to change practices is much lower than in circumstances where more of the costs of conventional practices are privately recognised and borne by farmers instead of being socialised to the broader community.

The range of agricultural production inputs for which farmers do not bear the full cost is quite broad, including irrigation water, electricity for pumping irrigation water, petroleum products, fertiliser, herbicides and pesticides. In addition, the benefits accruing to the community from the reduction in stubble burning related pollution include: improvements in human and animal health; reductions in traffic accidents and delays; reductions in damage to community roadside infrastructure, plantations and biodiversity; and reductions in GHG emissions. The consequences of these price distortions and broader impacts being invisible to farmers (potential adopters of the Happy Seeder technology) was borne out in the initial financial evaluations undertaken by Singh et al. (2006), which demonstrated a marginal financial benefit for farmers adopting the technology.

4.5 Alternative technologies for managing rice stubble residues

While a very high proportion of rice stubble residues in Punjab are currently managed using the stubble residue burning or incorporation technologies evaluated in the initial financial evaluations, there is a range of potential alternative uses for rice stubble residues. These alternative uses are in various stages of being operationalised, and all have significant technical and/or economic limitations which researchers and policy makers are attempting to address. Rice stubble residues may have the potential to be used:

- in thermal power plants as a fuel for electricity generation;
- for bio-gasification in electricity generation;
- in ethanol production;
- as livestock feed;
- as cushioning material in the packaging of manufactured goods;
- in paper and plywood;
- in floor tiles; and

- as a soil conditioner, using improved stubble incorporation technologies.

It should also be noted that most of these potential alternative uses have at some time also been investigated in Australia. None have been found to be financially feasible in the Australian context.

4.6 Policy maker focus on financial viability

Consultations regarding technology and policy issues were conducted with Punjab State Government policy makers including representatives from the Department of Agriculture, Punjab Science and Technology Council, and Punjab Pollution Control Board. Whilst there was strong interest in the potential of the Happy Seeder technology, there were some reservations about adoption prospects. These agencies considered that the proof of usefulness of the technology will be whether farmers independently adopt the Happy Seeder on the basis of its private financial viability (in comparison to continuation of existing practices or adoption of alternative rice stubble residue management options).

We agree that the Punjab Government should not be looking to intervene in the adoption process with financial incentives/subsidies if there is sufficient private financial incentive for farmers to independently adopt on the basis of the inherent profitability of use of the technology, and if the level of privately driven adoption approximates the efficient level from the point of view of society more broadly. However, given the significant external benefits associated with the Happy Seeder technology, it may be both necessary and appropriate for the Punjab Government to intervene in the market in order to encourage adoption at levels more in line with socially efficient outcomes. The best way for the Government to intervene is through policies which internalise negative externalities associated with the alternative (privately) more financially attractive residue management options (eg. stubble burning for some farmers). However, given the complexity of the policy reform process, the Government is also likely to consider second-best options such as the provision of subsidies and other incentives to enhance adoption of the Happy Seeder.

The above would suggest that there is a strong case for undertaking an economic evaluation of the technology, including evaluation of the external benefits (and costs) of the technology which accrue to the broader community, in order to determine a more complete valuation of the net benefits of the Happy Seeder technology. This evaluation needs to be undertaken in a way that the results can be compared with outcomes under alternative approaches to rice stubble residue management. It would seem that without such an evaluation, there may be inadequate recognition of the rationale for intervention and an inefficiently low level of adoption of the Happy Seeder technology.

4.7 Low policy maker awareness of the limitations of alternative technologies

The Punjab Science and Technology Council and the Punjab Pollution Control Board have identified the Happy Seeder concept as one of several technologies that would enable the phase-in of enforcement of bans on residue burning over the next two years. They are strongly supporting ACIAR to fund a Happy Seeder policy linkages project on this technology. In addition, the Punjab Department of

Agriculture, supported by the Punjab Farmers Commission, also has identified the Happy Seeder concept as one of several options to phase in enforcement of bans on residue burning. However, there appears to currently be only a rudimentary understanding of how the Happy Seeder technology may fit into the mix of alternative rice stubble residue management options.

While technical research has been undertaken on many of these alternative technologies (including long-term trials of some of the technologies), the technical (and/or economic) limitations of these technologies, as expressed by technical experts in research institutions such as PAU, may not have been effectively conveyed to the relevant policy makers. Examples include: the belief that long term trials of a pilot thermal electricity generation plant (operating for over 15 years) have now determined a way to efficiently operate on rice straw based fuel (whereas technical experts maintain that this has been unsuccessful and that the power plant now only uses rice husk as fuel); and the belief that the manufacture of high quality floor tiles from risk husks may also be possible with rice straw (which technical experts refute due to high silica content that makes it unsuitable for manufacturing high quality tiles).

A state level Taskforce has now been established in Punjab to review the full range of technologies that could be used as an alternative to the burning of rice stubbles in the field. This is an important step, as there is currently a lack of synthesis occurring in the presentation of technical and economic information to policy makers regarding these alternative technologies. During the consultations, it was acknowledged that there is little expertise in economics within the Pollution Control Board, and that past attempts to involve university based research economists in projects relevant to their work had not been successful. The current Taskforce presents a valuable opportunity and mechanism to present the case for the Happy Seeder within the context of the currently unrecognised limitations of the alternative technologies.

4.8 Government impediments to the manufacture of the Happy Seeder

Discussions with the management of Dasmesh Mechanical Works indicated that, from their perspective, the most significant variable controlled by government that is likely to impact on the commercial success of the Happy Seeder, is the current non-enforcement of State Government stubble burning regulations. Enforcement of the existing regulations would be of significant benefit to Dasmesh, given that they produce possibly the only commercially viable technology to enable the planting of a wheat crop within the time available after rice harvest. Whilst Dasmesh would welcome the provision of government subsidies to encourage the purchase of Happy Seeders, this is of secondary interest relative to the enforcement of existing stubble burning laws.

The management of Dasmesh Mechanical Works were also asked if there were any other institutional constraints which significantly impact on their capacity to produce the Happy Seeder (and to significantly increase production levels if demand for the Happy Seeder technology increased rapidly). Such institutional constraints might include restrictions on access to material inputs required in the production process, regulatory constraints on the operation of their business, bureaucratic delays in any approvals or licences etc. Dasmesh considered that there were no significant binding constraints in these areas. Some earlier constraints have already been addressed independently by Dasmesh (for example, Dasmesh have installed their own power generation capacity to overcome the constraints of an otherwise unsuitable and unreliable electricity supply).

4.9 Patenting issues

The issue of patents and other intellectual property protections over the Happy Seeder design were also discussed. Dasmesh do not see a need to patent the novel innovations contained within the Happy Seeder design. This is largely due to a number of market and technology factors including: their significant head-start over any potential competitors; the Dasmesh reputation for producing quality machinery; and their commitment to making on-going improvements to the Happy Seeder design. Dasmesh consider that these factors will continue to provide them with a competitive edge over any other manufacturers who commence development of similar machines. However, Dasmesh are concerned about inferior copies of the Happy Seeder affecting the overall reputation of the technology. This concern was also strongly supported by PAU engineers involved in the development of the Happy Seeder (eg. Dr H.S. Sidhu). Their concerns are that patents may restrict transfer of the technology, but they would like to ensure that there is quality assurance oversight in the production of the implement by other agricultural machinery manufacturers.

This issue needs careful analysis before patenting options are dismissed. An alternate view to those expressed above is that failure to patent the technology may itself lead to lower levels of technology transfer. While patenting is often motivated by the potential to extract rents (or rewards) for the innovator, this need not be the only motivation for pursuing patent options. Patenting can be used as a very effective means of keeping control over the technology transfer process. It would provide a much stronger base for ensuring that manufacturers producing sub-standard quality Happy Seeders do not establish themselves and harm the reputation of the technology within the farming community. Patenting would ensure the ability of the patent holder to specify a profile of key design characteristics and standards as a condition of the licence, even if multiple licences were available at minimal cost. In addition, historical evidence suggests that for many new innovations, some level of protection from completely open competition (for example through co-exclusive licensing) is necessary initially to encourage the necessary start-up investment (Heisey et al., 2006).

Management of intellectual property is a complex issue and it is important to recognise that strategic behaviour by others to either capture the technology, or artificially protect inferior products in the marketplace can create significant disruption for producers of unpatented innovations. So patenting by the developers of the Happy Seeder may also be useful in preventing strategic behaviour by competitors.

Full consideration of patent issues should be undertaken promptly, as public disclosure of the Happy Seeder technology to the point where it is common knowledge may adversely impact on the ability to place patents on the innovation.

The level of public disclosure at which the ability to patent the Happy Seeder technology is compromised, may already have been exceeded.

4.10 Private impediments to the manufacture of the Happy Seeder

Dasmesh manufacture a wide range of implements (including threshers, rotary tillers, reapers and seed drills), and fabricate almost all components of their machinery on site. The company is operationally experienced in responding to rapid shifts in demand for individual machinery products. They manage this process by maintaining high stock levels of the individual machinery components, and by maintaining flexibility in their assembly operations which allows for rapid changes in production to supply particular types of machines. Dasmesh indicate that they have the capacity to manufacture up to 5 Turbo Happy Seeders per day. This level of manufacturing capacity is a highly relevant parameter for policy makers when they are determining a feasible timetable for enforcement of the ban on residue burning.

Dasmesh Mechanical Works currently market their implements directly to Punjab farmers from their manufacturing facilities at Amargarh and Ludhiana. The company also markets their products throughout India through a network of 15-20 dealers outside of Punjab.

Current pricing of the Happy Seeder is Rs.60,000 (approximately A$1800). Dasmesh expect this price to remain relatively stable for the next few years, with economies of scale from increased production volumes expected to counter the current inflation of 6-7% p.a. in the Indian economy (approximately 10% p.a. for key steel, energy and other machinery manufacturing inputs). Consequently, the real price of Happy Seeders may decline by around 6-10% p.a. over the next few years if there is sustained demand for the implement.

4.11 Training and extension issues for the Happy Seeder

One of the proposed advantages of the Happy Seeder is its ability to ensure that farmers can sow their wheat crop within the short window of opportunity following the rice harvest. However, this short window also means that there is only a limited period in which to productively utilise and generate a return on the capital cost of the machine (whether by own-use on farm, as a contractor, or by a local cooperative). Due to the critical nature of timeliness, an important consideration in determining the practical performance of the Happy Seeder is the reliability of the machine. Dasmesh maintain high production and reliability standards for the machines that they manufacture. Dasmesh recommend and provide advice on regular machinery maintenance practices, can provide spare parts, and offer machinery overhaul services (for example after 10 years) for a fraction of the machinery replacement cost in order to keep their products operating in optimum condition. In addition, a mobile breakdown service is available to undertake on-farm repairs anywhere within Punjab. Nevertheless, training of farmers in the appropriate use and maintenance of the Happy Seeder and in undertaking minor repairs should be considered as part of the adoption strategy for the technology.

4.12 Credit availability to purchase the Happy Seeder

The availability of credit was briefly discussed in section 3 above. Examples which illustrate that credit restrictions are unlikely to restrict adoption of the Happy Seeder include the recent capacity of approximately 33% of farmers to undertake individual farm capital investments in the order of Rs.70,000 - 100,000 to install groundwater tubewells and associated pumping infrastructure over the last 3 years.

An ACIAR policy linkage project is unlikely to require a focus on credit provision in order to facilitate adoption of the Happy Seeder technology. However, the anecdotal evidence of somewhat unconstrained credit provision to some parts of the agricultural sector does suggest that there may be value in ensuring that local credit providers are made aware of the potential variability in the financial performance of farmer investments in the Happy Seeder technology, depending on factors such as the scale of the farm and potential contracting opportunities.

5 KEY ISSUES TO BE ADDRESSED BY A POLICY LINKAGE PROJECT

This section outlines key issues which could be addressed by an ACIAR policy linkage project.

The final project workshop identified a range of engineering design and agronomic issues which require further developmental investigation and trialling. It is anticipated that there will now be a greater focus on trials with farmers and extension activities with the broader farming community (ie. a further move out of the research institution environment), and that where possible, the further development of the technology will also occur in this 'real world' environment.

This would be consistent with the expectations of State policy makers, who at this point are particularly focussed on both generating farmer interest and observing farmer acceptance of the technology. Farmer based trials would also be consistent with many of the requirements for improved data (from a wider range of circumstances) in refining the financial analyses and undertaking economic analyses of the Happy Seeder technology as outlined in Singh et al. (2006). For the reasons outlined below, there appears to be a key need for improved information in this area of the policy process.

5.1 Evaluation of financial viability of the technology

Assessment is required to determine the circumstances under which there is sufficient private incentive for independent adoption of the Happy Seeder by farmers, across the range of (rice-wheat) farm types. In particular, 'sufficient incentive' requires that the technology is not only financially viable, but also that it is financially preferable to alternative technologies and practices that are available.

While initial financial evaluations of the Happy Seeder technology have been undertaken, these evaluations are currently not sufficiently broad or robust to adequately inform a range of stakeholders in their efforts to further develop the technology and generate adoption. The types of issues which need to be accounted for in more comprehensive financial evaluations include:

- explicitly basing the evaluations on the Turbo version of the Happy Seeder instead of the Combo$^+$ Happy Seeder;
- refining assumptions regarding Happy Seeder technology utilisation levels, operating costs etc;
- refinement of the costs of the alternative management options for sowing wheat after rice, in comparison to the Happy Seeder
- detailed assessment of the potential for the Happy Seeder to increase opportunities for growing a short season crop following wheat;
- assessment of alternative modes of technology availability for farmers (purchase of the Happy Seeder by individual farmers; cooperative ownership of Happy Seeders by local groups of farmers; and encouraging contractors to purchase the Happy Seeder technology and provide contract services over a wide area);

- evaluations for a range of farm sizes and types, rather than an “average” farm

Full evaluation of the financial viability of the technology, would meet the needs of a range of stakeholders, including:

Extension officers and farmers

Successful extension efforts require farmers to be informed about not only the technical feasibility and performance of the Happy Seeder technology, but also about the financial implications in situations similar to their own.

Researchers

Financial evaluation of the technology for a range of farm sizes etc is necessary to inform researchers and engineers about the need for current proposals such as the development of a lightweight Happy Seeder which could be used with the less powerful tractors that are common on medium sized rice-wheat farms in Punjab. While there may be sound reasons for proposing these types of modifications, thorough financial evaluation of different modes of technology provision (eg individually owned by farmers, local cooperative ownership, contractor provision etc) may find that there are alternative, more efficient approaches to facilitating adoption of the technology across the spectrum of farm types.

Financial institutions

Making credit providers aware of the potential variability in the financial performance of farmer investments in the Happy Seeder (depending on the scale of the farm, potential contracting opportunities etc.), may be useful in facilitating appropriate adoption of the technology and minimising inefficient adoption.

Policy makers

The outcome of financial evaluations of the technology across a range of farm types is critical information for policy makers in that it informs them of the circumstances where there is likely to be sufficient private incentive for adoption, and the circumstances where there is not.

5.2 Evaluation of the net public benefit of the technology

Policy makers require information on the attractiveness of the Happy Seeder technology from the point of view of the community as a whole. That is, assessments which also include consideration of the many external benefits associated with the technology such as reduced natural resource use, reduced government costs otherwise provided through production input subsidies, reduced pollution related costs from stubble burning etc. Singh et al. (2006) identified a series of potential externalities associated with adoption of the Happy Seeder technology. These include reduced:

- GHG emissions (from both reduced stubble burning and diesel use);
- depletion of soil nutrients;
- use of water resources;
- biodiversity loss associated with stubble burning;
- use of electricity in agriculture;

- traffic hazards and accidents from stubble burning; and
- adverse impacts on human and animal health from air pollution.

Government needs information on these effects so that they can make judgements about whether the level of privately driven adoption is approximating the publicly optimal level. This information is essential in the design of appropriate policy instruments (discussed below in section 5.3).

Discussions during the scoping study demonstrated that, for some policy makers, there was a lack of appreciation of the relevance of this type of information within their decision making. That is, policy makers appeared to have a strong focus on understanding the financial viability of the technology to individual farmers, and were less focussed on issues of whether and how they should intervene if farmers did not find the technology financially attractive. Consequently, development of this type of information through an ACIAR policy linkage project will improve the recognition of public policy issues surrounding the Happy Seeder, and should increase the efficiency of policy interventions by Punjab policy makers in regards to both this and a wide range of future issues.

5.3 Assessment of potential policy instruments

If governments perceive that privately driven adoption of the technology is unlikely to approximate publicly efficient levels, then some form of government intervention may be warranted. In these circumstances, an ACIAR policy linkage project which provides policy makers with information about the performance of various policy instruments/approaches would be valuable.

These potential policy instruments include a range of regulatory and suasive (economic and education/information based) instruments to encourage or mandate the internalisation of some of the external costs which are associated with current high input agricultural practices (eg associated with high input use of water, electricity, fertiliser, herbicides) and with stubble burning practices. These approaches need not alter the total amount of assistance provided to the agriculture sector (or to individual farmers) but may simply change the array of incentives that they face to undertake particular practices.

Judgements about appropriate government interventions require information not only about the performance of the Happy Seeder technology, but about the alternative technologies which are available that could be used to achieve the same objective (eg. the livestock feed, ethanol, thermal power generation fuel options).

5.4 Review of intellectual property protection options

The specific issue of patents and other intellectual property protections over the Happy Seeder design should be reviewed as part of the proposed linkage project, with the objective of ensuring that optimal arrangements are put in place to encourage production and dissemination of the technology (whether by Dasmesh or other manufacturers), while maintaining the integrity of the design and a high standard of quality. The current proposal to forego patent opportunities may not be the best course of action for maximising the medium and longer-term availability and use of the new technology. Quick action on this issue is required because of the potential for extensive public disclosure of the innovation to nullify patent opportunities. These opportunities may in fact have already been lost.

5.5 Potential collaborators

Successful implementation of the potential policy linkage project on the Happy Seeder will require strong Indian collaboration. These collaborating individuals and their organisations in India are needed both in undertaking the research and as a conduit to influence policy makers.

An important aspect of the consultations with stakeholders in India during the scoping study was that it facilitated the identification of personnel/organisations involved in research, policy formulation and decision-making relevant to adoption of the Happy Seeder. The unpublished version of the final report (provided only to ACIAR) identified a number of potential Indian collaborators who may be interested in participating if an ACIAR policy linkage project is developed as a result of the scoping study recommendations. This personal information has been omitted from the publicly available version of the report.

6 REFINEMENT OF THE POLICY LINKAGE PROJECT PROPOSAL

While it would be valuable for all of the key issues identified in section 5 above to be comprehensively addressed within an ACIAR Policy Linkage Project, there will be both financial and time restrictions to any potential project. This means that the project will need to be narrowed to a subset of these issues. Refinement of the project proposal will be determined by the project objective, which at this stage is still somewhat fluid. In undertaking this scoping study, some of the stated and implied objectives of any subsequent policy linkages project have included:

- maximising farm profitability in rice-wheat systems in Punjab, through adoption of the Happy Seeder technology;
- maximising adoption of the Happy Seeder in rice-wheat systems in Punjab;
- promoting the role of the Happy Seeder as a means of dealing with rice residues (without burning) in rice-wheat systems in Punjab; and
- maximising net public benefits from addressing rice stubble burning in Punjab (including through use of the Happy Seeder).

While each of these objectives is relevant (and linked with each other), the emphasis of the proposed project changes, depending on which objective is seen to have priority. For example, if the principal objective of the project is to increase adoption of the Happy Seeder, then the project would have a greater emphasis on evaluating the farm level profitability of the technology, on evaluating the full range of additional external impacts of the technology (associated with reduced inputs of water, electricity, fertiliser, herbicides etc, as well as pollution reduction), and in evaluating alternative policy instruments for specifically increasing uptake of the Happy Seeder by farmers. However, if the principal objective of the project is to maximising net public benefits from addressing rice stubble burning in Punjab (including through use of the Happy Seeder), then the project would still require thorough evaluation of the farm level profitability of the technology, but would have a greater emphasis on evaluating externalities associated with the pollution reduction capabilities of the Happy Seeder, and in comparing these to alternative technologies and uses of rice stubble residues (eg removal for livestock fodder, as a fuel for electricity generation etc).

It is important to note that as a consequence of refining the research emphasis, some of the preferred project collaborators in India may also change, so that collaborators with the greatest capacity to influence policy makers relevant to specific project objectives, are associated with the project.

7 STAKEHOLDERS THAT PROVIDED INPUT INTO THE SCOPING STUDY

The unpublished version of the final report (provided only to ACIAR) included the names and full contact details of individuals who provided input during the preparation of this scoping study. This personal information has been omitted from the publicly available version of the report. Following is a list of the organisations to which the participating stakeholders were affiliated.

7.1 National policy-focussed government, semi-government and non-government organisations

- Indian Council of Agricultural Research
- International Maize and Wheat Improvement Centre (CIMMYT)
- The Energy and Resources Institute (TERI)
- National Centre for Agricultural Economics and Policy Research (NCAP)

7.2 State policy-focussed government, semi-government and non-government organisations

- Punjab State Department of Agriculture
- Punjab Pollution Control Board
- Punjab State Council for Science and Technology
- Punjab Farmers Commission

7.3 Technical agencies and organisations

- Dashmesh Mechanical Works
- Punjab Agricultural University
  - Department of Farm Power & Machinery
  - Department of Soils
  - Department of Economics

8 REFERENCES

Gajri, P.R., Ghuman B.S., Samar Singh, Mishra R.D., Yadav D.S., and Harmanjit Singh (2002). 'Tillage and residue management practices in rice-wheat system in Indo-Gangetic Plains – A Diagnostic Survey', Technical Report, National Agricultural Technology Project, ICAR, New Delhi and Department of Soils, PAU, Ludhiana, India.

Government of Punjab (2005). 'Statistical Abstract of Punjab', The Punjab State Department of Economics and Statistics, Chandigarh.

Heisey, P.W., King, J.L., Day-Rubenstein, K., and R Shoemaker (2006). 'Government patenting and technology transfer', Economic Research Report No. 15, Economic Research Service, United States Department of Agriculture.

Humphreys, E., Blackwell, J., Sidhu, H.S., Malkeet-Singh, Sarbjeet-Singh, Manpreet-Singh, Yadvinder-Singh, and L. Anderson (2006). 'Direct drilling into stubbles with the Happy Seeder', IREC Farmers' Newsletter, No. 172, Autumn, Irrigation Research and Extension Committee, Griffith NSW.

Singh R.P., Dhaliwal, H.S., Tejpal-Singh, Sidhu, H.S., Manpreet-Singh, Yadvinder-Singh and Humphreys, E. (2006). 'Financial and economic assessment of on-farm adoption of the Happy Seeder technology for rice-wheat farming systems in the Punjab state, North-west of India', paper presented to the ACIAR Project SMCN/2000/089 Workshop, PAU, Ludhiana, India 5-7 September.