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Final report

Small research and development activity

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1.1 Abbreviations used in the Report

ACIAR	Australian Centre for International Agricultural
ADO	Agricultural Development Officer
BARI	Bangladesh Agricultural Research Institute
BAU	Bihar Agricultural University
BIC	Bayesian Information Criterion
CA	Conservation Agriculture
CASI	Conservation Agriculture Sustainable Intensification
CBA	Cost Benefit Analysis
CHC	Custom Hire Centre
CIMMYT	International Maize and Wheat Improvement Centre
CSIRO	Commonwealth Scientific Research Organisation
e.g.	for example
EGP	Eastern Gangetic Plains
FGD	Focus Group Discussions
FPO	Farmer Producer Organisation
GDP	Gross Domestic Product
GFAR	Centre for Global Food and Resources
GRDC	Grains Research and Development Corporation
GST	Goods and Services Tax
GoI	Government of India
HP	Horse Power
HS	Happy Seeder
ICAR	Indian Council of Agricultural Research
IDCG	Insight Development Consulting Group
i.e.	that is
IFPRI	International Food Policy Research Institute
IIWBR	Indian Institute of Wheat and Barley Research
IGP	Indo-Gangetic Plains
InP	Innovation Platform
INR	Indian Rupee
KVK	Krishi Vigyan Kendras
LC	Latent class
LHS	Left hand side
MSP	Minimum Support Price

NABARD	National Bank for Agricultural and Rural Development
NAI	National Agroi Industries
NCR	National Capital Region
NGO	Non-Government Organisations
NE	North-East
Ns	Not significant
NW	North-West
OFRD	On Farm Research Division (of BARI Bangladesh)
PAU	Punjab Agricultural University
PES	Payments for environmental services
RDRS	Rangpur Dinajpur Rural Services
RHS	Right hand side
SMS	Straw Management System
SRFSI	Sustainable Resources Farming Systems Intensification
TAAS	Trust for Advancement of Agricultural Sciences
t/ha	tonnes per hectare
UBKV	Uttar Banga Krishi Viswavidyalaya
VCA	Value Chain Analysis
ZT	Zero-Till
2WT	4 wheeled tractors
4WT	2 wheeled tractors

2 Executive summary

The Australian Centre for International Agricultural Research (ACIAR) through the Sustainable Development Innovation Portfolio (SDIP) commissioned the University of Adelaide's Centre for Global Food and Resources (GFAR) to investigate and provide recommendations as to how the adoption of zero-till (ZT) technology (particularly the Happy Seeder (HS)) can accelerate in an effort to provide a viable option for farmers across the Indo-Gangetic Plains. An important objective examined how best to cease the practice of burning crop stubble residues and in turn reduce human health impacts through reduced air pollution.

Key outcomes from this study include the development of a policy brief that provides recommendations for creating enabling environments that support the accelerated adoption of conservation agriculture sustainable intensification (CASI) technologies. The policy brief identifies innovative implementation pathways and enhanced value chains, and a series of specific actionable recommendations are provided that need to be adopted as a matter of urgent action by Governments.

2.1.1 Impending challenges

The Indo-Gangetic Plains (IGP) region encompassing parts of northern India, northeast Pakistan, south-eastern Nepal and western Bangladesh is generally characterised by an intensive rice-wheat cropping system that represents a successful outcome of the green revolution. Farmers have readily adopted high yielding, short season varieties that when combined with high inputs, ready access to irrigation and tillage has resulted in regional food security. This success has come at a cost, since the increased intensification of cropping systems is leading to serious environmental concerns in relation to the long-term impact on sustainability. The fragility of the farming environment is reflected in the impact of significant air pollution from the burning of crop residues, decreasing soil health (declining soil fertility and soil structure), increased weed and pest resistance (such as herbicide resistance in *Phalaris minor*) and declining water resources and water quality (through contamination from nitrate fertiliser, pesticide residues from excessive use). At the same time, farmers are under immense pressure to maintain their livelihoods as increasing costs of production and a lack of market opportunities place them under financial hardship. Maintaining regional food and water security remains a significant challenge under the current environmental conditions that place long-term sustainability on a knife-edge. The introduction of financial penalties for farmers burning rice straw residues particularly in NW India is likely to lead to a sense of panic and uncertainty amongst farmers in an environment characterised by a low level of awareness of alternative options such as the Happy Seeder.

2.1.2 Research approach

Extensive field research involving on-farm adoption studies and a value chain analysis (linked to the supply and availability of ZT seed drills including the Happy Seeder) was conducted amongst farmers and other stakeholders associated with ZT/HS adoption. Using an action research approach, a series of consultative workshops followed that targeted value chain stakeholders as well as senior policy makers in an effort to provide evidence-based policy recommendations that could be implemented by Governments across the targeted regions. In particular, the study identified reasons why policy change is required, what policy changes would be effective, and how best relevant policy could be best implemented.

2.1.3 Geographical areas of focus for the study

The study targeted a number of regions across the IGP, comprising NW India (the States of Haryana and Punjab), the Eastern Gangetic Plains (EGP) Indian states of Bihar and West Bengal, and NW Bangladesh. A motivation for the study was prompted by the serious incidence of air pollution shrouding the national capital of Delhi (brought about farmers from Haryana and Punjab burning rice stubble residues prior to sowing of their winter wheat crops). However, the study also included the EGP region as a contrasting area where it was considered that in the future the incidence of stubble burning by farmers would increase as the cropping systems intensified and mechanisation systems adopted.

2.1.4 Research findings

Cropping systems in NW India (Haryana and Punjab)

Long-term sustainability of the intensive rice-wheat cropping systems are being questioned by farmers and agricultural experts. The impact of farmers burning rice straw residues prior to cultivating and sowing wheat is now recognised as a significant environmental problem, affecting the wider Indian community notwithstanding the serious air pollution problems in the nation's capital New Delhi. Despite the Happy Seeder being available commercially for more than 10 years as the only viable option to direct seeding cereal crops into standing crop stubble there is little farmer awareness of the technology. A lack of awareness and difficulty in accessing information combined with traditional farmer beliefs that crops can only be sown into well-tilled residue free seed beds serve as some of the major constraints to adoption of the HS and ZT seed drills.

Cropping Systems in the Eastern Gangetic Plains (Bihar and West Bengal)

Increased intensification of cropping systems across the Eastern Gangetic Plains (EGP) region is being achieved through the introduction of mechanisation in place of manual labour (that increasingly is becoming in short supply and more expensive). Whilst the manual harvesting of rice crops removes much of the straw (that is regarded as a highly valued animal feed source), an increasing trend towards the machine harvesting of crops is seeing a greater amount of stubble residue remaining in the field that is being burnt prior to the sowing of the next crop. Wheat straw residue levels (less valued as an animal feed source) are also increasingly being burnt in a trend triggered by the introduction of mechanical harvesting. The burning of rice straw residues is becoming an issue in western Bihar (in close proximity to the UP border region), as well as in the Malda district of West Bengal. As mechanical harvesting of rice crops becomes popularised it is anticipated that burning will become a much deeper concern. Availability of HS seeding equipment remains a challenge with poor sales and distribution networks, and very limited capacity in terms of machinery servicing, maintenance and operation.

Cropping Systems in northern Bangladesh

In northern Bangladesh farmers are also intensifying their cropping systems. Whilst rice straw is a valued commodity for animal feed, like in other surrounding regions, the burning of stubble residues will increase where the mechanical harvesting of crops increases. Agricultural mechanisation in the region is largely undertaken using two-wheeled tractors, and there has been a localised industry that provides the sales, servicing and maintenance support for the two wheel tractors. Implements designed and manufactured locally for the two-wheel tractor include ZT seed drills. The smaller tractors are more affordable for the smallholder farmers and are well suited to fragmented land holdings comprising small plot sizes. The two-wheel tractors however require significant physical strength for the operator, placing the four-wheel tractor at a more significant advantage; particularly suited for larger land holdings and/or for use in CHC operations.

Cropping Systems in Terai region of Nepal

Increased intensification of cropping systems across the Terai region of southern Nepal has only in recent years become more of an accepted opportunity. However, the benefits of such intensification is becoming apparent and has been clearly demonstrated through the SRFSI project. Increased mechanisation offers many advantages to village communities, but the opportunity to access tractors and ZT seed drills remains a significant challenge for most smallholder farmers. The establishment of CHC's at the farmer level presents a real opportunity as part of the out scaling initiatives associated with CASI systems development. Issues relating to the need to retain crop residues as part of a CASI system will require continued farmer awareness and education. This is due to the conflicting practices between harvesting of straw for livestock production and the risk of stubble residues being burnt as stubble loadings post-harvest begin to build up as mechanised crop harvesting becomes more popularised throughout this region of Nepal. Availability of HS seeding equipment remains a challenge with poor sales and distribution networks, and very limited capacity in terms of machinery servicing, maintenance and operation.

Opportunities for accelerating adoption

Initiatives introduced to date across the Indo-Gangetic Plains (IGP) have successfully demonstrated the opportunity and potential for conservation agriculture sustainable intensification (CASI) technologies to significantly address cropping systems constraints. The development of ZT seeding systems (including the 'Happy Seeder' (HS)) to sow crops without the need to burn or remove crop residues or cultivate the soil provides an opportunity to reverse traditional farming practices. At the same time, accelerated adoption could significantly reduce crop establishment costs, improve irrigation efficiency and achieve similar crop yields.

Opportunities for the establishment of local service providers (Custom Hire Centres CHC's) that capture entrepreneurial spirit to assist in providing smallholder farmers with convenient access to the technology and locally adapted information are now available. Accelerating rapid adoption by farmers will not be realised unless the constraints to adoption, machinery technology and supply value chain inefficiencies (and impacts from the systems intensification associated with the green revolution) are addressed. Recommendations provided in the policy brief output of the project aim to support the development of an 'enabling environment' to assist in the accelerated adoption of ZT seeding systems in an innovation led farmer participatory driven environment.

2.1.5 Recommendations from the study

This study has identified a range of recommendations that when implemented offer the best opportunity for accelerating the adoption of CASI technologies such as the HS and ZT seed drills. Whilst a number of these opportunities have been identified in the past, it appears that little action has been initiated by Governments 'on the ground'. Whilst research has identified many of the technical improvements that have offered the best chances of developing an integrated approach to conservation agriculture, governments have failed to act on these evidence-based findings. Further, the complexity of the system has not been fully recognised, or appreciated by policy makers nor decision makers. Quick-fix solutions, such as providing subsidised machinery may have increased access to such technologies. However, these schemes have not been properly implemented or adopted at the farmer level, since there has not been an ‘implementation strategy’ developed that includes ‘how’ the technology will be implemented and what specific training and capacity building is required in the adaptation and application of the technologies. As a short to medium term policy recommendation, it will be especially important to focus on skill training with respect to zero-till machine calibration and working, effective crop establishment, and business operations. The recommendations presented from this study aim to provide guidance not only in the ‘what’, but also the ‘how’ to develop a strategy and implementation that will help to ensure successful adoption and long-term change.

Consistent and long-term policies are required to achieve change and support the adoption of CASI technologies. The objective is to achieve scaled outcomes across the IGP, with all Governments needing to adopt a long-term planned approach towards providing an enabling environment for the adoption of ZT and HS seed drills. Demonstrated impact and benefits arising from policy implementation needs to be integrated into all initiatives, through introducing simple monitoring tools to measure practice change and improvements in environmental sustainability, including the use of GIS and satellite monitoring tools. A ‘scorecard approach’ applied consistently across the IGP to measure impact and benefits is required to help demonstrate the success and returns to government, industry and farmer investment in CASI related technologies. A major initiative includes developing strategies as to how all stakeholders along the HS/ZT value chains can collectively be engaged in the successful implementation of the HS/ZT technologies; that importantly form part of the broader objective of introducing the CASI improved production systems across the IGP region.

An overview of the key recommendations from this project are:

Introduction of the ‘Zero-burn from Zero-till‘ awareness raising campaign

A lack of awareness and availability of information relating to CASI technologies (such as the Happy Seeder) amongst farmers across all regions served as a significant barrier to adoption. An awareness campaign, through introducing a marketing campaign *‘ZERO BURN FROM ZERO TILL’* is strongly recommended, featuring both ZT and HS seeding systems. The environmental, agronomic and economic benefits of these systems need to be highlighted, in addition to addressing common farmer misconceptions that a well-cultivated soil (often using a rotavator) that is also stubble and plant residue free is required to successfully achieve high yielding crops. Awareness raising through social media, traditional media avenues, billboard advertising and the appointment of local ‘champion farmers’ as local advocates of the technology should be considered.

Innovation Platforms (InP) as an inclusive extension vehicle for CASI technologies be expanded

The introduction of Innovation Platform (InP) groups offers a collaborative framework opportunity to reach common goals. InP groups have successfully motivated farmer participants to work more closely with the private sector, and to develop entrepreneurial skills as a means of gaining access to CASI technologies such as ZT in the EGP. Through utilising the skills and experience of local research and extension specialists, supported by farmer advocates and stakeholders associated with the provision of CASI related services, technologies and inputs ZT technologies have been successfully introduced. This study highlighted the need to firstly create awareness of the HS/ZT seed drills, and secondly the need to change farmer perceptions (and acceptance) of CASI; notably misconceptions relating to the requirement to have a residue free, well tilled soil in order to successfully establish a crop.

It is therefore important that Governments, Universities and the private sector develop a renewed focus for the delivery of extension services based on innovative extension approaches that includes support for the establishment of Innovation Platforms. The lessons learnt from the SRFSI InP project would assist extension agencies/providers in developing a renewed focus that allows locally based farming groups to form InP groups in partnership with stakeholders. Forming such groups does not happen on its own, but through the provision of local support, training and capacity building efforts over time.

It is also important that a 'whole of systems approach' is taken to the introduction of such technologies. The development of a CASI system is extremely complex, given the transition towards retaining crop stubble residues, an increased reliance upon chemical weed control, and the introduction of cultivars of differing growing season duration as a means to improve overall crop production efficiencies and responses to climate variability.

Building a more effective ZT/HS seed drill supply and service sector

Field studies concluded that there is an urgent need to improve the quality, supply and availability of ZT and HS seed drills to farmers (particularly in EGP), the need to provide additional instructions on machinery operation and use, and maintenance of such equipment (including the supply of spare parts). The development of a series of initiatives supported by Government and manufacturers is an immediate priority in order to ensure the successful introduction of such equipment and minimise dis-adoption. Recognition that the lack of access to manufacturers and skilled technicians/service expertise is important, particularly in the EGP, requiring incentives to manufacturers to fill such a void and improve farmer access and the overall efficiency of the value chains associated with the ZT and HS seed drills.

Re-orientation of Government subsidies and support mechanisms

The provision of subsidies for the purchase of machinery provided by government is in urgent need of review, from the perspective of ensuring that funds directed towards incentivising adoption is maximised in a non-discriminatory manner in an environment of increasing public scrutiny. Subsidies provided to rotavators that reinforce poor farming practices need cease immediately, since this sends 'mixed messages' to farmers. In the long-term subsidies need to be phased out due to inefficiencies in the allocation of financial resources and the need for all custom hiring services to be established on commercial cost-recovery/profitable business operating models. The removal of the goods and Services Tax (GST) in India would also make the equipment more affordable to farmers. It is also important to engage with, and involve the finance sector to provide farmers (through CHC's) with improved access to finance for the purchase of machinery, which in turn should be based on soundly based commercially-driven custom hiring business models as opposed to a subsidy model for machinery provision.

Establishment of profitable and sustainable business models for Custom Hire Centres (CHC)

CHC's provide the opportunity for smallholder farmers to access ZT and HS seeding services that are easily expandable to include other technologies that support the development of CASI farming systems, cost-effective cropping inputs, marketing platforms, training and capacity building services. Once established, and then linked to local InP Groups, CHC's tend to be driven by the entrepreneurial spirit of local community-based operators. These businesses then provide adaptable services and advice to farmers that in turn builds local capacity in relation to CASI systems. The development of CHC's at district level is considered to be one of the best ways to achieve widespread adoption and out-scaling of technologies that is affordable and accessible by all farmers regardless of farm size. Proper functioning CHC's need to focus on providing convenient and affordable access to machinery for all farmers, including smallholder farming women, and serve as the gateway to introducing sustainable and profitable conservation agriculture based systems to all farmers. It is important to recognise that many farmers who wish to establish the CHC generally lack sound financial and business management skills to ensure that such CHC's can be managed in a professional and profitable manner, and therefore concerted effort needs to be devoted to the training and upskilling of such operators. The study highlighted the importance of providing technically efficient custom hiring services to farmers in order to maximise the area of crop that can be sown using the HS within the short 'sowing window' available.

Formation of a Regional Collaborative Platform (RCP) for the Indo-Gangetic Plains (IGP)

Establishing a RCP for the IGP region (comprising country representation from Pakistan, Nepal, India and Bangladesh) provides a central platform for supporting the out scaling of CASI technologies. The sharing and dissemination of technical research and extension experiences, knowledge and resources is critical to addressing the regional challenges associated with ensuring widespread adoption of CASI, and active engagement and participation by all stakeholders in particular the private sector, farming women and other marginalised stakeholders. RCP membership should include: Principal Agricultural Secretaries at national/state levels; private sector representatives (manufacturers, input suppliers, finance sector), research (national and international), farmer/CHC representatives, and women's groups.

The policy brief drafted as an output from the project therefore offers the following key recommendations to regional Governments:

RECOMMENDATION 1: A communication/awareness strategy incorporating innovative digital media approaches that support the adoption of CASI technologies (focusing on ZT and HS) should be developed and implemented as a long-term opportunity to create positive motivation for on-farm adoption.

RECOMMENDATION 2: Expansion of the InP on-farm program from EGP regions to other targeted regions as an immediate priority to support the introduction and implementation of CASI related technologies (focusing on ZT and HS), facilitated through KVK's and Farmer Producer Organisations (FPO's).

RECOMMENDATION 3: Machinery manufacturers should be provided with financial incentives to assist them in providing a larger network of retail agents, service centres and farmer training schools (focusing on the maintenance and operation of equipment) in addition to introducing random market place quality checks for equipment to help support the adoption of ZT and HS seed drills.

RECOMMENDATION 4: Establish a collaborative platform with representatives from the highest level of Government, responsible ministries and the manufacturing sector to help ensure that long-term relationships and the needs of the industry sector are clearly identified and supported to help improve and support the development of effective ZT/HS seed drill supply chains.

RECOMMENDATION 5: A re-orientation of mechanisms that currently provide direct subsidies for machinery purchase be reviewed, and alternative models of support directed towards a range of options. This includes the removal of Government GST on machinery, providing access to affordable finance (consideration towards interest rate subsidies for both manufacturers and purchasers of equipment) in addition to developing business planning skills for custom hire centre operators.

RECOMMENDATION 6: It is strongly recommended that a specific project team and support service comprising state governments, universities and international experts be established to provide a range of support services for the establishment of CHC's, including business and financial planning and governance support, business leadership, technical training (conservation agriculture equipment and CASI systems approaches).

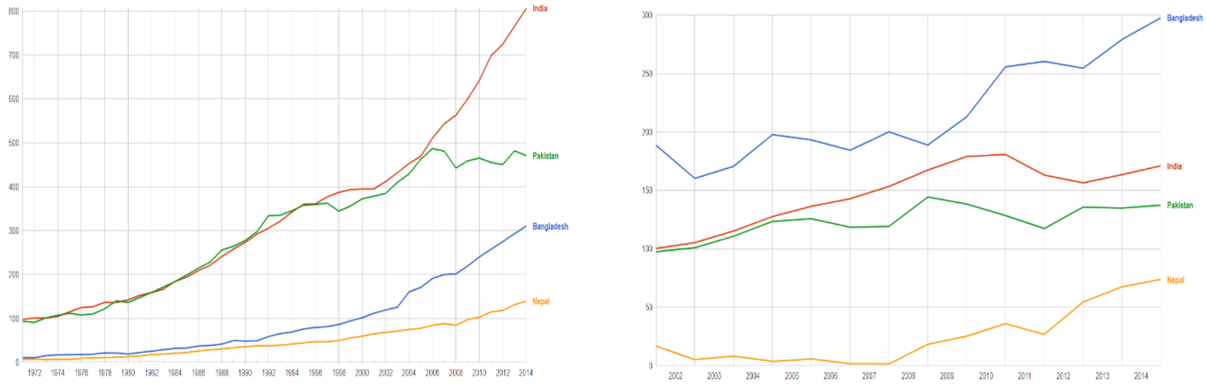
RECOMMENDATION 7: A Regional Collaborative Platform (RCP) comprising representatives from the highest level of Government (Agricultural Ministry; research, extension and policy related) for the IGP region (comprising country representation from Pakistan, Nepal, India and Bangladesh) be established and maintained. This group provides a central platform for supporting the development of supporting government policy and the out scaling of CASI technologies through sharing and dissemination of information, knowledge and training resources, on-farm validation of best management CASI practices, training and capacity building.

3 Introduction and Background

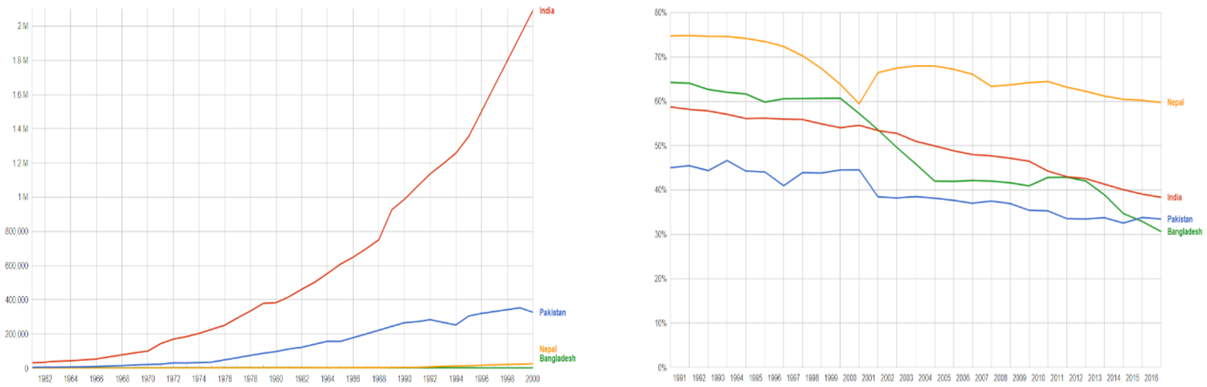
The Indo-Gangetic Plains (IGP) of India is an important region for agricultural production and food security contributing 50% of the total food grain production and supporting food security of about 40% of the population (Pal et al., 2009). Wheat and rice are two of the most important crops grown in this region, which includes much of eastern Pakistan, the northern India states of Punjab, Haryana, the National Capital Region (NCR comprising Delhi), Uttar Pradesh (UP), Bihar and West Bengal, as well as the Bangladesh states of Rangpur, Khulnar and Rajshahi. The IGP is therefore an important source of future agricultural production and economic growth in South Asia (Figure 1).

Figure 1: Map of the Indo-Gangetic Plains region (source: www.pinterest.com.au)

In the face of significant population growth and concerns about food security following independence, the IGP benefited significantly from increased agricultural productivity associated with the Green Revolution (1960s-1990s). The Green Revolution transformed IGP production systems through technology innovations including the adoption of high-yielding cereal varieties, higher inputs (including chemical fertilisers and pesticides), improved irrigation systems, the varied introduction of four-wheel and two-wheel tractor mechanisation across different countries, and subsidised inputs (fertilisers, seed, and electricity in villages that previously were not connected to the national grid). These changes have resulted in decreasing agricultural sector labour participation rates among males; (Figure 2a-d).



a. Electricity consumption per capita   b. Fertilizer (kg/Ha) consumption



c. Agricultural machinery use   d. Male labour participation rates

Figure 2: Increased input and mechanization use by country (World Bank, 2018)or

Impacts from the Green Revolution aimed to address impending food insecurity and improve farming livelihoods to enable countries to become self-sufficient in food production, alleviate hunger and rural poverty. In these respects, the Green Revolution was very successful. While arable land availability plateaued (Figure 3), cereal-crop productivity increased exponentially across the IGP countries (Figure 4). The Green Revolution thus changed India's food status (for example) from one where they were importing rice to feed the population, to one where the country became a net exporter of cereal crops by the 1990s.

The Green Revolution was extremely successful in raising cereal yields across the IGP region for all four countries as illustrated in Figure 4, a trend that has continued well into the 21st century.

Despite the increase in yields, total production and increased GDP per capita, such achievements have come at significant environmental and health cost in the form of soil degradation, increasing groundwater depletion and water scarcity, pesticide resistance and social marginality (Saunders et al., 2012). These issues now threaten to undo all of the positive gains from the Green Revolution, and stall (if not reduce) any potential opportunity for continued growth in agricultural productivity as the region's population continues to increase.

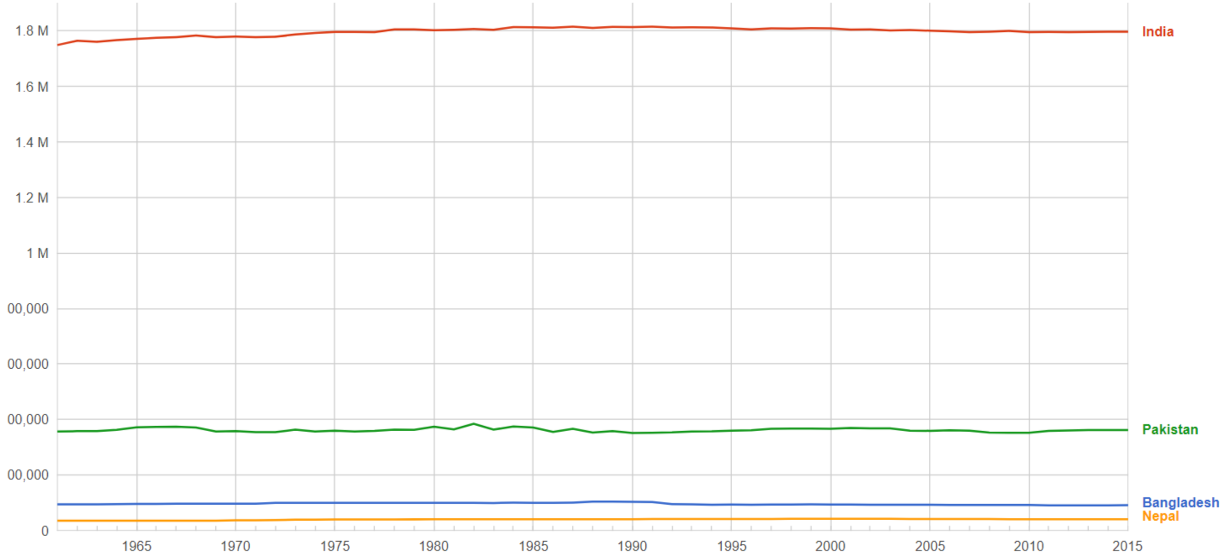


Figure 3: Arable land by study country (World Bank 2018)

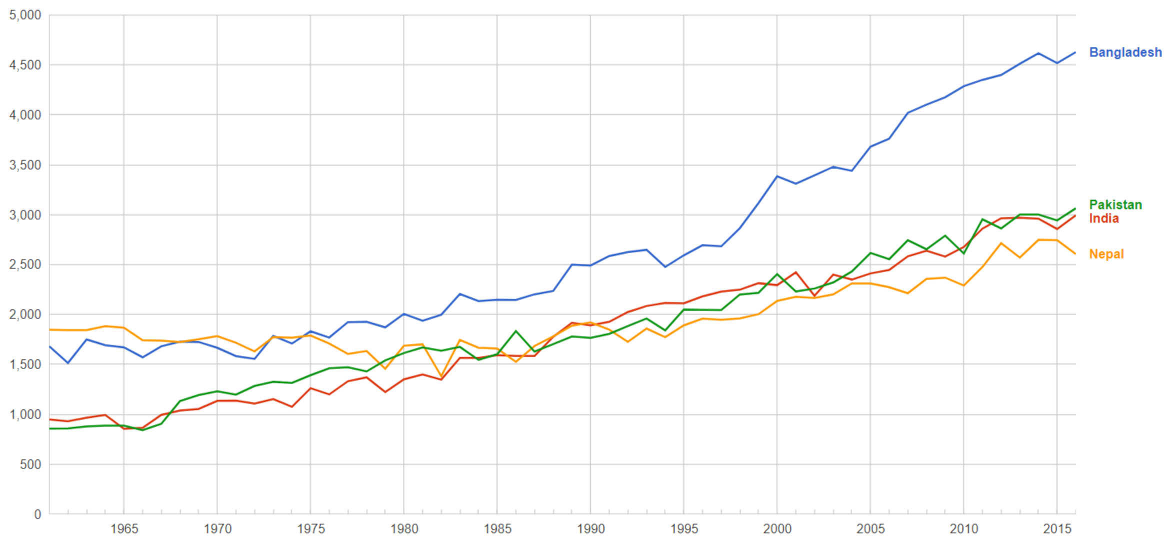


Figure 4: Cereal yield (kg/Ha) by study country (World Bank 2018)

Thus, future challenges for IGP countries seeking to modernise their agricultural production include closing the rural-urban income gap, integrating smallholders into value chains, and managing natural resource issues (Pingali, 2010).

3.1 Conservation Agriculture and Sustainable Intensification

Conservation Agriculture and Sustainable Intensification (CASI) approaches to farm production may hold the key to addressing future food production requirements across the IGP. Intensified production systems are claimed to further increase crop yields and farm income, reduce water inputs, lower input requirements and costs (such as fertilisers and pesticides), improve resistance to environmental stresses, and reduce carbon emissions (Cornell University, 2014); although there are also many earlier studies that dispute these findings (e.g. McDonald et al., 2006). Additional agronomic benefits are said to be improved soil health and organic matter levels, increased soil carbon levels, and moisture retention in fields where crop residues are retained following harvest.

However, there is often significant pressure to remove crop residue from fields in the IGP which reduces the potential for CASI benefits to productivity growth. In the north-west IGP (e.g. Punjab and Haryana) farmers often burn crop residue after harvest because of the volume of material left behind, shortage of farm labour to physically remove the residue, and short windows of opportunity between the harvesting of rice crops and sowing of wheat crops.

Residue burning in NW India has created substantial air pollution problems that drive economic losses, health issues and political problems (Crean et al., 2013) (Figure 5). In the Eastern Gangetic Plains (EGP) rice crop residues are a valued source of animal feed and are collected following harvest. Anecdotal evidence suggests that the trend towards machine harvesting of rice crops is leading to increased crop residue burning; whilst similarly the burning of wheat stubble residues is also said to be increasing (and viewed less favourably as a source of animal feed in this region). In both cases, the removal of the residue reduces the potential for CASI yield and agronomic benefits in agricultural production areas of the IGP.

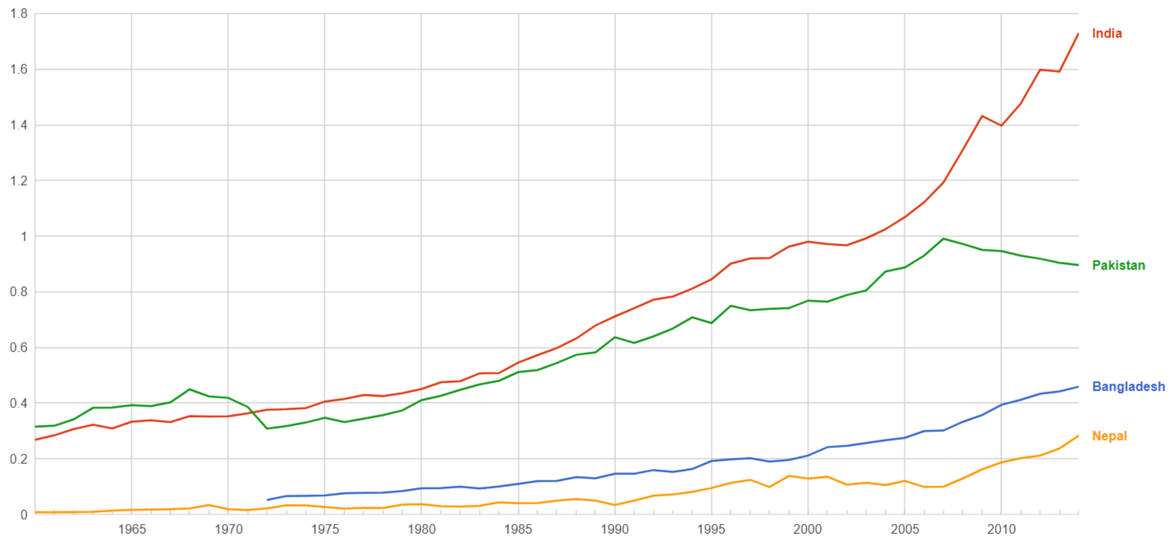


Figure 5: CO2 emissions per capita by study country (World Bank 2018)

3.2 The Happy Seeder alternative

While current farmer approaches to residue management across the IGP (and in particular NW India) clearly create negative externality impacts for broader society, governments are largely unwilling to enforce penalties or bans as a response to the problem despite regulations to that effect being in place. Governments believe that until practical alternative practices are widely available, they must forgive farmers for carrying on as before.

One alternative to current residue management practices in the IGP is the Happy Seeder (HS) zero-tillage machine. The original Happy Seeder was designed and developed in India in 2001 by engineers from both Australia's CSIRO at Griffith University, and researchers at the Punjab Agricultural University (Zhang et al., 2017), with financial support being provided by ACIAR as an Australian Government initiative. The original 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 model was improved by combining the forage harvester and drill into a single machine known as the Combo+ Happy Seeder, which had a very narrow strip tillage assembly in front of the sowing tines to improve seed-soil contact on the sandy loam and loam soils (Zhang et al 2017).

More recently, the Turbo Happy Seeder has been developed by upgrading the Combo+ Happy Seeder with flail blades mounted on a counter rotating drum that works ahead of the machine's furrow openers to clean any residue in front of tines. This helps to facilitate better drilling of seed and fertilizers into the seed rows (Figure 6). Further to this, a Straw Management System (SMS) fitted to the rear of the combine harvester units distributes harvested straw residues across a much wider swath, thus avoiding issues of rows of stubble residues forming into rows in the harvested fields (this providing an even distribution of stubble residues). This has in turn improved the overall performance of the HS.

Figure 6: A Turbo Happy Seeder zero-till machine in Haryana (Sidhu et al., 2015)

Studies have shown that the Happy Seeder provides the capability of sowing wheat in rice stubble with reduced or zero tillage, at the same time maintaining or increasing yield for residue loads up to ~9 t/ha. The technology avoids the need for burning or physical residue removal, and enables benefits including retention of organic matter, suppression of weeds and reduced soil water evaporation (Sidhu et al., 2007).

Farmers who have adopted the HS together with extension officers and scientists agree that this machinery is a viable alternative to the widespread practice of burning and/or physically removing stubble residues. Both the HS as well as Zero-Till (ZT) seed drills provide the opportunity to provide a greater role in retaining crop residues as a cornerstone to developing CASI systems for adoption across the IGP region. Disappointingly since the launch of the HS in India, the innovation is yet to find broad acceptance among farmers (Gupta and Somanathan, 2016). Research conducted by Sidhu et al. (2015) found that only 450 machines had been sold to farmers in the NW of India—mainly in the Punjab and Haryana states where the majority of manufacturers are located (Table 1).

Table 1: List of Happy Seeder Manufacturers and purchase prices (2017)

Name of Manufacturer	***State***	***Purchase Price of Machine***
Kamboj Mechanical Works	Punjab	₹ 151,000
National Agro Industries	Punjab	₹ 140,000 - ₹ 150, 000
Landforce (Dasmesh Mechanical Works)	Punjab	₹ 140,000 - ₹ 150, 000
Jaspal Singh and Sons	Punjab	₹ 140,000 - ₹ 150, 000
Satwant Agro Engineers	Punjab	₹ 140,000 - ₹ 150, 000
Pal Agro Industries	Haryana	₹ 140,000 - ₹ 150, 000
Hind Agro Industries	Haryana	₹ 140,000 - ₹ 150, 000

Source: authors' collation via telephone interviews

3.3 Study objectives

The issues raised above highlight a number of factors that are of significant importance in terms of the context of this study and its objectives:

- There is now a long-entrenched crop production system across the IGP that is reliant upon government subsidies that heavily off-set the costs of crop production inputs, agricultural machinery and electricity that is largely politically motivated.
- Limited time-frames between the harvesting and sowing of crops have pressured farmers to adopt timely, inexpensive and 'effective' solutions for dealing with crop residues that are extremely unsustainable.
- Despite bans on residue burning in NW India, ineffective enforcement and limited alternative options have seen successive governments disregard such law to the detriment of the environment and environmental pollution.
- The national Government of India (GoI) together with the Australian Government through ACIAR have invested in an alternative to conventional residue management practices; principally the Happy Seeder machinery technology which allows the direct sowing of crops into standing stubble residue without the need for cultivation or removal/burning of crop residues.
- The HS innovation has the potential to augment positive CASI agronomic and crop productivity benefits, but adoption levels remain low across the IGP, and mainly concentrated in the NW states of India where heavy crop stubble residues make it nearly impossible to use conventional ZT seed drills (as is the opportunity throughout other regions of the IGP).

There are a significant number of previous studies that have identified specific reasons for low HS adoption rates in NW India (see literature review section); together with suggested policy interventions or incentives to increase adoption rates. Thus, what does this new study have to offer?

This project focused on two distinctive regions of the Indo-Gangetic Plains; namely north-west India (states of Haryana and Punjab) and the Eastern Gangetic Plains (Indian states of Bihar and West Bengal and northern Bangladesh). The reasons for this focus were two-fold. First, there is clearly a need to identify how to accelerate farmer adoption of HS innovative technology across the IGP. This has links to reducing local undesirable farming practices such as residue burning in the north-west. Second, farming systems in the Eastern Gangetic Plains (EGP) are less developed compared to north-western India in terms of the level of mechanisation particularly from a conservation agriculture perspective, and in some districts the level of intensification. There is a need to explore the role that a range of different approaches can have on accelerated adoption, including the establishment of custom-hiring services. Therefore, this project will also identify how farmer adoption of ZT seed drills (including the Happy Seeder) can be accelerated across the EGP region. The opportunity to share experiences between both regions will be a valuable outcome from this study.

Specifically, this project focused on addressing the following objectives:

1. Understand the full range of stakeholder contexts associated with accelerated HS/ZT seed-drill adoption in each of the targeted states/regions.
2. Improve knowledge and understanding of adoption constraints, and opportunities to achieve the accelerated adoption of HS/ZT seed-drills.
3. Inform policy makers to help create a conducive environment for the accelerated adoption of HS/ZT seed-drills for CA based sustainable intensification.

We begin with a review of the literature surrounding these issues, to identify particular knowledge gaps and contributions for academics, policy-makers, research and extension professionals and farmers.

4 Literature Review

The decision as to whether or not to adopt a new technology or farming practice can be a critical decision for any producer (GRDC, 2012). Researchers, extension officers and agronomists are increasingly the link between new studies of technology benefits/costs and adoption awareness and action. Lindner (1987) categorises adoption studies into two groups: i) adoption studies that are concerned about adopter attributes (why some do/don't adopt and/or are early-adopters/laggards); and ii) diffusion studies that consider innovation attributes (why innovations are adopted and/or why some innovations are quicker than others). Ideally then, the data behind adoption studies over time will have temporal characteristics so that changes over time can be identified and measured.

As such, cross-sectional (i.e. snap-shot in time) studies generally offer limited adoption value and insight. However, Rogers (2003) usefully identifies five attributes that help explain variance in adoption even where cross-sectional data has been employed:

1. **Relative advantage**: is the innovation better than what preceded it? This may be in terms of economic profitability, or welfare improvements.
2. **Compatibility**: is the innovation consistent with existing values, past experience, and needs? Can the innovation fit into existing farm systems?
3. **Complexity**: is the innovation relatively difficult to understand and use? Will it require specialised skills or training to operate?
4. **Triallability**: how much can the innovation be trialled at small scale? Can we demonstrate the innovation to reduce uncertainty about any changed practices?
5. **Observability**: are the benefits or outcomes of the innovation observable to others? Can these be effectively and convincingly communicated more broadly to users at scale?

Rogers (2003) concluded that unless there are tangible innovation benefits across these five criteria then it is unlikely that future (or current) adoption will be high.

If we consider the Happy Seeder zero-tillage innovation there are a number of adoption studies that precede this project. Each of these previous studies can be broadly categorised into investigations of policy-based, extension science-based, economic-based and/or social science-based reasons for adoption/non-adoption of HS/ZT technology. Many focus on NW India, but there are examples from other IGP countries as well.

4.1 Policy-based adoption studies

One of the earliest studies into HS adoption was conducted by Pagan and Singh (2006) where they identified valid reasons for HS technology adoption in NW India. They also investigated policy barriers that constrained adoption, concluding that issues such as farmers' financial capacity, short timeframes for economical use of the technology, a lack of available farmer training resources, and the non-enforcement of burning bans lowered the probability of adoption. To address these constraints, Pagan et al. suggested policy changes were needed to affect adoption support arrangements (e.g. subsidised purchasing support arrangements for farmers).

Saunders et al. (2012) built on the work of Pagan and Singh (2006) to examine rice-wheat cropping techniques on raised beds and how the Happy Seeder technology could fit into that cropping system. Adoption barriers identified through their research included the cost of the HS machine, risk aversion of farmers, and government subsidization of inputs (such as herbicide, fertiliser and electricity). That is, that while HS technology adoption may reduce the level of farm inputs over time, any savings in such inputs did not serve as a motivating influence for farmers to adopt, due to the high level of subsidies provided. To overcome these barriers, they suggested the introduction of purchasing subsidies. They also identified the need to create a greater awareness of the technology amongst farmers through introducing extension programs and field day demonstrations.

Saunders et al. also provide some useful economic theory with respect to the differences in benefits for HS adopters and non-adopters. At different prices (*P*), the quantity (*Q*) of goods will change. For example, an original minimum support price (P_{MSP}) could be improved through government subsidies, lowering the effective price to P'_{MSP}. If the price change prompts manufacturers to increase supply (from original supply *S* to new supply *S'*), then the total consumer surplus for adopters will be larger than that for non-adopters—assuming a moderate change in demand from *D* to *D'*. Figure 7 and Figure 8 show that adopters of the HS technology should be better off in terms of total consumer surplus as a consequence of the lower MSP and reduced input costs.

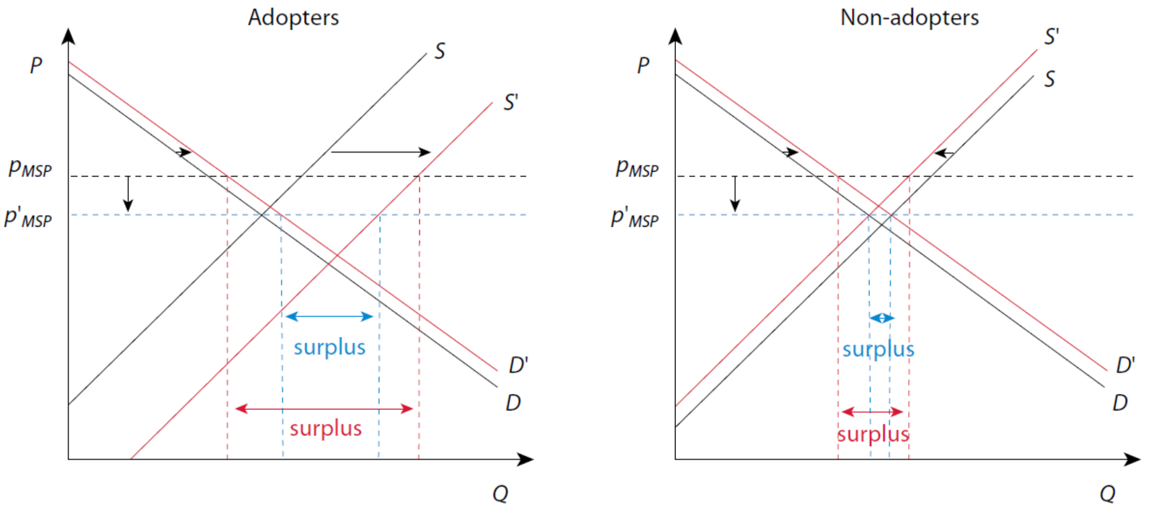


Figure 7: Surplus benefits from lower MSP (Saunders et al. 2012)

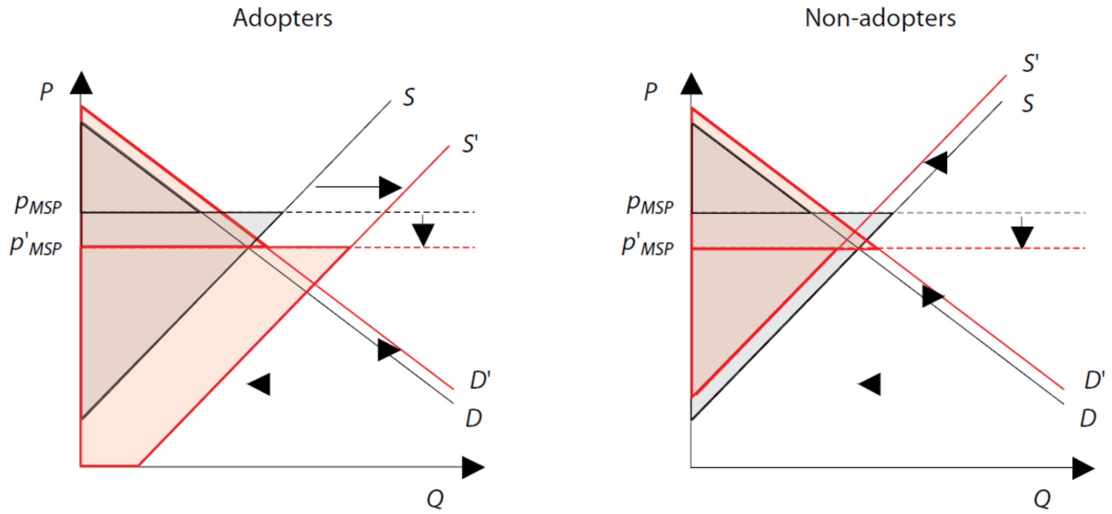


Figure 8: Increased total surplus for HS adopters (Saunders et al. 2012)

Although the economic theory in support of wider HS adoption appears sound, the authors stated that adoption remains stubbornly low. In response, they too advocate a range of policy changes and intervention efforts to address risk-averse attitudes by Indian cereal farmers, as well as programs to promote and communicate the benefits of HS technology more broadly.

With regard to different intervention approaches, Crean et al. (2013) examined which policy responses might increase HS adoption using whole-of-farm models to evaluate different incentives. Their small-scale farm model for the Punjab region also identified that factors such as subsidies on electricity and fertiliser costs had limited the gains from production technology adoption. They saw subsidy support as a temporary measure at best, coupled with expanded demonstrations of the technology. They considered that increased farmer access to carbon (burning) offset markets would help to enable flexibility around adaptation to the issue in NW India. These findings thus echo those of Saunders et al. (2012) above.

Finally, looking specifically at policy instruments to address air pollution in India, Milham et al. (2014) explored the role that HS technology could play, and how HS adoption may be increased in NW India. They observed relatively low adoption levels and noted that while legal power to restrict/ban burning existed there was little political will to enforce the laws unless alternative practices were available. However, the study suggested that there was no consistent view in India on what the best alternative technology option(s). Further, the authors found that Green Revolution policies (i.e. increased access and subsidy support for fertiliser/chemical use, seed, electricity, water and machinery) were all now firmly entrenched responses to maintaining productivity gains, where the (environmental) cost was beginning to materialise. Whilst the state and national governments in India remained focussed on these intervention responses, Milham et al. (2014) suggested that through removing fertiliser/electricity subsidies HS adoption would increase; especially when subsidy funds were also targeted at increased awareness and demonstrations in the field over purchase supports. Again, the study therefore concluded with much the same findings as those that preceded it.

4.2 Extension science-based adoption studies

Agricultural extension science focuses on the study of the change process by individuals, communities and industries involved in primary production and natural resource management, as well as the design of appropriate intervention strategies. Communication of change may be achieved through farm field trials, experimental agriculture, training workshops, technology transfers, advisory engagement and/or participatory technology development.

With respect to extension studies associated with the adoption of the HS, a study conducted in the Punjab by Singh et al. (2013) examined a series of on farm trials to test the benefits of HS technology with respect to in-situ field management of rice paddy-straw residues during the 2009-10 season. The results indicated that HS zero tillage and Rotavator (conventional) residue management practices produced the same or slightly higher yields as compared to traditional cultivation practices (i.e. mechanical incorporation of stubble into the soil leaving a ‘clean’ planting bed). However, HS was found to be the most efficient method for reducing the costs of production, manage the combine-harvested paddy straw, and ultimately improve the soil productivity.

Keil et al. (2015) also examined the potential yield benefits from ZT use (over conventional tillage practices) in Bihar, NE India. In contrast to Singh et al. (2013), they found substantial yield increases were possible with the use of the ZT seeding system. It was suggested that increasing access to custom-hire service (CHC) networks by smallholders in that state must be achieved through targeted policy interventions (e.g. increased awareness and support until scale is achieved across communities to provide economies of operation and adoption).

In Haryana where the rice–wheat rotation dominates cropping systems, Coventry el al. (2015) found that many farmers adopted ZT farming methods for planting wheat. In contrast, where cotton or pearl millet/cluster bean rotation was favoured no ZT was practised. The authors also observed that combine machine harvested crops resulted in an uneven distribution of rice stubble residues in the field. This resulted in a tendency for farmers to burn the stubble residues followed up by cultivation prior to sowing the wheat crop, a response largely due to the difficulty for ZT seed drills to penetrate excessive rice straw residues. Further to this, it was observed that where bans on residue burning had been introduced in Haryana, many farmers were now adopting the unsustainable practice of rotary tillage.

In a subsequent series of on-farm trials conducted in NW India from 2008 to 2011 by Sidhu et al. (Sidhu et al., 2015), it was observed that even though the operational costs for sowing wheat with a Combo HS were 50 to 60% lower than conventional methods, there were technical limitations identified with regards to the efficiency of the HS. These included a high tractor-power requirement, heavy machine weight and purchase cost (approximately ₹140,000 to ₹150,000), machine blockages under heavy straw loads, and poor germination of emerging crops. It was noted by the authors that development of the Turbo HS had managed to address all of these technical problems; however, the rate of adoption continued to remain low despite large subsidies being offered. Apart from the poor signalling to farmers that the issues associated with the Combo HS had been solved, some other suggested barriers to adoption included the following:

- A limited window of operation (25 days/year).
- Low seeding capacity (0.3 ha per hour) compared with (0.5 ha per hour) from conventional seed-drills.
- Lack of versatility of the HS to sow alternate crops.
- High subsidies for diesel for operating tractors (tillage) and electricity to pump ground water offsetting operational cost reduction benefits.
- Poor implementation and enforcement of legislation on stubble burning bans.

Finally, a more recent study by IFPRI (Khan et al., 2016b) found that adoption of ZT in NW India was about 37%--with no mention of HS adoption. Non-existence of HS technology suppliers or support services, and the relatively lower cost of ZT technology from local suppliers or manufacturers outside India may explain this outcome. They suggest that the reduced operational costs of ZT machinery adoption offset the hire-costs. They also argue that adoption of ZT is potentially beneficial for farmer-resilience to future adverse weather shocks.

4.3 Economics-based adoption studies

Numerous economic and/or financial studies have analysed conservation (Zero-till) options in developing and developed countries with many showing higher net farm income returns relative to conventional tillage systems. This is considered to be attributed largely to reduced costs of machinery, fuel and labour coupled to either static or increased yields over time (Knowler and Bradshaw, 2007). However, this may not be the case with respect to Happy Seeder technology adoption.

Land holdings vary in size from state to state in the Indo-Gangetic Plains; relatively larger in the NW of India, and smaller marginal landholdings in the eastern IGP. For smallholders who still plough their fields using livestock or manual physical labour, a solution discussed in the context of the IGP is shared access to machinery via farmer syndication/cooperatives, and/or custom hire centres (CHC). In their ACIAR report, Mudge et al. (2011) engaged with stakeholders in NW India (farmer user and non-users of the HS, manufacturers, government officials and finance providers) to capture their views about viable HS contracting and/or syndication options. They concluded that CHC’s was best for smaller marginal farmers; that cooperative societies have a role through agricultural service centres; medium-sized farmers could become CHC providers; and there were no regulatory barriers to establishing any such businesses/groups. They also found: no farmer access barriers to finance; that subsidies play an important (but potentially distortive) role for marginal farmers where the technology is expensive; that support payments should be linked to broader sustainable agriculture objectives; that manufacturers can meet demand at present (similar to Pagan and Singh

2006); that small operation windows are a barrier; and that on-farm trials (with low financial commitments from potential adopters) have worked well to date. Adoption could be accelerated with greater awareness of the HS technology, changes to farmers' perceptions of the value of clean fields, an increased farmer realisation and acceptance of the value of CASI, demonstrations highlighting comparisons between conventional and zero-till applications, and the identification of farmer-champions to promote the technology's benefits.

In support of the previous study, Gupta (2012) argued that a lack of economic advantages for individual farmers was responsible for the slow adoption rates in NW India. Rice residue was considered to have limited alternative economic value (e.g. in the manufacture of paper and the economic cost of labour was high in part due to scarcity). Further, failure by farmers to recognise any economic returns from adoption results in continued stubble residue burning rather than adoption of HS technology as part of a CA system. Thus, Gupta also suggested that government promotion of the technology, subsidy support payments and attaching spreaders to combine harvesters were required to overcome some of the more significant adoption barriers.

In a similar study but this time conducted in the NE of India, Krishna et al. (2012) examined CA adoption patterns and zero tillage farm profitability impacts for wheat systems in West Bengal. Studies revealed the high cost of wheat growing in this region, that ranked the second-highest in India, thus placing smallholder farmers under considerable financial hardship. Scarcity of ZT drills was identified as the main reason for non-adoption (i.e. lack of supply), followed by a lack of information or awareness (relating to the proper use/benefits of the technology) and poor quality seed used for sowing. Low quality seeds were also another adoption-constraining factor. Their studies also revealed that farmers adopting ZT technology were more likely to have greater access to public extension information sources; higher cattle ownership; higher levels of education; farm in closer proximity to other adopters; and lower competition for access to ZT drill resources at critical times; thus contributing to the likelihood of higher adoption rates. However, in contrast to the rice-wheat cropping systems studies in NW India, they found evidence of significant cost-savings in wheat systems; but no significant evidence of increased yields with income benefits.

In a study of wheat systems in Central Nepal, Ghimire et al. (2013) examined crop production economics and the potential economic benefits of CASI systems. They noted that ZT adoption was marginal, but CHC's were more common; it was the larger farmers who were providing a custom hire service role, and were acting as a source of progressive information relating to CA systems improvement. Overall, the study considered that farmer awareness of CA benefits was extremely limited. The study also highlighted the importance of understanding value chains for increased profitability and income (e.g. better links to final markets), but unfortunately did not explore the links between value chains and innovation diffusion. This suggests a possible contribution from further value chain work, which would also build on the study by Mudge et al. (2011).

In contrast, Bhan and Behera (2014) suggested that there is a far greater recognition of the benefits of CASI systems in India, although they also noted that several issues were responsible for influencing adoption. These included a lack of availability of the ZT seed drills for small and medium-sized farmers, competition for residues as a source of livestock feed (particularly in the EGP region), stubble burning incentives, and a lack of skilled extension manpower for addressing and influencing current tillage mindsets amongst farmers. They argue that policy-makers needed to:

- scale up CASI systems through involving all stakeholders in the discussion;
- introduce a paradigm shift from a food security to a livelihood security focus;
- create a centralised database of information and resources in support of CASI;
- implement training and education at all levels;

- remove tariffs on imported CA machinery, and encourage local hire service industry growth;
- promote Payment Eco-system Services (PES) schemes and fines for bad practice continuation; and
- subsidise CASI equipment purchasing or investment.

More recently, (Keil et al., 2016) pointed out that CHC's were essential for smallholder access to innovative technology, but the industry was in its early development stages. Typically, they found that CHC providers comprised larger farmers who owned their own tractors and engaged in CHC business operations as a side business. Such farmers were more likely to have higher levels of education and wider social networks, and had greater capacity to provide services at a sizeable scale. The study identified that extension efforts to date has only targeted the larger farmers, and that there was a need to determine how best smallholder farmers could be reached efficiently, given the high transaction costs required to reach them. One possible solution that they had identified was the opportunity to appoint village-level point entry persons (who could assist in creating greater awareness of the technology).

In a further study conducted by (Keil et al., 2017) it was discovered that around 44% of (mainly larger) farmers in the EGP region were aware of ZT technology and had adopted it. Network membership, proximity to CHC, and timesaving benefits were found to contribute to the higher adoption rates. It was recommended that any future awareness campaigns should be aimed towards the smallholder farmers (relating to social networks) to help broaden awareness and innovation diffusion impacts. Sims and Heney (2017) argued that mechanization services were needed to promote and grow CA practices. However, this model also required training and business skills. The authors also argued that local manufacturing of the seed drills may also help reduce costs and encourage higher levels of adoption.

Expanding on this theme, Mudge and Cummins (2017) conducted an analysis of the operational costs of HS machinery with and without subsidy supports. Unsurprisingly when compared to unsubsidised business models, they found that the operational costs reduce where subsidy support is available and that farmers can provide profitable HS custom hiring services from the outset—even if only using the HS technology 10 days a year. Profits with respect to underlying subsidy support also increased linearly in relation to the number of acres sown per year.

Finally, Pandey (2018) examined the CA machinery value chain in the EGP; specifically four-wheel tractors (4WT) and self-propelled two-wheel tractors (2WT). Pandey argued that 2WT, whilst remaining popular in Bangladesh, had disadvantages over 4WT in relation to a higher degree of operational complexity and maintenance requirements (and associated costs), but were supported with a higher level of training support provided by the manufacturers. Further to this, he argued that CASI business models in eastern IGP will only be viable under expanded service provision arrangements that could combine to offer training and capacity building services.

4.4 Social science-based adoption studies

Other methodologies have contributed to the literature surrounding HS technology adoption. Such studies may focus on issues of importance to society other than economic, and thus touch on interesting issues with respect to this project.

For example, Erenstein (2010) examined ZT technology uptake in Haryana and Pakistan, noting that dynamic change, spatial diffusion of adoption, and ground-truthing of uptake were important influencing issues. They used triangulation approaches through three datasets to judge the adoption rates in these areas. They noted the need for follow-up surveys related to actual use, dis-adoption reasons, and adaptations (if any) in the field. This suggested some benefits from ex post analysis to reflect on HS adoption to date in NW India, ahead of promoting adoption in other regions/states.

An IFPRI report (Khan et al., 2016a) involving a study of farmer household gender related decision making in NW India found that men played a greater role in decisions relating to increasing yield/income (or reducing costs), whilst women exercised some influence over technology adoption decisions. Women valued the labour-saving aspects of CA. This highlights the importance that women play in relation to influencing technical innovation related decision making at the farm household level, and the need to also target and influence women in any extension related awareness or promotion campaign.

In a paper exploring alternatives to the HS, Gupta and Somanathan (2016) outlined a survey of 92 farmers who used both HS technology and conventional tillage systems on different areas of their farm land. Whilst they observed cost savings, the authors argued that such savings were relatively small and insufficient to generate adoption without the need for subsidy support. Rather than addressing the barriers to HS adoption, the authors instead suggest that using an organo decomposer (a combination of lignite powder and trichoderma or type of bio fungicide) was capable of converting rice stubble residues into organic matter in 35-40 days, thus avoiding the need for stubble burning.

Finally, a recent workshop that addressed the continued low level of adoption of HS technology (Tallis et al., 2017) identified six recommendations that could assist:

1. Strengthen innovation networks: activate farmer-driven learning
2. Clarify the HS business case compared to other residue management options: develop the business case for farmers and CHC providers, and specify the policy case including social and environmental metrics
3. Create model business plans for entrepreneurs: tailor plans to agro-economic zones, farm systems, and service models
4. Awareness and capacity-building: co-design initiatives with key public and private sector institutions
5. Increase production and purchase through finance mechanisms: implement purchase guarantees and pilot low-cost credit provision for farmers and CHC providers
6. Support bans of stubble burning and viable alternatives: communicate alternatives to farmers and CHC providers.

To summarize these findings, it may be useful to construct a matrix diagram that collates the different study categories listed above, and the issues raised in each:

Adoption Problems:	**Policy-based**	**Extension-based**	**Economics-based**	**Social science-based**
Short operating time frames	✓	✓		
Unenforced bans on burning	✓			✓
Subsidies in farm inputs	✓	✓		
Cost of HS/state tariffs*	✓		✓	
Risk aversion by farmers	✓	✓		
Yield increase uncertainty	✓	✓		
Manufacturing capacity*	✓		✓	
‘Clean field’ perceptions	✓		✓	
Operational training needs		✓	✓	
Seed germination/quality*		✓		

Adoption Solutions:	**Policy-based**	**Extension-based**	**Economics-based**	**Social science-based**
Demonstrations/champions	✓		✓	✓
Purchase subsidies*	✓	✓	✓	✓
Increased awareness	✓	✓	✓	✓
Enforcement of laws*	✓	✓		
Reduced operating costs		✓	✓	
Remove input subsidies	✓	✓		
Extend operational window		✓	✓	
Entrepreneurial businesses		✓	✓	✓
Training capacity scaling			✓	✓
Local manufacture*			✓	
Ex-post analysis needed				✓
Including women in process*				✓
Value chain analysis*			✓	

* Equates to an issue that can be specific to, or may be different in, the EGP states/areas

The above review suggests that despite the availability of HS technology in the NW of India, and a significant air pollution problem that has needed to be addressed for some time, farmer adoption remains limited. Some clear deductions that can be drawn at this early stage include:

- Awareness remains low despite recognition of that fact from the very earliest stages of HS adoption analysis. Has extension failed to promote and/or demonstrate the technology, or are more resources to that end required? Will they make any difference?
- The farm machinery purchase/input support subsidy policy In India is confused, and tending towards cancelling one another out.
- Coupled with poor incentives to change burning practices (and/or the failure to adequately police legislation banning the burning of crop residues), farmers are not compelled to change.
- The economic arguments in support of individual farmer HS adoption (i.e. cost reductions) are not strong, nor are they effectively communicated.
- Business models in support of expanded HS use must contend with small economic windows of use, high purchase costs, and skilled operator requirements. CHC businesses are at a range of developmental stages, with few considered to be fully mature from a commercial operating perspective.
- Availability of machinery, high technology costs (e.g. purchase costs of HS), elevated use of 2WT machinery, and continuing concerns about seed quality/germination behind ZT are all problems specific to Bangladesh; although networked access to ZT technology has performed well for servicing smaller farm plots.

These points suggest that the problems span all sectors of the value chain (manufacturers, retailers, extension providers, finance or credit sources, policy-makers and farmers); although only one prior study of the value chain has been attempted to date. There is the need to identify how the adoption of ZT (both the HS and ZT seed drills) can be accelerated across the IGP region. The introduction of the ZT seed drills as part of the push towards increased mechanisation has only materialised in recent years in the EGP region, compared with NW India where the history of introducing such technologies is far greater. Despite the greater depth of experience in NW India (in terms of farmer exposure to ZT/HS), there is still not the level of awareness nor adoption of ZT (and HS) that one would have expected. Further, there has only been a handful of social science based studies that have focused on identifying adoption behaviours and constraints in the NW region.

Finally, as entrepreneurial business models are at an early stage of development, (but signalling positive potential in the EGP), some better understanding of such business models in that context is warranted. The following section therefore outlines the methods used in this study to explore all of these issues.

5 Methods

As already discussed, the data collection was undertaken in two distinct regions of the IGP, these being NW India (Haryana and Punjab) and the EGP (Bihar and West Bengal in India) and northern Bangladesh). Figure 9 (below) illustrates where the data collection took place.

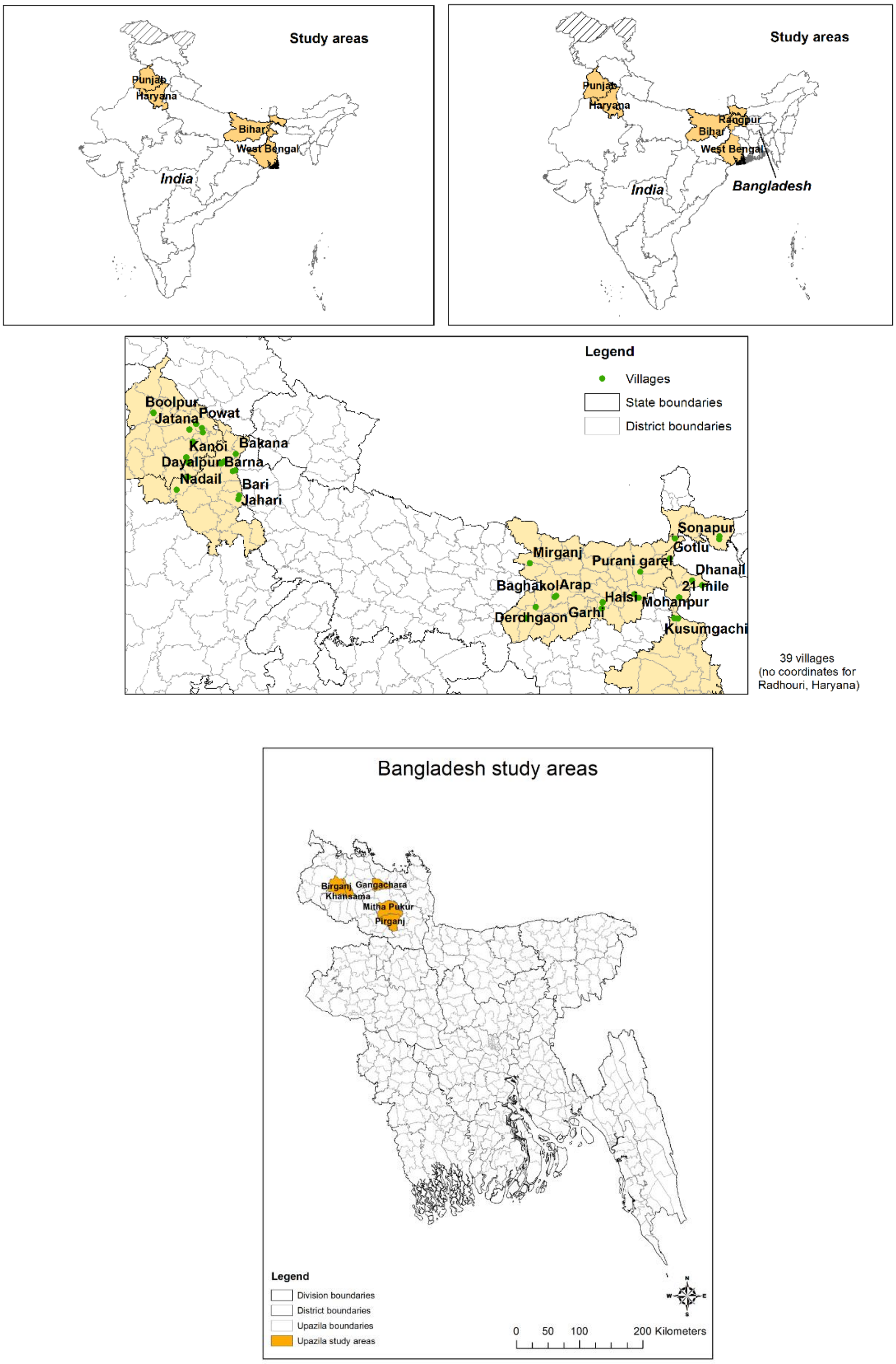


Figure 9: Study areas by country

This project applied three distinct methodologies to collect HS/ZT technology adoption/non-adoption data in line with the literature review assessment above: i) value chain analysis; ii) farmer focus group discussions; and iii) farmer household surveys. These methodologies are detailed below.

5.1 Value Chain Analysis

As an introduction to the value chain analysis (VCA) methodology, a brief overview is provided. The term value chain was first proposed by Michael Porter in his book “Competitive Advantage: Creating and Sustaining Superior Performance” (Porter, 1985). Porter’s argument was that organisations which arrange systems and systematic activity will produce something that will be competitive in the marketplace and the notion that consumers may be more willing to adopt is therefore used to describe those activities within and around organisations, to clearly identify which/where each particular action adds value or creates barriers.

Value chains across organisations also act as external interactive systems where products flow from manufacturers to consumers, money flows back through the system, while information, governance or coordination, and relationships ideally flow in both directions. An example for traditional agribusiness relationships is shown In Figure 10.

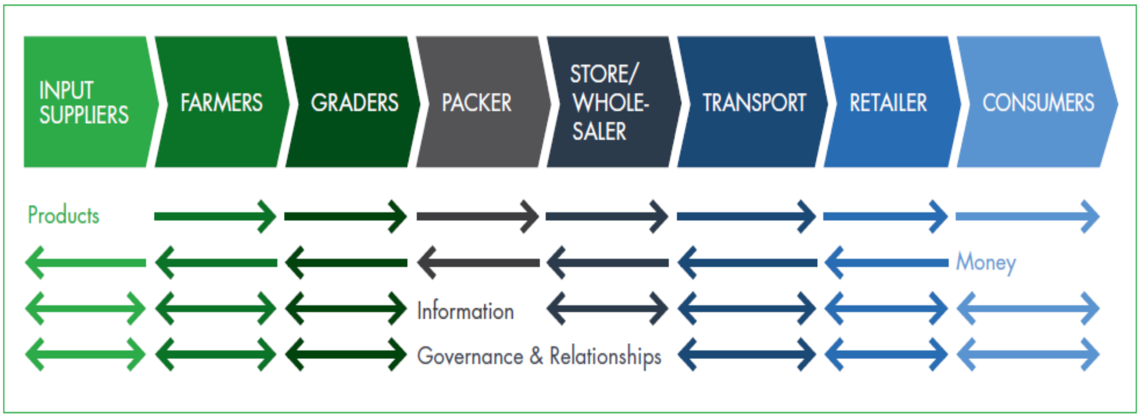


Figure 10: Value chains as interactive systems

Porter’s emphasis on competition may mean that each individual organisation or business will aim to maximise their individual benefit by competing for cheaper inputs and/or higher prices. However, this works to erode the interactive benefits of any well-functioning system, and may lead to signals from farmers not being transmitted/received clearly, waste and inefficiency going undetected in the system, weaker members of the chain being exploited by stronger members, and collective responsibilities (e.g. quality standards or training requirements) being ignored.

Ideally a well-functioning value chain will result in consumer demand-pull outcomes which see products or innovations transferring (relatively) effortlessly through the chain from one organisation to another (e.g. from manufacturer to retailer, and eventually to the farmer). For this to occur, the underlying system must be at least cooperative, if not coordinated and even (best practice) collaborative by nature, where all businesses are related in some way and act jointly to achieve mutual value and benefits (Figure 11). This should overcome barriers to adoption, and provide larger opportunities for the organisations involved.

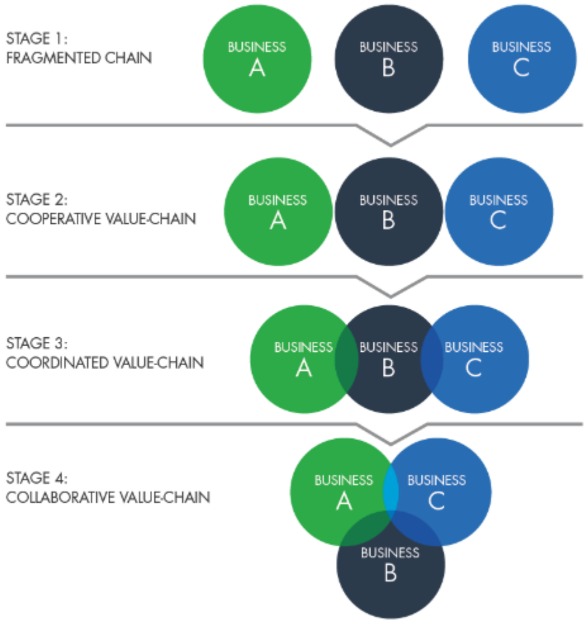


Figure 11: Stages of value chain development

If we consider the barriers to adoption described in the literature review above as the current state, then a VCA methodology is aimed at describing a possible future state, as well as a proposed map for achieving that future state. This follows an approach outlined by Taylor (2005) that is useful for analysing agribusiness and farming sector issues. Figure 12 summarises the VCA methodological approach.

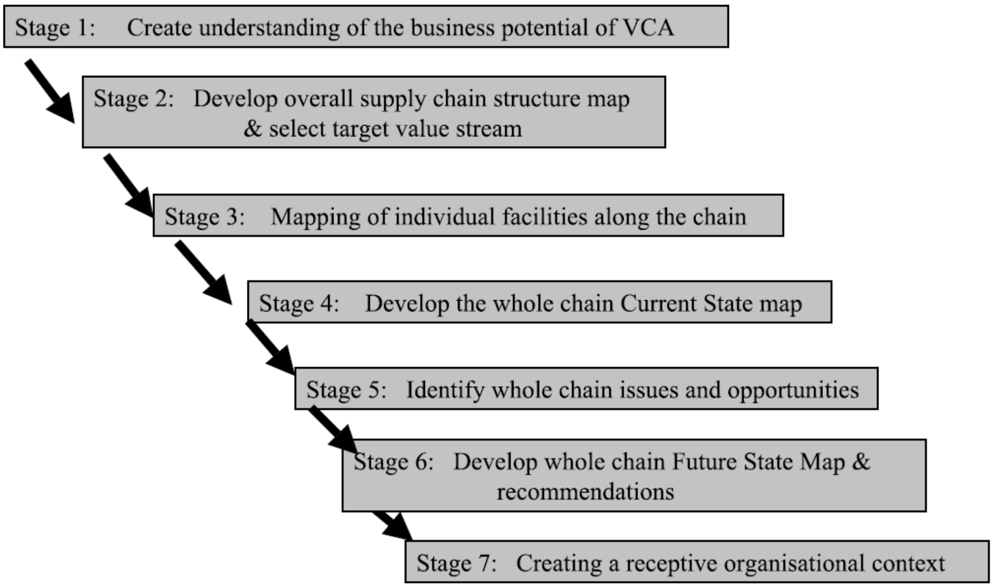


Figure 12: Summary of the VCA methodology (source: Taylor (2005))

The potential benefits from a VCA methodology were recognised as offering a novel and valuable research approach, and were agreed to at the design stage of the project with ACIAR. This then provided the key research focus for Stage 1 of the VCA methodology depicted above.

As the objective of any VCA is to improve value for end-users, a pre-requisite is to understand the scope of the processes involved and to map that complex network. This can be achieved using a process developed by Jones and Womack (2002). A critical objective of this mapping process is to highlight any interactions between stakeholders. These interactions can then be used to prompt discussion with all stakeholders, and to identify potential pathways to improvement through structured field data collection. The project team therefore developed a map to test with HS technology stakeholders and identify any barriers to and/or opportunities for accelerating HS/ZT technology adoption, as shown in Figure 13. This process fulfilled the requirements for Stage 4 of the VCA approach.

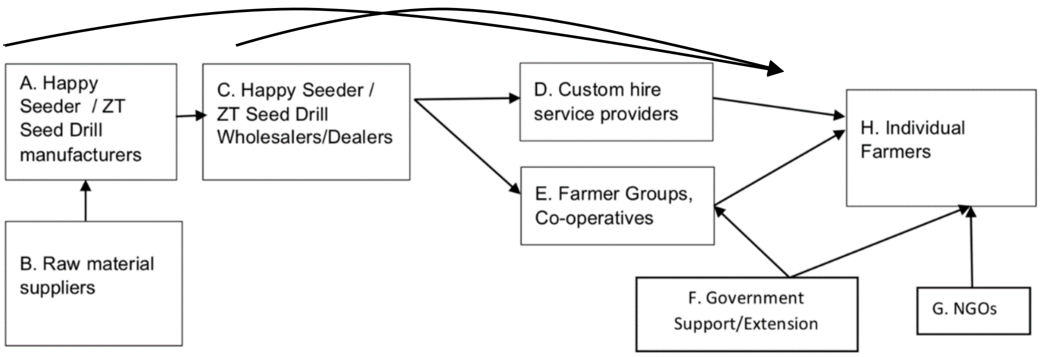


Figure 13: Map of HS/ZT adoption barriers and supply processes

5.1.1 Stakeholder interviews

To better understand the overall value chain, the interaction map (above) served as part of a larger VCA structured interview documentation. This was then discussed and tested with a full spectrum of stakeholders from across the IGP (Table 2).

Table 2: Happy Seeder (HS) and Zero Till (ZT) Value Chain Stakeholders

Categories	**Haryana**	**Punjab**	**Bihar**	**West Bengal**	**Bangladesh**	**Total**
Custom Hire Businesses	10	2	3	2	7	**24**
Machinery Dealers	3	0	1	1	3	**8**
Farmer Groups/Cooperatives	1	0	0	2	10	**13**
Individual farmers	13	8	4	0	11	**36**
Manufacturers	0	3	1	0	0	**4**
Research extension/KVK	12	6	2	5	10	**35**
Finance	2	0	1	0		**3**
Government policy-makers or NGOs	0	0	0	0	10	**10**
Total	**41**	**19**	**12**	**10**	**51**	**133**

Local partners to assist in undertaking the VCA were identified in each of the relevant states (i.e. Haryana, Punjab, Bihar, West Bengal and Bangladesh), and meetings with key stakeholders across seven categories (Table 2) were undertaken. A total of 133 VCA interviews were conducted (an example VCA is included in Appendix 11.1). These interviews provided data for Stage 5 of the VCA approach.

5.1.2 Data

As indicated, data for the VCA was collected through personal interviews with relevant stakeholders. The survey consisted of questions that enabled the gathering of views on the advantages of HS/ZT technology, challenges within and along the chain, any barriers faced by each stakeholder, breaks or failures in the current chain, and any recommendations from stakeholders on measures to effectively deal with these challenges.

It should be noted that in some instances where resources had previously been provided (e.g. in the last five years or so) to encourage farmers to adopt HS/ZT technology in specific villages, at the time of conducting this VCA study there was little evidence of any significant adoption being maintained, with evidence of dis-adoption having occurred in some instances. For example, our survey teams returned to villages that had previously been involved in concerted efforts to introduce the HS through on-farm research/extension activities, only to discover that no adopters of the HS could be found for the purposes of participating in this study. This was a concern for the project team, and emphasised a possible need for longer-term extension support activities with farmer groups to ensure sustained adoption.

5.1.3 Analysis

Analysis of the VCA data was conducted using the Nvivo software package. The interview data was first transcribed and uploaded so that subsequent coding of the interviews could commence. This process resulted in a total of 27 nodes being created, which were then used to highlight and allocate individual data across four major themes: i) current interaction linkages among stakeholders; ii) stakeholder perceptions of HS/ZT technology; iii) barriers or challenges to HS/ZT adoption; and iv) opportunities for accelerated HS/ZT adoption.

The stakeholder linkage analysis provided the basis for the project team to then update the adoption process issues and opportunities for HS/ZT adoption (Stage 5 of Figure **12** above), and to develop a whole chain future state map including proposed recommendations for further reflection and comment (Stage 6 of figure above). The results of this analysis are detailed in the following major section.

5.2 Focus Group Discussions

While the VCA approach considered a relatively complete range of HS technology stakeholders, the project was also very interested in collecting much more detailed qualitative data from what is considered to be the main research subject for this innovation; farmers. The project team therefore conducted a series of focus group discussion sessions (FGDs) with farmers in targeted village communities (usually following the 'one to one' individual farmer surveys that explored HS/ZT adoption behaviour and socio-economic characteristics).

The aim of the FGDs was to gather in-depth information in relation to the adoption characteristics and processes associated with HS/ZT technologies that farmers underwent within their local village communities. To initiate the farmer group discussions, the project team presented them with the following images and question:

Q: Which of the above images would you prefer to see in your own farm/field?

Figure 14: Images used in the FGD to initiate discussions

Each participant was asked to indicate which of the above field situations they preferred to see prior to the sowing of their cereal crops. Crop A (LHS) represents a field sown with the Happy Seeder technology, while Crop B (RHS) represents a traditionally-cultivated field (where previous stubble and crop residues had been removed, and the field repeatedly cultivated ahead of sowing). Based on the farmer response, the facilitator would then explore the basis for that perception, how it might feed into technology adoption (or dis-adoption) reasoning, and more detailed information about current barriers/opportunities preventing the opportunity to achieve accelerated adoption.

5.2.1 Data

A total of 45 focus group discussions were conducted, involving 402 farmer participants. Of these, 189 were considered to be adopters of HS/ZT technology, 172 were non-adopters, and 41 were found to be dis-adopters (i.e., they had been users of HS/ZT technology, but had stopped using it at some stage in the past). The Indian FGD workshops were facilitated by trained staff from the Delhi based market research company Insight Development Consulting Group (IDCG), while the Bangladesh FGDs were facilitated by the NGO RDRS. The project coordination team from the University of Adelaide were involved in briefing and training these field staff, and also provided support services for any required points of clarification while the FGDS were being conducted in the field.

The FGD workshops were conducted in India during February and March 2018, and in Bangladesh during May 2018. Notes associated with the focus group discussions were recorded during the course of the focus group discussion workshops.

5.2.2 Analysis

Analysis of the final FGD data was again undertaken using NVivo, which eventuated in 12 themes with collective and individual relevance for the four areas included in the study.

5.3 Farmer Survey

The third research tool employed in the project was a farm household survey. A total of 500 surveys were conducted, with 100 surveys being conducted in each of the 5 targeted states/regions (Haryana, Punjab, West Bengal, Bihar and northern Bangladesh).

Specific villages engaged in the farmer survey were identified from village lists provided by a number of University Extension Service KVK's (Krishi Vigyan Kendra (KVK) including Haryana Agricultural University, Punjab Agricultural University, Bihar Agricultural University and Uttar Banga Krishi Viswavidyalaya (UBKV (University)). Lists of suitable villages in Bangladesh were provided by Rangpur based RDRS. Selection of such villages was based on the villages being recognised as being either relatively (1) high adopters and (2) low adopters of the HS and/or ZT seed drills.

Once the survey teams visited the villages, farmers were then selected based upon existing adopters and non-adopters (including dis-adopters) of either the HS (in the case of Haryana and Punjab) and ZT seed drills (West Bengal, Bihar and Bangladesh). Instances where no adopters could be identified resulted in survey teams selecting an alternate village (since it was a requirement to have a selection of both adopters and non-adopters within each village).

Partnerships with the Indian Council of Agricultural Research (ICAR) assisted the project team to liaise with the KVK's, in addition to accessing support in field survey design and sampling through the Indian Institute of Wheat and Barley Research (IIWBR).

The survey structure was aimed at collecting household member characteristics, crop/plot-level data, and farm economic/financial data for each household. Similar surveys used by GFAR in Indonesia, and by IFPRI in India, were used to provide some guidance in survey questionnaire design. Qualitative responses were kept to a minimum given the VCA and FGD data collection that was running alongside the survey instrument. Initial survey drafts were pilot-tested in the field with some changes to the text and questions resulting in an effort to ensure quality information was collected. The final survey instrument was then implemented in February-March 2018 by a team from IDCG (India) and RDRS (Bangladesh). The survey process took six weeks to complete.

5.3.1 Data

Data collected from the farmer surveys include a range of household characteristics, farm and plot level information, adoption of HS, ZT, credit access, information source, decision making influencers, household head's attitudes and beliefs, etc. Appendix 11.2 presents the survey instrument.

5.3.2 Analysis methods

In the results section the responses to all questions are discussed under the headings:

- summary statistics on demographics;
- summary statistics on adoption of ZT and HS;
- summary statistics and latent class models for decision-making factors for crop sowing and crop management practices; and
- summary statistics for behaviour and attitudinal statements and probit/bivariate probit regression models for zero tillage and happy HS adoption.

Summary statistics reported include the mean values and statistics tests (that were used to test if there are significant differences in the mean values for the variables of interest between adopters and non-adopters of ZT and HS, respectively). The statistical tests used in the findings sections are Pearson Chi-2 test for two way associations (see Conover, 1999, pg. 240), and t-test on two sample equal means (see Hoel, 1984, pp. 140-161).

Latent Class (LC) Cluster Models

Latent class (LC) modelling, also known as Finite Mixture Modelling, is used to identify unobservable (latent) subgroups/classes in a sample. Observations within the same latent class are homogenous on certain criteria (Vermunt and Magidson, 2005). The aim of this analysis was to find distinct clusters of farmers with different attitudes to crop sowing/management decision-making practices and to find out whether adopters/non-adopters of Zero Tillage and Happy Seeder can be associated with certain identified clusters.

LC modelling differs from more traditional cluster analysis methods, e.g. by providing model selection criteria and probability-based classification. Observations are assigned to a class for which the posterior membership probability is highest.

Six indicators (dependent variables) were selected for the analysis, which were used to define/measure the latent classes. Indicators belonged to the decision-making question *("When you decide on crop sowing and crop management practices, please rate each of the following factors from not important at all (1) to very important (5)"*) and were selected based on the distribution of the responses (>5% in each category) and on their theme. Themes relate to farming costs, timing of operations and biophysical issues (two indicators per theme).

There were then five different LC models estimated containing 1, 2, 3, 4, and 5 clusters respectively. The 3-cluster model was chosen because of a small Bayesian Information Criterion (BIC) value, fewer number of parameters (more parsimonious model) and low classification errors, and because the 3 clusters are more practical/interpretable than a higher number of clusters. The restriction of independence between some of the indicators were then relaxed, i.e. adding direct effects associated with two variables that have large bivariate residuals.

Probit regression models

A probit model (see Cameron and Trivedi, 2009, pp. 459-462 for details of the estimation method) is appropriate when the dependent variable is binary (0/1). In the case of adoption of the ZT or HS, the dependent variable is classified into two categories, namely, adopters and non-adopters.[1] The interest in using a probit model[2] was to uncover the characteristics associated with farmers' adoption behaviour whilst controlling as many other variables as possible that may influence adoption.

For Bangladesh, a bi-probit model (Greene, 2008, pp. 817-820) was estimated for zero tillage adoption for the Rabi and Kharif crops simultaneously to account for the correlation of the error terms of the two separate probit models for Rabi and Kharif crops respectively. The HS adoption model was not estimated for Bangladesh since there was no adoption in the sample.

The independent variables in the regression models included farmer, household, farm level characteristics, variables measuring how important different aspects are in their decisions on crop sowing and crop management practices, and farmers' attitudes statements towards a range of issues.

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[1] Note that the happy seeder adoption model is for Punjab and Haryana only, since almost none of the farmers in West Bengal and Bihar were aware of the happy seeder technology. For zero tillage, the model is only for the Rabi crop in 2016 since there was no zero tillage for the Kharif crop.

[2] We may have chosen a logit model instead of a probit model for a dependent variable that is binary in nature. However, as shown in the literature (e.g. Amemiya, 1981), there exists a similarity between the two approaches in terms of comparing the marginal effects of the same independent variable between probit and logit models.

5.4 Workshop consultations

An important element of the project was to better understand the major issues and constraints associated with the adoption of the HS and ZT seed drills amongst the stakeholders associated with the HS and ZT value chains and on-farm adoption activities. This was achieved through conducting a series of project inception workshops prior to the field survey work being undertaken. Workshops were conducted in Chandigarh (representing Punjab and Haryana states), Siliguri (representing West Bengal and Bihar states) and Rangpur (representing northern Bangladesh). The valuable feedback obtained through this process assisted in ensuring that the specific research tools (questionnaires, value chain analysis approaches and focus group discussion themes) were relevant and were designed in such a way to provide significant contributions towards addressing the key research questions.

5.4.1 The Virtual Advisory Group

An outcome of the three project inception workshops was the formation of the Virtual Advisory Group (VAG), largely comprising attendees from the project inception workshops who were identified on the basis of their key technical and policy related skills and knowledge. The VAG served as a technical reference group for the project, allowing the sharing and exchange of technical project related information, ideas and opinions. This collective input into development of the emerging project themes served as a means of reviewing and validating the findings and formation of policy related recommendations arising from the study.

5.4.2 Policy briefing workshop

Following the extensive collection and analysis of field data, a summary of the research results and recommendations were then presented at a two-day Policy Briefing Workshop conducted at the Australian High Commission in Delhi. The working group attending the workshop comprised recognised technical and policy development specialists, who all contributed positively towards the verification of results and the shaping of policy recommendations arising from the study. An additional and significant output from the workshop was the preparation of a draft policy brief (comprising draft policy recommendations and key findings from the field research activities) that was in turn provided to senior technical and research experts and policy makers (including members of the VAG) prior to a series of state and regional ZT Summit Workshops being conducted.

5.4.3 Regional Summit Workshops

In all, there were three state/regional ZT Summit Workshops held in Delhi (Haryana and Punjab States), Patna (Bihar and West Bengal) and Rangpur (northern Bangladesh). The one-day workshops were attended by local policy makers, senior research and technical experts and other stakeholders associated with the HS/ZT seed drill value chains. These workshops provided the opportunity to help inform and agree on future recommended state and national actions including policy recommendations and specific initiatives conducive towards accelerating adoption of the ZT and HS seed drills. Valuable (and practical) feedback from the workshops were then integrated into the revised draft policy recommendations.

5.4.4 Regional Collaborative Platform Workshop

The final workshop activity conducted had the primary aim of exploring the opportunity (and support) to form a Regional Collaborative Platform (RCP) amongst partnering countries. One of the core functions of the RCP was identified through the need to accelerate (and support) the adoption of CASI technologies across the Indo-Gangetic Plains region through knowledge sharing and building on the experiences relating to ZT drill adoption for conservation agriculture based sustainable intensification. The formation of a platform was also considered to provide the opportunity to bring together key stakeholders to drive change at the policy and ground level and help to build on the lessons from the Rice-Wheat Consortium, CISA and other organisations/projects.

Attending the Kathmandu workshop were senior Government Ministry representatives from the four countries across the Indo-Gangetic Plains (Pakistan, India, Nepal and Bangladesh), representatives from international research and development organisations (actively working across the region), University of Adelaide project team members, ACIAR representatives and the Australian Ambassador to Nepal H.E. Peter Budd. The workshop provided the opportunity to present the key policy recommendations arising from this research study whilst determining the opportunity, support and commitment from represented governments at the workshop to bring together experts to develop innovative approaches to accelerating the adoption of ZT seed drills, foster collaboration in research and extension outreach and influence government policy.

The RCP Workshop concluded with a signing of the Kathmandu Resolution (copy attached at Appendix 11.3). Other outcomes from these workshops are discussed in Section 6 below.

6 Results

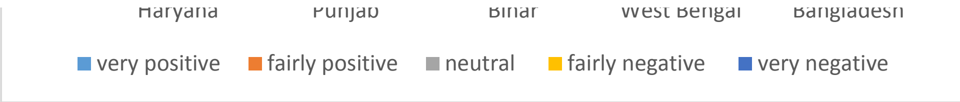
The results from each of the methodologies described above are presented here in separate sections.

6.1 Value Chain Analysis results

To accommodate differences between the two study countries, the value chain analysis results in this report have been separated into two major sections: the first deals with the data associated with the Indian states, while the second deals with the data for Bangladesh.

6.1.1 The Indian IGP states' VCA results

Perceptions of Happy Seeder (HS) and Zero-Till (ZT) technology



gather stakeholder technology.

Figure **15** shows that these perceptions vary in relation to the stakeholder's exposure to these technologies, (although to be noted the different composition of stakeholders across the four states makes direct comparison between states difficult). For example, stakeholder composition in Haryana included a higher number of farmers, manufacturers and retailers (associated with the production and sale of HS/ZT machines). Haryana recorded far higher numbers of positive perceptions than those stakeholders in Punjab, Bihar and West Bengal, who had a far lower level of awareness of, and direct interaction with the HS/ZT technology.

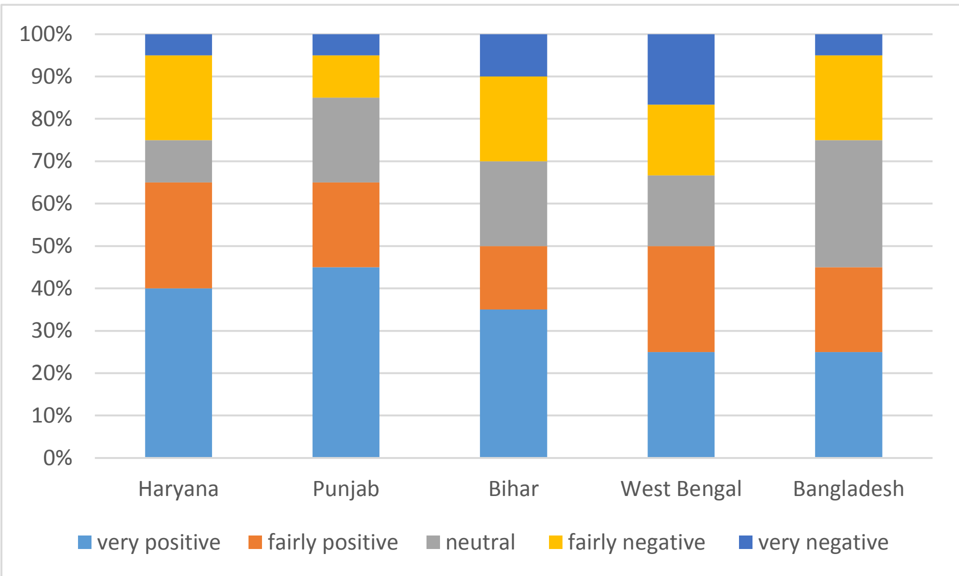


Figure 15: Perceptions of HS/ZT technology, percentages by Indian State

The majority of stakeholders interviewed were very positive about the future of HS/ZT technologies in their state states. The Nvivo analysis showed that these positive perceptions were linked to the level of trust that stakeholders held in relation to the ZT/HS technologies, as well as increased awareness about the benefits of these technologies in terms of cost savings, reduced uses of farm inputs, and outcomes that were highly beneficial for the environment. These are expanded upon below.

Advantages of Happy Seeder (HS) and Zero-Till (ZT) Technologies

Stakeholders were asked to provide reasons for their positive perceptions about HS/ZT technologies. Qualitative responses were coded and placed into 6 categories according to their major advantages. Overall, 66% of the stakeholders interviewed indicated the key advantages associated with the technologies related to farm cost or resource saving attributes (with a further 22% also identifying savings in labour that similarly represent cost savings). One such stakeholder commented:

'This machine has many benefits like time saving, saving on cost of cultivation, water etc., and thus makes this machine a favourite among farmers. Its business will improve in the coming years'.

Specific resource-related savings included soil and water, and reductions in weed infestation levels (a significant issue for farmers). The use of CA technologies like HS and ZT largely reduces the weed infestation issues (such as *Phalaris minor* as a result of reduced seed germination that otherwise would be stimulated through repeated cultivation).

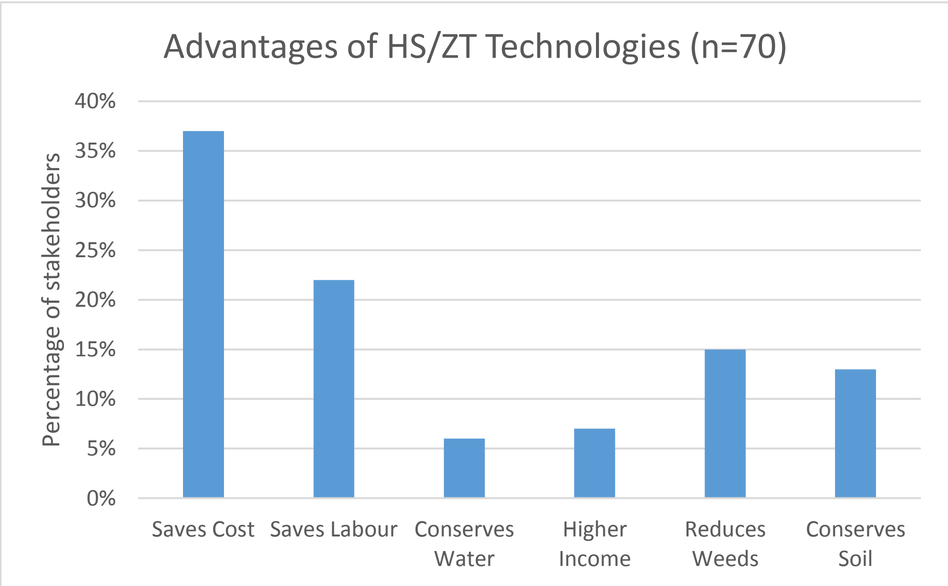


Figure 16: Main advantages of Happy Seeder (HS) and Zero-Till (ZT) Technologies, for Indian states

The relative low level of awareness of the benefits associated with the ZT/HS technologies as illustrated in Figure 16 is disappointing. This lack of awareness is reflected in the low levels of adoption across the IGP. Contributing to the low levels of adoption are the specific challenges along the supply chain, and this will be discussed in further detail as the specific challenges along the VCA are explored in further detail.

Challenges along the Value Chain

Currently it is estimated that there are 1,641 Happy Seeder machines in operation in Punjab on approximately 25,600 acres (Manjit Singh, Punjab Agricultural University (personal communication)). Using data from an agricultural profile of Punjab state (Singh et al., 2012), noted a total of 1,058,000 holdings covering 3,996,000 hectares under farming, this equates to an adoption rate of less than 1% (based on the hectares figure). What is driving this continued poor adoption?

Responses from stakeholders interviewed in this VCA study were coded and categorised into six major themes. There were a range of challenges identified with the current HS/ZT value chain from the analysis, with three themes in particular that stood out amongst others;

1. Issues with the subsidy policy, including limited access for smaller farmers and misdirection of funding (26%);
2. Limited availability of machinery in States outside of Haryana and Punjab (where retailers/dealers were unfamiliar with or do not stock HS/ZT machines (26%);
3. A lack of general awareness among stakeholders in the EGP states about the HS/ZT technology (24%).

The remaining challenges that influenced the accelerated adoption of the HS/ZT seed drills as identified by stakeholders included high machinery cost (11%) and associated low demand (9%) (Figure 17).

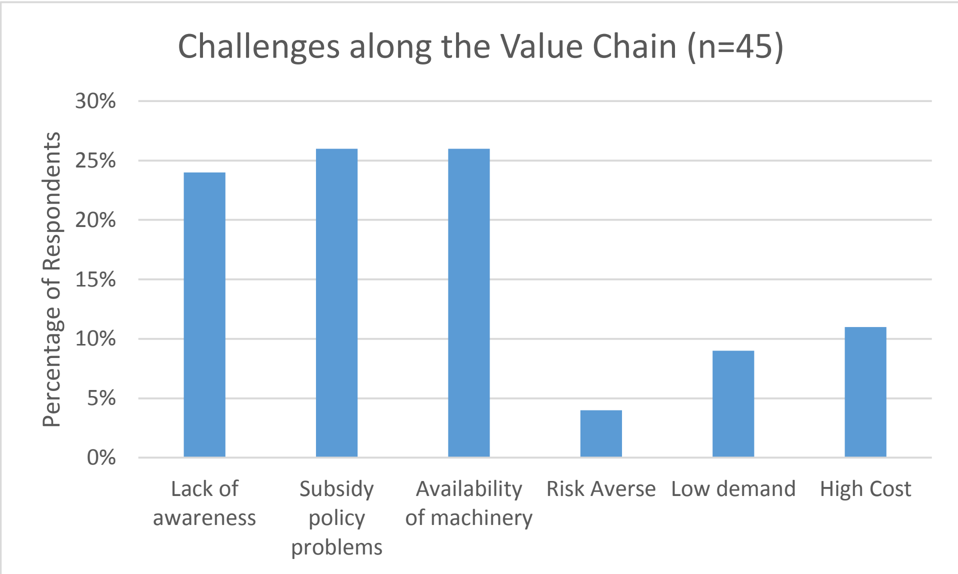


Figure 17: Challenges for the HS/ZT value chain, for Indian states

A series of follow-up VCA questions provided stakeholders with the opportunity to elaborate further on the identified challenges through providing more detailed responses to a series of open-ended questions. Their responses covered a broad range of issues including financial assistance/subsidy programs offered to farmers (by the Government of India) and the application of a Goods and Services Tax (GST) policies on the sale of HS/ZT seed drills.

Subsidy issues

Specifically, at the time of this study being conducted, there was a difference in the level of subsidies offered between farmers in Haryana/Punjab (50%) and those in Bihar/West Bengal (40%). It was evident that this inequity sent a negative signal, with some of the stakeholders commenting that given the relatively more wealthy-status of farmers in Haryana/Punjab; this subsidy difference should be reversed to encourage greater adoption in those states where HS/ZT uptake remains low. Since then, the level of subsidy in some states has increased significantly, with registered farmer companies opting to establish custom hiring businesses in Haryana now receiving subsidies of up to 80%.

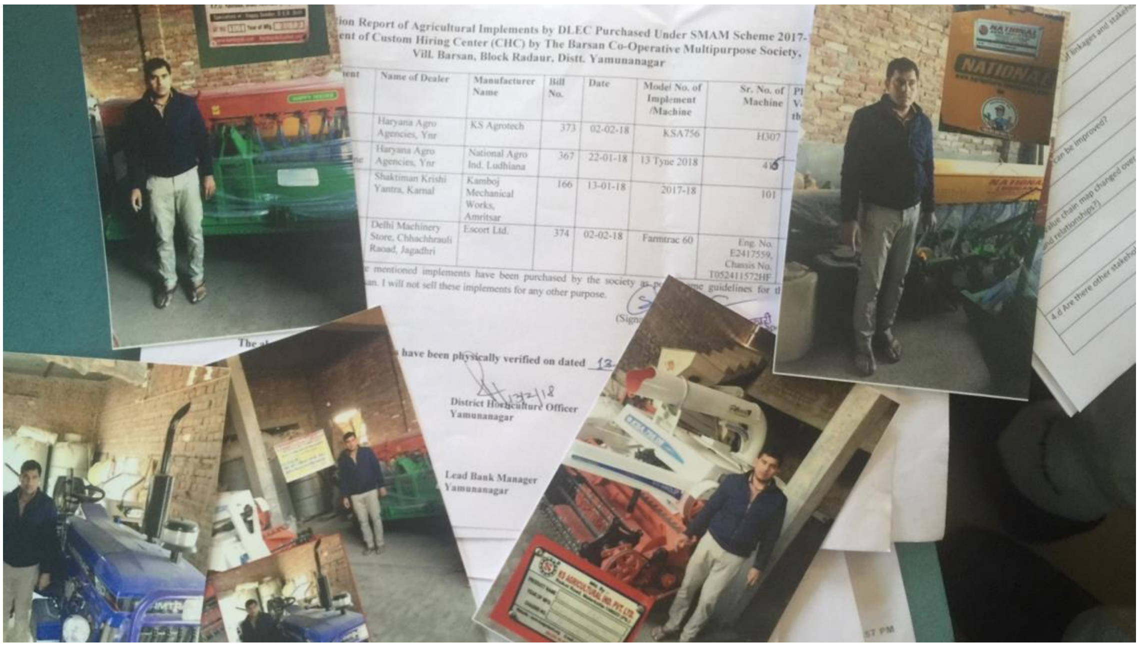


Figure 18: An example of proof of evidence for approving machinery subsidies by Government authorities for the state of Haryana. Photo Jay Cummins

Many stakeholders across the value chain identified problematic gaps in the process of applying for machine subsidies, the process of funds disbursement and the protracted time between the farmer applying for funds and eventually receiving the subsidy payment. The application process was considered by many farmers to be complicated with significant amounts of paperwork, and a prevalence of 'red tape' in the overall subsidy system that hampered efficiency.

Subsidy availability was viewed as being limited and not based on the level of demand (or need) from farmers. To illustrate this many stakeholders commented that only a limited number of farmers could access the subsidies, and that that could were categorised as medium to large landholders (farm area of 20-30 acres or more). Not surprising up to 20% of the adopters of HS/ZT technology had purchased their seed drill without seeking any specific subsidy support, due to a combination of both the difficulty in obtaining a subsidy in the first place and secondly the fact that the benefits alone associated with the technology provided sufficient motivation to purchase the drills.

From this, it is evident that there is an opportunity to reduce or eliminate subsidies altogether, or at least some capacity for adopters to avoid subsidies. This would enable the added benefit that if farmers value the HS/ZT technology and are willing to pay for it, (without subsidy incentives), then they may be more likely also to use it properly to maximise their CA and yield/income outcomes.

Stakeholders across the value chain also noted that the Indian government does not have any control over how the price is established for such machinery and that there are no regulations in place to monitor prices. This leads to the risk of inflated machinery prices and 'deals' between more educated farmers and machinery dealers to maximise personal financial gains through the subsidy system; although in some instances maximum subsidy ceilings are in place to limit those gains.

Farmer stakeholders therefore argued that it would be ideal to have some firmer regulation and local monitoring in place when it comes to setting the price for the HS/ZT seed drills and that certain manufacturers should not be able to take advantage of the farmers or the subsidy system.

Finally, the GST component (12%) of any machine sale is split equally between the central Government and the relevant state in which the machine is bought. Stakeholders noted that this had the negative effect of increasing the total price of the HS/ZT seed drills significantly. Many argued that if the GST were to be removed, this would provide a substantial incentive toward HS/ZT technology adoption, and reduce the total price of the machine for purchasers of the equipment.

From the manufacturer's perspective in the VCA process, the subsidies were also considered to pose a challenge in terms of the empanelment process for each state. Empanelment is the process by which manufacturers register their specific equipment products for inclusion on an official list of subsidy qualifying equipment with each state government so that those purchasing the equipment are eligible for any subsidies on machines sold. However, the cost of registration varies from state to state (e.g. up to 10 Lakh, or ₹1 million), which most manufacturers (both small and large) considered was largely cost-prohibitive.

Availability of the technology

Availability of the seed drills has implications for demand in states where manufacturing of the HS/ZT does not take place.

Outside of those states where manufacturing of the HS/ZT seed drills take place the availability and demand is often less, and for many manufacturers there is insufficient incentive to register their seed drills on the subsidy lists in such states (such as Bihar and West Bengal). In these states it is likely that awareness and demand will remain low, presenting a 'chicken and egg' challenge in the value chain. As one comment from a manufacturer (echoed by stakeholders from the finance, farming and machinery dealer sectors) noted:

'Issues for us in the empanelling process, plus the GST on this technology, are unjustified. Give farmers incentives instead of subsidies'.

The ability to meet any increased future demand for HS/ZT technology was a challenge frequently raised by manufacturers. Farmers in the IGP practicing a rice-wheat cropping system have a small planting window between the harvest of rice and the sowing of wheat—typically between October and November, during a period when the demand for access to HS/ZT seed drills spike.

Some manufacturers considered that they had little capacity to increase their manufacturing output of HS seed drills should a significant increase in demand occur, particularly in the months leading up to the wheat sowing period during peak season demand. It was considered this situation would be exacerbated as the government moved to monitor and enforce stubble burning bans and increased/promoted subsidy schemes for the equipment. It was also mentioned repeatedly by farmers that increased demand would also result in price increases.

Table 2: Machine Specifications in Haryana

	Happy Seeder Manufacturer	Date of purchase	Price (INR)	Finance source	Quality rating	Subsidy Assistance
CHC 1	Kamboj	Jun-17	163000	Own savings	9	63000
CHC 2	Dashmesh	Jun-12	110000	Own savings	5	15000
CHC 3	Kamboj	Jun-14	150000	Own savings	10	60000
CHC 4	Kamboj	Oct-17	160000	Informal lender	8	50000
CHC 5	Kamboj	Feb-17	140000	Own savings and borrowed from friends	10	63000
CHC 6	Kamboj	Oct-17	163000	Own savings	10	63000
CHC 7	Kamboj	May-10	108000	NGO sponsored	7	0[3]
CHC 8	Kamboj	Oct-17	155000	Own savings	9	50000
CHC 8	Kamboj	Oct-16	145000	Own savings	9	50000
CHC 9	Kamboj	May-14	130000	Own savings	8	50000
CHC 10	Kamboj	Oct-17	151000	Own savings and money lender	10	63000
Farmer 1	Kamboj	Sep-16	150000	Own savings	9	50000
Farmer 2	Kamboj	Feb-18	160000	Own savings	10	64000
Farmer 3	Kamboj	May-10	100000	Own savings	8	0
	ZT Seed drill Manufacturer	**Date of purchase**	**Price (INR)**	**Finance source**	**Quality rating**	**Subsidy Assistance**
CHC 7	Pummy (Samrala)	Sep-16	45000	Own savings	10	15000

Table 3: Machine Specifications in Punjab

	Happy Seeder Manufacturer	Date of purchase	Price (INR)	Finance source	Quality rating	Subsidy Assistance
Farmer 1	Dashmesh	Aug-17	165000	Own savings	10	0
Farmer 2	Kamboj	Aug-17	165000	Own savings	10	0
Farmer 3	Dasmesh	Sep-17	153600	Own savings	5	0
Farmer 4	Kamboj	Aug-12	125000	Own savings	10	0
Farmer 5	Dashmesh	Aug-17	153600	Own savings	10	0

[3] While the subsidy support in this case may be zero, the out-of-pocket expenses for users may also be zero due to supply by an NGO.

Table 4: Machine Specifications in Bihar

	Zero-Till Manufacturer	Date of purchase	Price (INR)	Finance source	Quality rating	Subsidy Assistance
CHC 1	National Agro	Jun-14	55000	NGO sponsored	8	0
CHC 2	Mac Shyam Agro (fluted roller)	Nov-14	60000	Own savings	10	0
CHC 3	National Agro	Jun-14	56000	NGO sponsored	10	0
Farmer 1	National Agro	Jun-14	55000	NGO sponsored	5	0
Farmer 2	National Agro	Jun-14	56000	NGO sponsored	5	0

Table 5: Machine Specifications in West Bengal

	Zero-Till Manufacturer	Date of purchase	Price (INR)	Finance source	Quality rating	Subsidy Assistance
CHC 1	National Agro Industries	Nov-16	80000	Own savings	7	0
CHC 2	National Agro Industries	Nov-15	80000	NGO sponsored	8	0

There was the expectation that manufacturers would be able to increase production of the HS in response to any increased demand for HS/ZT machines. However, one of the major constraints identified related to the issues surrounding cash flow for the manufacturers (purchase of raw materials, components, labour) thus representing a large capital outlay required.

Despite a large increase in the number of manufacturers of the HS/ZT seed drills in recent years (as noted by the project team), the majority of sales are still dominated by a small number of manufacturers (e.g. National Agro, Dashmesh and Kamboj). These companies were highly respected through being considered the pioneers in the development of HS/ZT technologies having worked with the research community to refine and adapt equipment to suit a range of varying soil and climatic conditions across the IGP.

During the VCA process, farmers and custom hire centres revealed details of their machines, along with financial sources and ratings for quality of the machinery in the value chain interviews (Table 2 to Table 5).

In particular, smallholder farmers were found to have a tendency towards being highly risk averse due to lack of capital resources and access to financial assistance (both subsidy assistance and lending by finance providers). This was considered to influence their continued reliance on conventional methods of tillage, acting as a barrier to adoption of costly HS/ZT technology:

'Because of high (HS/ZT) machine costs I am not able to purchase it on my own, and have to depend on custom hiring; which may be busy at the time of sowing, as the sowing window of wheat is very short.'

Following up on these comments, further investigations were conducted to try and explain why HS seed drills may be high. It was found that as the quality perceptions and usefulness of the HS/ZT technology have grown so too has the observed market price: that is, there has been a trend towards on-going price increases for the HS machines. It is clear that there has been a significant price rise in this technology from about INR108,000 in 2010 to about INR163,000 in 2017, which may also in part be reflective of increasing input prices over the time period (e.g. cost of steel).

Some new manufacturers of the HS had in recent years entered the market on the hope of meeting increased demand and potential returns from sales, but it was observed that farmers had lower levels of trust compared with the larger, established manufacturers. Interestingly however, despite quality perception differences, competition between manufacturers and low levels of product differentiation meant that the machine pricing levels and marketing strategies appear to be consistent across the manufacturers.

The majority of the stakeholders having purchased and adopted the HS/ZT generally used their own savings to do so. Only a few were identified who had resorted to informal borrowing from moneylenders or friends. Discussions with financiers revealed that many banks were unwilling to lend to smallholder farmers who were considered to be higher risk propositions, reflected in high loan default rates of 45%; thus creating further challenges to smallholder farmers wishing to adopt the technology and re-enforcing the need for alternative models of ownership and custom hiring centre service models.

Some finance stakeholders viewed farmer cooperative/group-membership models highly favourable in terms of providing a professional business model of operation in terms of managing the physical machinery assets and ability to achieve high rates of equipment utilisation. For example, NABARD were responsible for providing financing to many of the Farmer Producer Organisations (FPO's) who were involved in the custom hiring services in West Bengal. This was important in assist in the access of finance by the FPO's providing the custom hiring services. The stakeholders also mentioned that these groups typically applied for funds using business feasibility approaches that are more tailored to financiers' requirements for loan assessments.

Figure 19: This Farmer Producer Organisation in West Bengal is an example of a farmer group who have established a custom hiring centre, with support provided by the NABARD Bank. (photo Jay Cummins).

In general, finance providers were interested to work with farmer groups to assist them in applying for financing to purchase ZT seed-drills, for the purposes of establishing custom hiring services. However, they stated clearly that it was also important to manage risk, and so the farmer groups also needed to be able to demonstrate the likely demand and income they would receive from their custom service hiring activities.

Finally, the finance stakeholder representatives considered that their engagement in providing access to finance for the equipment purchase was required to help accelerate adoption and a necessary policy input. The State Bank's Committee, Chaired by the Finance Minister, sets the policy focus for their membership: this was noted as being critical for gaining finance involvement and connections to broader policy in support of HS/ZT adoption.

Key Barriers to Adoption

Stakeholders were asked to describe what they considered to be the key barriers that in their view hindered the adoption of HS/ZT technologies. Qualitative answers were coded and categorised into six major barriers to adoption. Policy failures linked to the challenges discussed above were important for 19% of the stakeholders interviewed. However, some important new themes emerged, including farmers' mindsets in the IGP (31%), technical issues with the HS/ZT machinery (13%), and agronomic issues in the local region (10%) (Figure 20).

Policy failures

In terms of policy issues, stakeholders considered that there was an increasing awareness amongst the farming community of the scientific aspects and harmful effects of burning stubble as a result of educational efforts from the government and scientific research community.

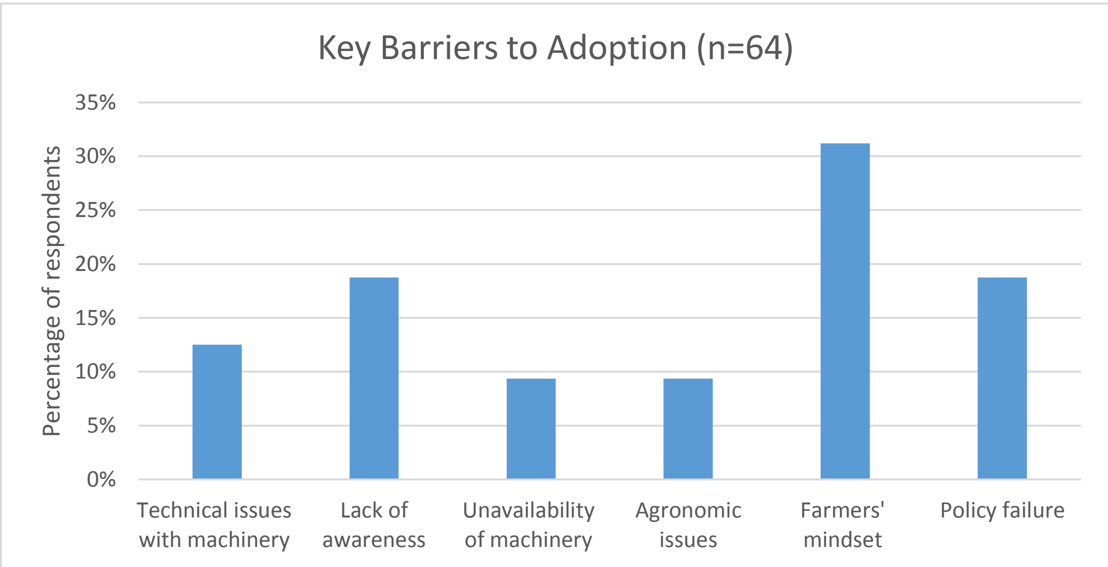


Figure 20: Key Barriers to Adoption

Implementation of a ban on burning crop residues was viewed as ineffective for a variety of political reasons since farmers in this region formed a majority vote-bank when it came to elections (having a high degree of influence over political decisions and the election process). There have been instances in the past where political leaders seeking to win votes have promised farmers that no action will be taken against them even if they burn their stubble.

Further, it was noted by many stakeholders that custom hire-service providers without land were unable to access subsidy support since they needed to have existing links to a farmers' group to be eligible. This policy related issue needs to be addressed if it considered private service providers will play a significant role in the future in terms of improving farmer access to ZT/HS seed drills..

Farmer perceptions of the need for 'clean' fields

The concept of the 'farmers' mindset' raised in workshop discussions related to their specific perceptions they held that a clean repeatedly cultivated soil having a fine soil tilth and free of stubble residues provided the ideal situation for sowing a crop and achieving successful germination and productivity. It was considered that this 'mindset' was difficult to overcome and is further elaborated upon in the focus group discussions sections in the following text. One comment from a farmer in Punjab provides a good example of this issue:

'We like the look of the farm when it is clear of all stubble, it gives a good feeling.'

The perception of a clear field with no stubble as an ideal field for sowing is a clear barrier for farmers who remain unsure about whether to adopt these technologies, and they will remain insecure until they see evidence of field germination following HS/ZT uses. One farmer has commented on this:

'I was very Insecure initially about the germination of wheat as it looked like it won't germinate in so much stubble.'

The addition of the press wheel in the Happy Seeder has helped to address this perception, according to the manufacturers. The addition of the press wheel improves the seed-soil contact, thereby improving the germination and overall crop emergence, though comes at an additional cost. One manufacturer commented on this issue:

'I believe there is a major gap between the knowledge in the university community and the researchers, who are themselves divided over a few different issues, and the views of farmers. For instance on the whole whether there should or should not be a press wheel in the HS'.

Some farmers using customer service providers to gain access to the ZT seed-drills also reported being dissatisfied with the end result of the sown crops. Often the service providers would sow the crops poorly, due to a combination of the providers attempting to sow as many acres of crop as possible in a short period of time, and/or poorly trained operators who simply did not know how to properly use the HS/ZT seed-drills (in terms of the seeding operation, calibration of equipment). In addition, the small areas of land owned by farmers (and size of crop plots sown) often made the sowing operations inefficient, this created an additional burden on the service providers who usually had 'fixed prices' on their ZT seed-drill hiring charges.

These barrier-related issues might have been partially addressed by government incentives in the State of Haryana that (at the time of the survey) were being introduced to provide additional incentives (up to 80% of the purchaser price of equipment) to farmer producer organisations committed to establishing their own custom hiring services. As a result, some stakeholders observed that a number of business-focused or more entrepreneurial farmers were forming their own registered farmer organisations, making significant investments in the purchase of machinery and equipment including HS/ZT seed-drills and tractors to establish commercially focused custom hiring businesses (whilst capitalising on the generous level of government subsidies for machinery purchases).

This meant that a number of respected and progressive farmers were also now involved in the provision of custom hiring services, taking on the voluntary role as 'advocates' of the technology and its promotion, and importantly willing to support extension outreach initiatives led by research and extension initiatives. Some of these farmers were proud that 'their local village had achieved adoption rates of 100% for the HS/ZT seed-drills'.

Finally, some stakeholders reported that there remains a high level of conflict in relation to certain custom hire businesses who want to maximise their business (and profits) from providing a wide range of services (not just HS and ZT seed-drills) but also rotavator and tillage/cultivation services to farmers. This was because providing HS/ZT seeding services to farmers in effect reduced their business turn-over (e.g. one operation to sow a crop, versus repeated cultivations and then sowing the crop). This plays on farmer mindsets of 'clean is good', as discussed above. But again, this issue brought to mind the issue of confusing subsidy support signals evident amongst stakeholders involved in the study.

Lack of awareness and agronomic concerns

It was considered amongst stakeholders that the improper application of the HS/ZT machinery (based on adequate training, operation and maintenance) contributed towards poor agronomic outcomes in the field. Addressing these issues was seen as a means to improve the success of the equipment in the field and help accelerate adoption. The lack of farmer awareness of the technology was also attributed by some stakeholders to lack of qualified training staff available at the research and extension institutions; more specifically in the KVKs (*Krishi Vigyan Kendra*; the extension wing of the Indian Council of Agricultural Research). Several extension officials commented on the unavailability of resources for training at village level, including access to machinery and equipment, making it difficult to change farmer behaviour. One such comment included:

'We have access to less machines for demonstrations at each district level, this affects our efficiency to reach maximum number of farmers and thus only few farmers benefit from our programs.'

Figure 21: Conducting a VCA interview with female farmers in Bihar

Related to this training and demonstration barrier, many farmers felt insecure about trying new technologies since the risk of failure would threaten their livelihoods due to financial loss. Many smallholder farmers tended to be risk-averse, preferring to wait for technologies to be successfully adopted by larger farmers before they contemplated adoption themselves. Success among other stakeholders was attributed to having good technical staff working for them, maintaining the equipment in good working order, and working through the ACIAR

SRFSI project. For example, the Satmile Farmer Producer Organisation continued to receive unprecedented demand for the hiring of ZT seed-drills by their smallholder customer base, and as such they continued to expand their business and personnel.

There were a range of specific challenges farmers faced in the operation of the HS/ZT machinery. One of the most common problems was the high tractor Horse Power (HP) requirement for the HS, requiring a tractor having a 50HP requirement. With most farmer tractors being 40HP, there was a significant mismatch, thus requiring the upgrading of tractors for many farmers if they were to purchase the HS themselves. Other issues in the operation of the HS as raised by farmers included the large amount of dust generated during the operation of the machine (due to the 'chopping' of the cereal straw during operation); worsened by the fact tractors do not have closed cabins and are open to the elements.

There was a criticism held by farmers that the HS can only be used to sow wheat and so therefore could only be used for a limited period annually. This in fact is not the case, with the latest generation of HS seed drills being capable of sowing a range of field crops (reflective of a general lack of awareness and poor promotion/marketing of the seed drills).

Additional criticism was directed at the HS inability to operate effectively under heavy straw loadings in the field, with one such observation being:

'The straw is high in the farm and the seed pipe is not long enough; my sowing uniformity is compromised as the pipe gets blocked from time to time. The stubble is also dense and the distance between two furrows (sowing tines) is not enough to allow for them to move freely, so I have to manually remove the blockage from time to time.'

Technical issues

There was also a frequent issue associated with poor quality inputs such as seed and fertiliser that can have a negative impact on crop yields, no matter what the method of crop sowing used.

In relation to the ZT seed drill, agronomic related issues included clogging of the machine with crop residues, inability to manoeuvre the machine at the end of the sowing run in small tight fields, and an observation that the seed drill did not perform effectively in fields mechanically harvested. One such comment included:

'The machine does not have a cover on the seed and fertilizer drums; this poses problems while cleaning it after use. Moreover, it does not perform well in a field that has been harvested using a combine harvester.'

Access to spare parts and technicians capable of servicing the HS/ZT machines was also considered to be a barrier to adoption, and this was raised as a particular concern amongst stakeholders in West Bengal and Bihar, far away from the location of the majority of manufacturers located in Haryana and Punjab.

There are however some efforts to address this issue in West Bengal for example, where the Satmile Farmer Producer Organisation in Cooch Behar had established a retail outlet for the National Agro Industries (NAI) ZT seed-drills and were also carrying a range of spare parts as well as having trained mechanics and service personnel. Such linkages between the manufacturer and Satmile (as the appointed agent) were extremely strong, with NAI representatives visiting twice yearly to provide training and technical support to Satmile staff; thus serving as a useful exercise in building the regional skills and capability of local service agents.

Unfortunately the Satmile example is largely uncommon, and highlights the high level of effort required to establish such facilities (and improvements in the ZT seed drill value chain) in an effort to accelerate HS/ZT adoption, an issue of concern outside of the existing group networks and current initiatives.

6.1.2 The Bangladesh results

In Bangladesh, knowledge of the HS seed drills amongst farmers was almost non-existent with a very low level of adoption. In contrast, the adoption of ZT seed drills was quite high, reflected through far greater awareness and access to the ZT seed-drills.

Prior to the VCA being undertaken, potential stakeholders targeted for the VCA field study were identified jointly by project team staff and local partner RDRS (who were appointed to undertake the field study).

The data collected was consistent with that of India: perceptions and views of the advantages of ZT technology, identified challenges along the value chain, key barriers faced by each stakeholder group, and recommendations from stakeholders on measures to effectively deal with these barriers/challenges. There was a total of 51 stakeholders interviewed from the Rangpur and Dinajpur divisions of North Western Bangladesh. The results from those interviews are detailed below.

Perceptions of Happy Seeder (HS) and Zero-Till (ZT) technology

New technologies are adopted when they are perceived as being in the farmers' best interests (Nowak, 1992). To better understand how Bangladesh stakeholders perceived ZT technologies in the context of their suitability and usability in agriculture in the region, questions were asked in relation to the level of positiveness they held towards the future of ZT/HS technologies (Figure 22).

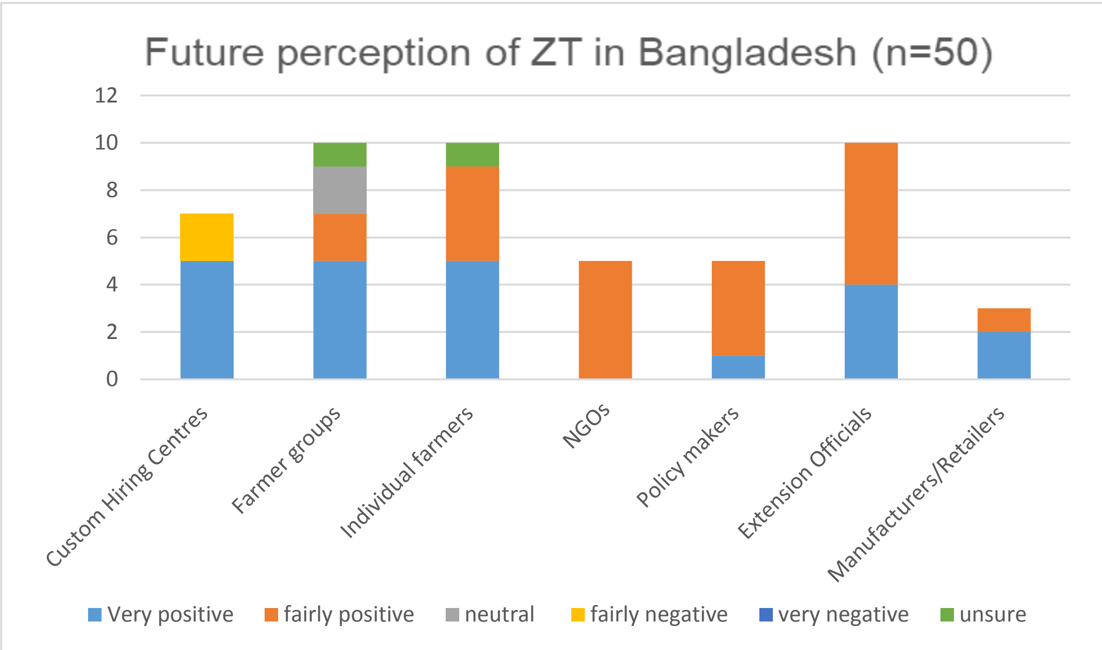


Figure 22: Future perceptions of ZT technology, Bangladesh

Analysis of results indicate that a majority respondents hold positive perceptions towards the future of ZT seed-drills in Bangladesh, however it should also be noted that the views of some farmers' groups and individual farmers remain neutral, unsure or even negative (in the case of custom hire service providers). Overall, it is evident that there is a good base to work from in Bangladesh, however there may be the need for some specific policy intervention approaches tailored to the specific situations in Bangladesh. It is noted that the level of positive perception towards ZT seed drills was found to be higher in NW Indian States.

Advantages of Happy Seeder (HS) and Zero-Till (ZT) Technologies

Respondents were next asked to clarify their reasons for the specific response to positive perceptions about ZT technologies. Qualitative answers were coded, analysed, and categorised into six major advantages (refer to Figure 23). Overall, approximately 37% of the respondents indicated that key advantage of ZT seed-drill technologies related to the cost saving attributes.[4] One such respondent commented:

"The technology saves cost and allows for timely plantation of the crop, so more farmers are interested in receiving the ZT machines"

Other identified advantages included savings in time and labour, the ZT machines were easy to operate, and that using the technology helps to achieve higher crop yields. One of the respondents observed:

"We can use this machine immediately after harvesting the previous crop and it is easy to plant. With this new technology and timely plantation our yields have increased"

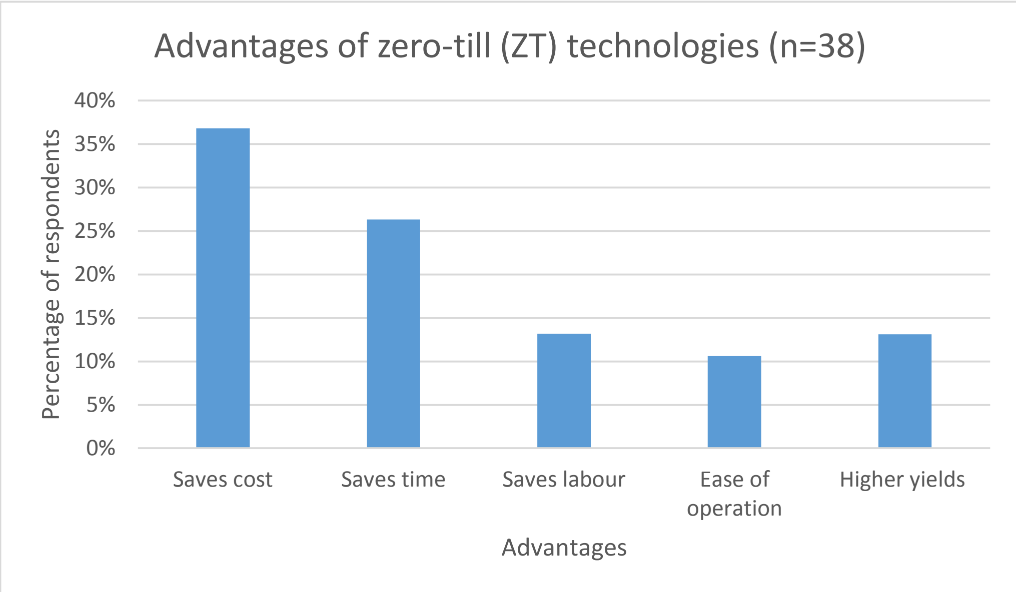


Figure 23: Advantages of Zero-Till (ZT) technologies, Bangladesh

Challenges along the Value Chain

Stakeholders were next asked to describe the key barriers that were considered to hinder adoption of CA technologies such as ZT seed-drills. Qualitative answers were coded and categorised into six major barriers to adoption (Figure 24). Poor availability of spare parts was considered the largest barrier to adoption (41%), reflective of the absence of local manufacturing facilities and spare parts.

It should be noted that in this study, the type of ZT seed drill that was referred to was the ZT seed drills generally used in combination with 2WD tractors (with these seed drills either

[4] Note here we are talking about zero-till seed-drills rather than Happy Seeder seed-drills which are very rare in the NE. As such, the adoption of these cheaper, more accessible, and better-supported machines is much higher than that of Happy Seeder in the NW areas.

manufactured locally in Bangladesh or imported from China). The 2WD tractors tend to be more popular in Bangladesh in comparison to other regions of the IGP. One of the respondents typified the situation through the following remark:

“Good quality spare parts are not available anywhere in Bangladesh locally, and it becomes very challenging if something goes wrong with the machine”

A general lack of awareness about the potential benefits from using ZT technology was also identified as a major challenge to achieving further adoption. It was evident that farmers were not yet aware about the many benefits of these technologies. There was also a lack of technical knowledge within the farming community that hampered the dissipation of awareness and knowledge further amongst farmers as illustrated by respondent:

Farmers are not aware of the benefits of ZT technologies: like higher yield, time saving, increasing cropping intensity and reduced production costs. These things are not well known to farmers”

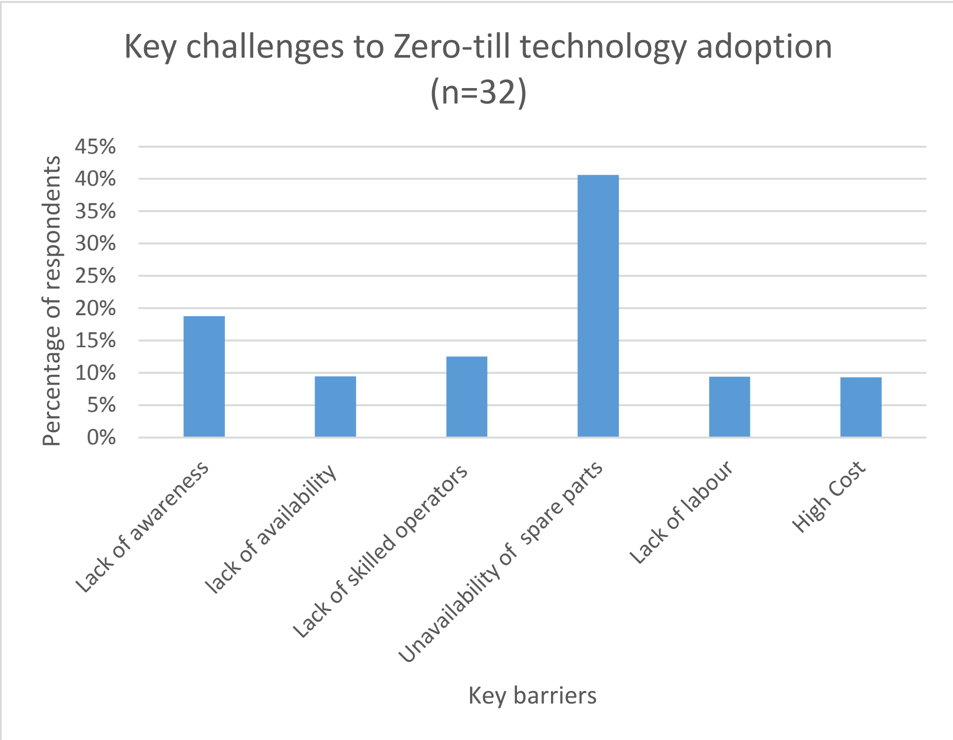


Figure 24: Key barriers to Zero-Till technology adoption, Bangladesh

Another critical issue identified was a lack of skilled operators capable of calibrating and operating the machinery effectively, with an apparent shortfall in the number of skilled operators currently available to meet the increasing demand of ZT operations in peak season presenting the farmers with additional challenges. As a result, there is little incentive for farmers to change practices, and farmers continue to practice conventional tillage since they do not have access to ZT technologies and if they do the prolonged period to access such services poses the risk of reduced yields due to late sowing of crop. One of the extension officials summarised this issue:

“The people involved in the agro-machinery business, particularly irrigation machinery, harvesting machineries as well as tillage machineries, are not remarkably familiar with these technologies. And those who have delved into it are operating with less capacity and expertise. There are only few operators of ZT machines in this region, and their

demand goes up during peak season. It is challenging for the businessmen or custom hiring centre."

Affordability of the ZT seed drills was identified as a significant challenge particularly amongst small marginal farmers, with the best option for them being to access the technology through CHC's. Table 6 and Table 7 provide details on the manufacturer, purchase cost and the average usage of ZT machinery (the specific ZT seed drill models correspond to those recommended and approved by the Bangladesh Agricultural Research Institute (BARI)). It is worth noting that there is no subsidy for machinery purchase provided by the government. The typical machine cost of 150,000 Taka is equivalent to approximately INR120,000 (as at April 2018).[5]

The cost of the machinery in Bangladesh is therefore relatively higher to those ZT drills sold in India (priced between INR65,000 to INR80,000), however it is noted that the Bangladesh machinery is used for extended periods of time (90-130 days on average), thus off-setting the higher cost. The cost of maintaining ZT machinery in Bangladesh is much higher, since the majority of spare parts are either simply not available or are imported. As indicated in Table 6, some of the ZT machines have been provided under the Sustainable and Resilient Farming Systems Intensification (SRFSI) project conducted by ACIAR. This is again similar to the situation reported by farmers and farmer groups in Bihar and West Bengal.

Table 6: Machinery specifications of custom hiring centres, Bangladesh

	Zero-Till Manufacturer	**Purchase date**	**Price (in Taka)**	**Finance source**	**Quality rating**	**Tractor Capacity (in HP)**	**Average usage in one year (no. of days)**
CHC 1	Alim Engineering	Aug-17	150000	Own	8	16	105
CHC 2	Alim Engineering	Aug-17	150000	Own	8	16	105
CHC 3	Resma Engineering	Jun-14	150000	Own	7	16	105
CHC 4	Mahabub Engineering	Jun-14	150000	SRFSI	8	16	105
CHC 5	Mahabub Engineering	Jun-14	150000	SRFSI	8	16	105
CHC 6	Mahabub Engineering	Jun-14	150000	SRFSI	8	16	105
CHC 7	Resma Engineering	Jun-14	150000	SRFSI	8	16	90

[5] It must be stressed that ZT seed-drills in Bangladesh are built for two-wheel tractors, and therefore the prices quoted may include the cost of the two wheel tractor. This limits our ability to make direct comparisons across the two countries. Further clarification on this point, as well as the broader issues surrounding the pros and cons of two-wheel versus four-wheel tractor and seed-drills from India, will be detailed in the discussion section of the report.

Table 7: Machinery specifications of farmer groups, Bangladesh

	Zero-Till Manufacturer	**Purchase date**	**Price (in Taka)**	**Finance source**	**Quality rating**	**Tractor Capacity (in HP)**	**Average usage in one year (no. of days)**
Farmer group 1	Resma Engineering	Jun-14	150000	SRFSI	7	16	120
Farmer group 2	Mahabub Engineering	Jun-14	160000	SRFSI	7	16	120
Farmer group 3	Mahabub Engineering	Jun-14	160000	SRFSI	7	16	100
Farmer group 4	Mahabub Engineering	Jun-14	160000	SRFSI	7	16	130
Farmer group 5	Resma Engineering	Jun-14	160000	SRFSI	7	16	130

Key Barriers to Adoption

The main barrier to the adoption of ZT by farmers across the value chain in Bangladesh was identified as being a lack of local quality manufacturers as well as retailers/dealers offering servicing and repairs. Despite a lack of local manufacturing capacity, the close proximity to India and China has allowed Bangladesh to import ZT machines with ease, but this comes at an additional importation cost, thus placing such equipment largely out of the financial reach of small and marginal farmers. As a result, it is the CHC's that dominate the business models associated with the provision of smallholder farmer access to ZT seed drills. The CHC businesses face similar challenges to those of Indian operators, relating to low numbers of skilled operators who ideally would be the target of training and capacity building as part of strengthening the value chain.

Farmers identified the need to increase subsidy support as well as providing more ready access to finance amongst the CHC's in an effort to improve access to the seed drills. Also identified was the need to increase local manufacturing capacity, in addition to providing manufacturers with access to good quality raw materials for manufacturing of equipment and spares.

The Bangladesh Government and farmers are committed to increased intensification of their farming systems due to increased population densities, fewer land resources and an agri-dependent society, however specific constraints identified (including variable soil moisture and a lack of suitable cultivars adapted to specific growing season length) were identified as constraints to achieving increased intensification of the cropping system.

Use of CA machineries such as strip-till planters and zero-till seed drills are considered to help increase crop yield and intensification (TAAS et al., 2017).Despite this gaps in the level of communication between stakeholders associated with the value chain between key stakeholders including farmers, machinery retailers and extension providers was considered to serve as a significant barrier to adoption. One of the stakeholders commented on this issue:

"There is a lack of communication between researchers and farmers and no coordination between the researchers and extension providers. The benefits of ZT technologies are therefore not known to many farmers because of this"

Other constraints identified included a lack of basic services and transport infrastructure that in turn impacted on the ability of extension agencies to adequately deliver promotional campaigns and training activities at the farmer level, as illustrated in the following comments expressed by a machinery dealer:

"We do not have proper roads, and electricity supply is unreliable. Thus extension activities are challenging, especially farm demonstrations and trials"

Despite this, programs delivered through the SRFSI project, funded through ACIAR and co-delivered through CIMMYT were identified as the catalyst for creating increased awareness and demand in specific locations. The challenge remained as to how a significant shift in the provision of resources towards out scaling could be introduced, which in essence required commitment and support from the implementation of significant changes in current government policy to help ensure resources were available to achieve accelerated adoption.

6.1.3 Issue summaries and updated Current State maps

From the results and associated statements provided above, a summary of the specific barriers/challenges and opportunities for India and Bangladesh were prepared (Figure 25 and Figure 27 respectively). The analysis of the value chain interview responses contributed to the preparation of state maps illustrating how stakeholders perceived the supply/adoption processes to be (Figure 26 and Figure 28).

Manufacturers and Retailers

- Would like more demand, but increased production capacity will need support
- Subsidy policy is problematic due to misapropriation of resources in some instances
- Availability and quality of raw materials
- Lack of spare parts and local support in areas outside Haryana and Punjab
- Direct dealing would drop prices and increase adoption rates
- Low trust by other stakeholders of this group

Custom Hire Service Providers

- Parts supply and support an issue
- Precise and accurate use of the machinery in the field is a significant barrier
- Raising awareness and knowledge outside existing groups/users is challenging
- Limited value from subsidy program - cannot access without land
- Lack of quality products across a range of inputs

Farmers and Farmer Groups

- High cost of machinery (yet some have purchased without subsidy)
- Weed issues and cropping changes in some states (e.g. West Bengal wheat)
- Lack of awareness and correct use practices - demonstrations needed
- Uneconomic nature (and some constraints) of HS from year to year
- Inability to operate the machinery and presence of agronomic constraints
- Expensive farm labour driving some demand
- Access to finance

Research and Extension

- Stubble burning reductions will impact more significantly over time
- There is limited skill development programs for extension staff
- Labour costs are increasing, which can be addressed by HS/ZT, but limited awareness of benefits - change of mindset needed
- HS too heavy for low powered (40/50HP) tractors to operate HS in field conditions
- Need for proper land preparation ahead of use, with small window of opportunity
- Correct training and use is a critical factor in gaining benefits

Finance Providers

- Finance to medium/large farm works well, but less so for smallholders
- Agriculture is one of very few opportunities for economic growth in India
- State-level bankers' committee may be key to policy involvement
- Farmers' Club business model viewed very positively
- Do not view subsidies as a good support platform for farm businesses
- Long-term support and program is needed for greater adoption

Figure 25: Summary of VCA issues by stakeholder, for the Indian states

6.1.4 Updated value chain map for the Indian states

The stylized value chain shown below presents the characteristics associated with the key actors and linkages along the value chain for the Indian states. It provides a much more detailed picture of the interactions between stakeholders and the critical roles played in each case. The biggest change is how this map depicts the process as one of dealers, farmers/farm groups and custom hire service providers being bounded by manufacturers and machine testing agents on the one hand, and finance, government (including research extension) and repair support agents on the other.

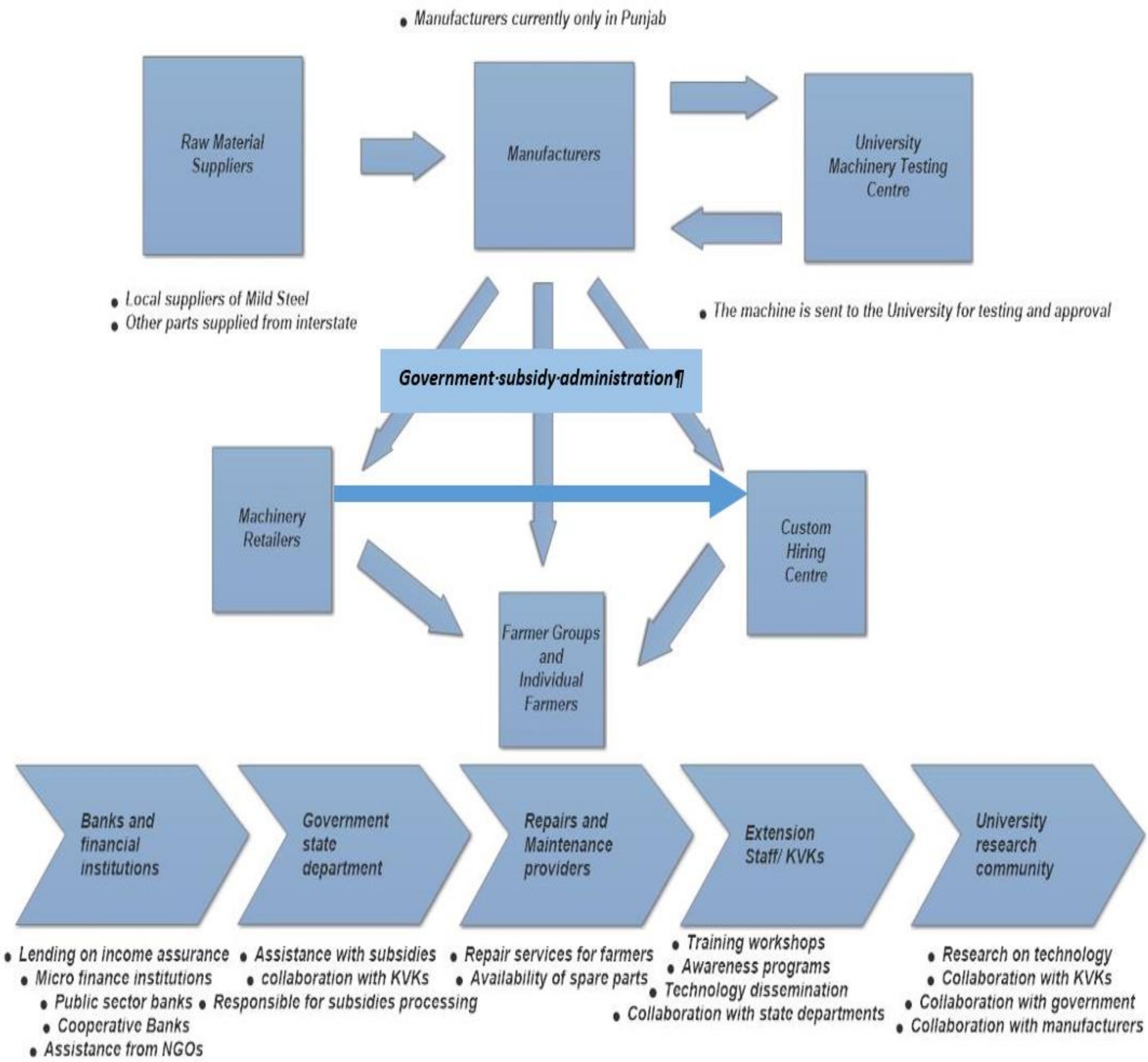


Figure 26: The Happy Seeder (HS) and Zero-Till (ZT) Value Chain for Indian states

While subsidy support may benefit individuals, there appears to be no oversight or monitoring of the program at the local or farm level. This is leading to stakeholder views of the system as corrupt, and a view that the program has little value to offer in terms of increasing adoption, increasing the spread of conservation agricultural practices, or increasing farmer incomes and financial resilience in response to regulatory change (e.g. stubble burning bans) over the long-term.

It was therefore identified that there are opportunities to improve the efficiency and effectiveness of subsidy support, through providing greater elements of accountability and monitoring of the provision. There were also some claims that not everyone wanting to access subsidies were able to do so, reflecting a degree of discrimination and a further lack of accountability.

This value chain map highlights the disconnect between the majority of farmers/farm groups and state or national research/extension personnel and machine repair/spare parts service support organisations. It is also evident that there is limited interaction between finance providers and smallholder farmers in India.

6.1.5 Updated value chain map for Bangladesh

The summary of issues and updated value chain map for Bangladesh whilst having some common elements to India does differ on a number of fronts, the major issues reported through the VCA interviews are summarised below:

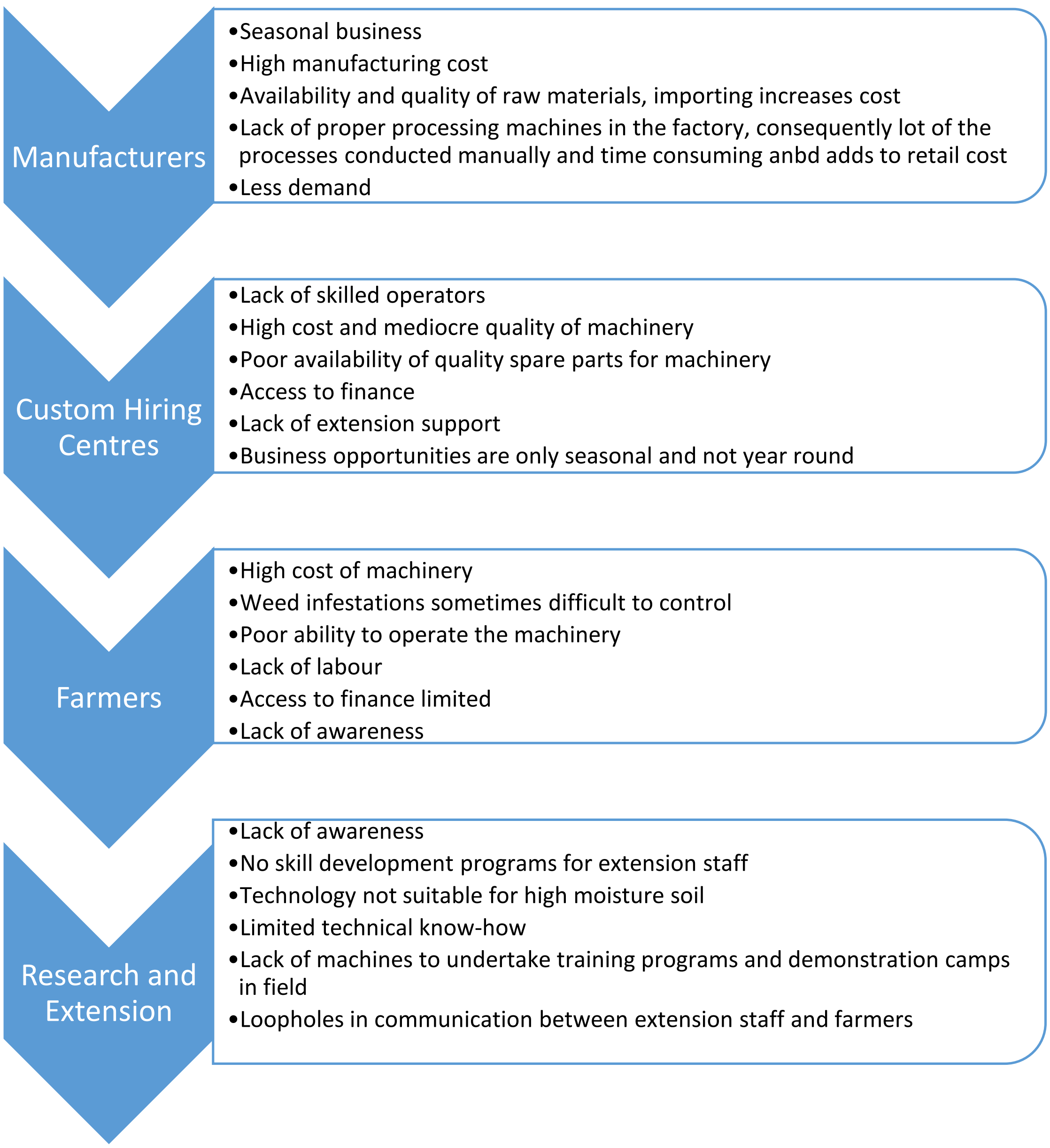


Figure 27: Summary of VCA issues by stakeholder, Bangladesh

6.1.6 Updated value chain map for Bangladesh

The updated value chain map for Bangladesh shares some similarities with India, particularly where farmers, farmer groups and CHC's are bounded in their interactions with external (international) manufacturers, machinery suppliers and support providers (such as banks for micro-finance provision and other services). There is a degree of collaboration with researchers, and local support from NGOs to raise awareness of and promotion for ZT technology. The most obvious point of difference is the role of BARI in approving and certifying imported machinery, as well as a higher level interaction between farmers and local dealers/service providers; although the availability of equipment parts remain a common constraint.

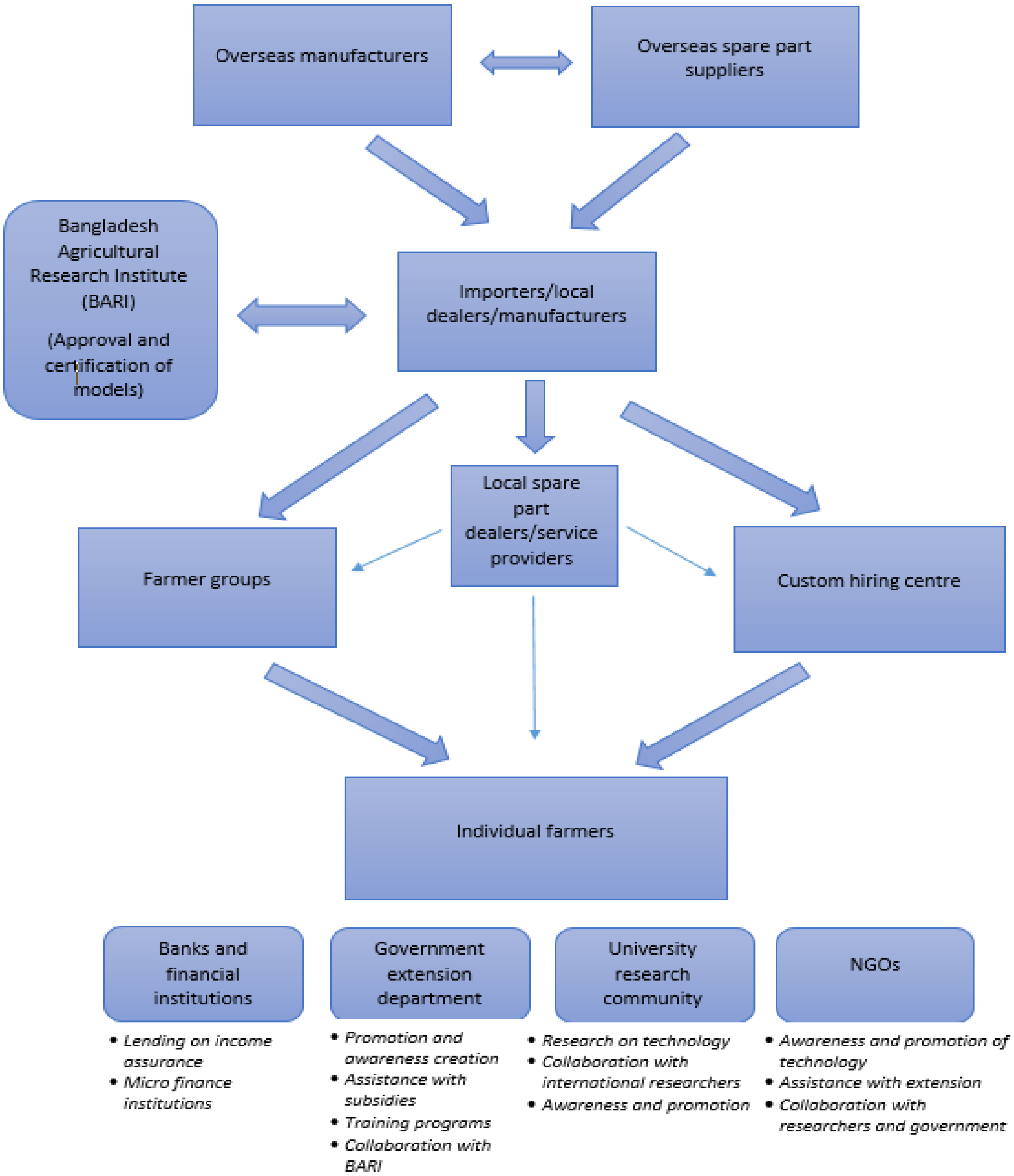


Figure 28: The Zero-Till (ZT) Value Chain for Bangladesh

6.2 Focus Group Discussion results

Results associated with the focus group discussions are provided separately according to the respective location of each. It should be noted that the discussions in the NW Indian states (Punjab and Haryana) related to HS seed drills, whilst in the eastern states and Bangladesh the discussions focused on the ZT seed drills.

6.2.1 Haryana Summary of Focus Group Discussions

General conclusions

- Farmers recognised the benefits associated with the adoption of both the HS and ZT seed-drills.
- Despite there being some adoption of both the HS and ZT seed-drills, the level of awareness of such practices reached only 50 to 60% of those farmers participating in the focus group workshops.
- Farmers prefer to see a clean seed bed with defined seeding rows free of stubble and other residues once the seeding operation had been completed. There is also the perception that seed will have difficulty in germinating when sown with the HS into thick and bulky rice stubble situations.
- Farmers consider that when crops were sown using the HS, it was difficult to assess how successful the seeding operation was been until after the crop has emerged. It was also considered that a high level of plant and stubble residue would shade sunlight from the soil, thereby being detrimental to seedling germination and early growth.
- Farmers experience in using the HS had generally accessed the equipment from local CHC's (who played an important role in providing farmers with access to such seed drills). Availability of the HS during the height of the sowing season proved to be a major stumbling block for farmers due to unprecedented demand.

Detailed Summary

Ability to identify a well sown wheat crop

Farmers considered that they could only assess the effectiveness of the sown crops once they had germinated (usually 15 to 20 days following seeding) when the emerging seedlings were easy to see. Farmers considered that if they sow their crops by hand then they have a greater level of control over seed placement and the seeding operation. When using machines, it was considered that this level of control 'or precision' diminished and farmers had a higher degree of confidence in the practice in comparison to using ZT seed drills.

Farmers experienced in sowing with a HS commented that they were unable to judge how effective the seeding operation was until long after germination. It was also difficult to ascertain the number of seeds sown per unit area given the presence of heavy stubble residues in the sown field.

Farmers considered that when sowing a crop conventionally the field is neat, clean and clear, with visible lines of sown seed. Where a HS is used the field is covered with the residue and it is difficult to see the sown crop lines.

Farmers from one of the groups preferred option A with the crop sown by the HS. They had formed favourable attitudes towards the use of the HS, including the value of soil organic matter build up over an extended period of time due to retaining plant residues.

Figure 29: Focus group discussions near Malda, West Bengal

Awareness of HS technologies

The level of awareness between groups participating in the focus group discussions were variable. In general, between 50 to 60% of participants were aware of the HS (even in those village communities who were considered to be high adopters of the HS). As such there didn't seem to be any differences in the level of awareness between villages considered to be high adopters of the HS versus those villages considered to have low rates of adoption. Farmers who were aware of the HS but had no direct experience in using the machine had heard about the HS from other farmer adopters within their local village communities. Other sources of information included extension officers and KVK offices.

Negative aspects

There were few negative characteristics associated with the HS identified by participants in the focus group workshops. Some farmers were concerned that due to the presence of high rice stubble loadings there was insufficient sunlight to reach germinating seeds (which would have contributed a negative impact on achieving satisfactory germination and seedling vigour).

Positive aspects

Farmers recognised the benefits associated with the use of the HS, including saving time, saving costs and increasing crop yields. Those farmers who had first-hand experience in using the HS were pleased in general with the performance of the equipment. Some groups recognised the longer-term value of the HS, in terms of returning plant residues to the soil and improving soil organic matter.

It was reported that in recent years the price of hiring the HS from CHC providers had declined, making it more affordable for farmers, and even putting the HS within affordable reach of the smallholder farmer. Use of the HS was thus considered to be a profitable exercise, since yields increased, time of sowing the crop was quicker (and optimal to maximising yield potential) and costs were far less (lower rates of fertiliser and the costs of tillage).

Farmers in general were satisfied with the quality of the HS and felt that the machine achieved a satisfactory level of performance when it came to sowing the crop.

The decision to trial the technology

Farmers became aware of the HS technology largely from other farmers within their village communities; however local extension officers from Government and KVK were also considered a valuable source in raising awareness. KVK's were also involved in providing some demonstrations of the HS and this was considered to be a positive element in convincing farmers to try the technology on their own farm themselves.

Availability and interest in accessing the technology

Within village communities, up to 50% of farmers either owned for accessed the HS from custom service operators. Between 40 to 50% of farmers owned some form of a seed-drill (including the ZT seed-drill, HS and other tractor drawn seed-drills used in conventional crop seeding systems).

In some villages, a limited number of smallholder farmers (having very small acreages_ would sow their crops by hand. By and large farmers had ready access to seed-drills. Access to the HS was gained through ownership (limited numbers of farmers), with the majority of farmers accessing through CHC's.

Relationships with custom service hire providers

Farmers in many village communities frequently found it difficult to access a HS since there were few CHC providers, with only 30% being able to access such equipment. For those farmers wishing to trial the technology, this situation proved frustrating.

Farmers often found it difficult to access a HS during the peak sowing periods of the season, creating a degree of inconvenience and frustration for those farmers wishing to trial the technology or those who were ready adopters.

Overall farmers were pleased with the business model of accessing HS through CHC providers, since the economic benefits (increased yield and reduced costs) was clearly demonstrated and the cost of hire was considered to be affordable.

Farmers using the HS owned tractors having 50 to 60 HP capacity. Others who did not own tractors usually hired them or borrowed tractors from other farmers.

Development of Business Models

Purchasing a HS together with other neighbouring farmers generally was not a preferred means, with many groups considering that such arrangements would lead to disputes. It was considered that during periods of peak demand there was the likelihood that everyone would want to use the HS at the one time.

In many of the focus groups, some 20 to 30% of farmers were considering the purchase of a HS. Much of this interest had been prompted through the recent publicity relating to State Government's threat to enforce for burning rice straw residues.

Access to finance

Being able to access finance for the purchase of equipment such as the HS was considered to be one of the main barriers to ownership. Farmers considered the process to be quite tedious, and reported that it would take a long period of time to access finance as well as any particular subsidies that may be available.

The cost of the HS, at around 1.5 lakh INR was viewed as being a major barrier to ownership amongst the majority of groups interviewed, with some quoting a figure of between 0.75 and 1 lakh as being more of an affordable (and appropriate) price. A subsidy in the order of 50% was viewed as quite a positive incentive for those farmers considering the purchase of a HS.

Extension Services

It was considered that many villages were regularly serviced by KVK and the local Agricultural Development Officer (ADO). KVK's were reported to be actively involved demonstrating the HS within the local village communities. In a small number of villages NGO's were also active in providing farmers with assistance in raising awareness and promoting use of the HS.

Recommended Government Intervention

There were limited suggestions in relation to how best Governments could intervene to help provide better support mechanisms to aid the increased adoption of the HS. Several suggestions were made in relation to supporting further research and capacity building at the farmer level. Farmers considered that they would benefit from receiving training in the use of the HS in the form of practical on-farm training. One group considered that the government should undertake research to develop alternative options to the burning of stubbles, other than using the HS.

Farmers were of the general view that compensation for not burning crop stubble residues would not work in a practical sense, was open to inequities in payment and would lead to further dishonesty in the process. Farmers participating in the workshops were in general agreeance that the HS was a viable alternative to stubble burning, and so in conclusion to was considered that incentives were best directed towards subsidising the purchase price of the HS.

Local farmer leadership

There were limited comments and feedback provided in relation to the characteristics and importance of local farmer leadership. Local farmer leaders were considered to fulfil an important role in addressing constraints in local farming environments. For some focus groups, they had difficulty in identifying local farmer leaders.

6.2.2 Punjab summary of focus group discussions

General Conclusions

- Farmers, whilst preferring to see sown fields free of stubble residues and well-defined seeding rows recognised that crops sown with the HS were more likely to benefit from CA practices.
- Awareness of the HS amongst focus group participants ranged from 50 to 60% of participants attending, however there were still significant numbers of farmers who were simply unaware of the technology.
- CHC's served as an important point of access for farmers wishing to use the HS with strong demand during the height of the crop sowing season often proving difficult and frustrating for many farmers.
- Farmers who regularly used the HS often found it difficult to assess the effectiveness of the seeding operation (including seed placement and distribution) until after the crop had germinated. They considered this to be a negative aspect of using the technology.
- Farmers encountered challenges in the first year of using the HS and felt that they would have appreciated additional support in the field from extension officers and organisations in general.
- There were a large number of farmers who were considering the purchase of the HS themselves (around 50% of farmers), indicating that not all farmers would in the future necessarily access the services through CHC's.
- Providing financial incentives to farmers for not burning their rice stubbles was considered to be impractical (in terms of implementing and administering).

Detailed Summary

Ability to identify a well sown wheat crop

Farmers considered that a clean field free of residues following the seeding operation looked best, compared with fields that contained excessive stubble residues from the previous crop (as per fields sown with the HS). A clean sown field was considered to lessen the risk of the particular crop seeds not germinating properly. There was more doubt in relation to the ability of seeds to germinate in heavy stubble laden fields as is the case with crops sown using the HS.

In terms of farmers being able to assess and recognise a crop that had been well sown, many farmers considered that this was a difficult matter to ascertain, since it is only when the crop has emerged that the overall effectiveness of the seeding operation could be properly assessed.

Awareness of HS technologies

Overall the level of awareness of the HS varied between 50 and 60% amongst the focus groups interviewed. Farmers became aware of the HS from a range of sources, that included other farmers within local village communities, farmer societies, farmer meetings, from KVK and universities, as well as representatives of the CHC's. There was limited awareness of the HS technology that was generated through the print and electronic media.

The decision to trial the technology

Some farmers who regularly use the HS indicated that in the first few years of using the equipment they did encounter issues (in terms of properly calibrating the equipment, the physical operation of the equipment, and ability to penetrate the stubble residues). Progressively over time as their experience built up they were able to resolve such situations.

Availability and interest in accessing the technology

The majority of farmers interviewed (around 90%) owned their own tractors, with the size of the tractor generally falling in the 50 to 60 HP range. Of those farmers participating in the workshops, around 50 to 60% of farmers owned a seed-drill in one form or another. These included ZT seed-drill, HS, other tractor drawn mechanical seed-drills and manual/animal drawn seed-drills.

For those who did not have access to a tractor/seed-drill, they either rented or borrowed a seed-drill from other farmers or CHC providers.

Relationships with custom service hire providers

Farmers having adopted the HS gained access to the equipment through CHC's. However, during peak periods of the crop sowing season there would be challenges in being able to access the equipment when the crops needed to be sown.

Many of the groups indicated that between 30 to 35% of farmers within their communities accessed the HS through the custom hire service providers.

Negative aspects

The negative elements associated with the HS included the risk of poor germination (due to the presence of high levels of stubble residue) and the inability for sunlight to reach the soil. Some farmers indicated that they had little control over the number of seeds that were sown with the HS equipment, indicating that there were issues surrounding calibration and seed delivery in the HS machines. Farmers new to the technology often in their first year of using the HS were not fully aware of the benefits of the technology (often it was after several seasons they fully appreciated the benefits of the HS technology).

Positive aspects

Overall, farmers held positive experiences towards the use of the HS. Most of the negative issues tended to occur during the first year of use, but generally were resolved by the third cropping season. Many farmers were able to reveal the positive aspects associated with HS sown crops: these included time saving, increased profitability through cost savings, higher crop yields, and no pollution (from the burning of stubble residues).

Awareness of the Happy Seeder

Across all groups participating in the focus group studies in the Punjab, the level of awareness of the HS (and understanding of the key features and role of the HS) ranged between 50 and 60%.

Development of Business Models

In many of the focus groups in the Punjab, there were a large number of farmers reporting to be interested in purchasing a HS themselves (40 to 50%), however, the high purchase price of the HS was viewed as a deterrent with the need to offer a subsidy seen as a positive incentive (to compensate the high purchase price).

Collective ownership of a HS between 2 to 3 farmers was considered to be an option, Regrettably, many of the farmers were deterred from such ownership models due to the risk of conflict and arguments arising. In particular, it was considered that farmers in the joint ownership arrangement would all want to use the equipment at the same time leading to conflict.

Some farmers expressed interest in forming a local business group where they could purchase multiple numbers of HS machines for the purposes of establishing a CHC business. Whilst there was still a risk of farmers wanting the equipment all at the same time, this would be partially reduced by having multiple numbers of the HS seed-drills available.

Access to finance

Farmers being able to have adequate access to funds to finance the purchase of the HS was seen as a serious barrier to HS. Farmers reported difficulty in their ability to access finance through banking institutions, with some farmers opting to source finance through local lending societies.

Extension Services

Several focus groups indicated that they were well-serviced by representatives of a local agricultural university, who regularly visited their village community and performed demonstration trials with the HS. Farmers indicated that they preferred being involved in field trials and demonstrations, as well as learning from other farmers in relation to the practical aspects of HS operations. It was the 'learning by doing' aspect of the field demonstrations that farmers valued the most. In one village, a local society was actively engaged in performing HS field demonstrations, which farmers found to be most worthwhile. These activities were also backed up with regular meetings at least on a monthly basis, allowing farmers to discuss the issues and concerns they had in relation to the technology and to address these as a collective group.

Recommended Government Intervention

There were a number of suggestions provided by focus groups. It was considered that if the Government wanted farmers to stop burning stubble and physically remove the straw, then Government assistance was required to store physically removed stubble.

It was also recommended that the Government should improve farmer awareness and access to subsidy support schemes. Providing a 50% subsidy was considered a very strong incentive for farmers wishing to purchase such equipment. One group considered that a HS should be provided in every village in the Punjab.

Compensating farmers for not burning residues

The majority of farmers were of the opinion that a Government policy that rewarded farmers for not burning the cereal straw would be difficult to implement, monitor and manage and therefore did not supportive of this idea. Of the few groups that did support the notion of compensating farmers for not burning stubbles, the level of financial incentive considered reasonable by farmers was in the order of 5000 INR per acre of land.

Local farmer leadership

Farmers considered it was important to have good local farmer leadership within a village community. Local leaders were considered to essential in providing assistance (and guidance) to other farmers in the adoption of the HS/ZT seed drills. It was not always possible to visit the agricultural department and KVKs, and so sharing information between other farmers was viewed as highly beneficial

6.2.3 BIHAR SUMMARY OF FOCUS GROUP DISCUSSIONS

General conclusions

- The introduction of ZT seeding systems was a relatively new practice for this region, but was considered to offer farmers many benefits in terms of timely sowing, reduced crop establishment costs and in many situations higher crop yields.
- Farmers had largely become aware of the ZT technologies through extension officers (from Government and KVK's) who had been involved in demonstrating the technologies in the farmer fields. Many farmers had been engaged in farmer groups supported through the SRFSI project.
- There were some on-going issues in relation to the effectiveness of the crop sowing operations associated with the ZT drills, often blockages in the seed delivery tube/seeding boot resulted in less than desirable results in the field.
- The HS was not used in this region of India since stubble residues were valued highly as both a fuel source and for animal feed. Stubble residues were also less as most of the crops were hand harvested and any surplus stubble residues removed from the field, resulting in less need for the burning of residues.
- Access to ZT seed-drills through CHC's was generally the preferred (and most convenient) means of accessing such equipment. This was due to the fact that tractors owned by farmers were under powered and not suited for using the ZT seed-drills, and secondly the cost of purchasing the seed-drills was too expensive.

Detailed Summary

Awareness of ZT technologies

Farmers had become aware of the technology through a number of sources, including the State Agricultural Department and KVK extension services. Some demonstrations had taken place at the local block level by the extension organisations.

There was however a general shortage of information and overall awareness relating to ZT technology. Some farmers who were familiar with the HS noted that a major problem with the HS were blockages with the seed delivery tubes resulting in a lot of seed missing from sown crop rows. This was considered to be less of an issue with crops that were sown by ZT seed-drills in comparison.

Negative aspects

There were few negative issues mentioned relating to ZT technologies. These included some sowing issues) missing rows sown when the seeding tube and boot became blocked under muddy soil conditions) and a general lack of skilled operators available for the ZT machines.

Positive aspects

Farmers considered that crops sown with ZT seed-drills were able to achieve higher crop yields, with water savings evident under irrigated crop situations. Much of these observations are ‘hear-say’, rather than from farmers having direct experience and familiarisation with the technology. Sowing of crops through CHC’s could usually be completed within a day, whereas sowing by hand (broadcasting) would often take more than 3 days for some farmers.

Farmers recognised the relationship between having an adequate level of cropping inputs (quality seed, fertiliser, proper weed control) sound irrigation practices and maximising crop yields. Some farmers were aware of the longer-term benefits of ZT, in terms of returning plant residues to the soil which would in turn decompose and result in increased soil organic matter levels.

The decision to trial the technology

After seeing the technology being demonstrated in villages locally, some farmers had commenced trialling the technology on their own farms. In these situations, the local extension service had sown wheat crops belonging to other farmers either within the local village or in neighbouring villages. Word had soon spread amongst the farmers in relation to the relative success and benefits of the ZT technology.

Availability and interest in accessing the technology

Availability of the ZT technology in some villages was virtually non-existent. There were few service providers available locally, however it was a constant problem to be able to obtain access to the ZT seed-drills in a timely fashion, often leading to delayed sowing.

In some instances, focus groups interviewed had been provided access to a ZT seed-drill by the local extension services. No farmers were found to own seed-drills. Most crops are sown by custom hire service providers often from neighbouring villages.

Farmer participants were interested in purchasing their own seed-drills, however the equipment was considered to be extremely expensive and there was a lack of access to finance for purchase.

Relationships with custom service hire providers

Being able to access ZT seed-drills often proved to be a major issue, largely due to the timing and availability of such drills, with all farmers wanting to access such equipment at the same periods of time during the crop sowing period.

Access to tractors

Many farmers did not directly own tractors themselves. However, many were able to access both tractor and ZT seed-drill implement through CHC providers. In some villages up to 20% of farmers were owners of tractors, though these tended to be of a low horsepower (often not powerful enough for pulling a ZT seed-drill).

For example, one farmer indicated that he was interested in purchasing a HS, but he was told that he needed to have a 60 HP tractor and he only had a 35 HP tractor. As a result, he was not in a position to purchase a ZT seed-drill.

Development of Business Models

Some farmers were contemplating the purchase of a ZT seed-drill, with the 50% Government subsidy acting as an incentive to do so. For other farmers such a subsidy would not act as an incentive to purchase such equipment, largely due to the high initial cost of the machinery, and the relatively small size of farming operation (area of farm land owned). Other farmers were less familiar with the process in which the subsidy would be provided since there was very little information available.

The overall price however remained an issue with the farmers. The inability to be able to access finance in the form of an agricultural loan remained a barrier to purchasing such equipment. Some groups had no desire to collectively purchase the equipment as a group, since they were able to access equipment through a local CHC service provider. Several groups had not given any consideration at all to the idea of collectively purchasing the ZT seed-drills, indicating an overall lack of awareness or appreciation of the opportunity. From the 10 focus groups, there was only one group that provided evidence of an intention to purchase a ZT seed-drill collectively (between three farmers).

Access to finance

Farmer access to finance to purchase seed-drills (if that was the desire) was considered to be a constraint to ZT ownership by many farmers. Farmers perceived that the process of applying for the loans was often a long and drawn out process, and stated that it was up to the banks to try and simplify the process.

Extension Services

Through local extension services farmers were able to access seed and fertilisers. They received advice on what the most suitable crops were for them to grow, with much of in the information obtained via local farmer groups. KVK Extension services and officers would considered particularly useful, in that they demonstrated ZT seed-drills on-farm within the local farming communities. The Kissan help centre was also valued highly.

Farmers also received advice from input suppliers when they purchased seed, fertiliser, chemicals and other cropping inputs. A large number of the farmer focus groups recognised the need (and opportunity) to be provided with training in relation to using the ZT seed-drills, proper sowing techniques and being able to adequately assess the effectiveness and efficiency of the sowing operation.

Recommended Government Intervention

Some groups considered that there should be penalties for burning of crop residues, since other farmers were affected in terms of fires getting out of control and damaging property to the extent of causing death and injuries to people. It was considered that Governments needed to simplify the process or purchasing and applying for machinery subsidies, which was viewed by many as being a complex and time-consuming process.

The provision of subsidies by Government was viewed overall as a positive incentive for farmers to purchase seed-drills. Farmers considered that the level of subsidy needed to reflect the relative cost of the equipment – it was important to make the equipment affordable in the first place. Many farmers considered that a 50% subsidy on the ZT seed-drills was a sufficient incentive to purchase such equipment, whilst a subsidy of up to 90% would be preferred in the case of the more expensive HS seed-drills.

Compensating farmers for not burning residues

Groups provided feedback in relation to what they considered to be a fair amount of money to compensate farmers who chose not to burn their crop stubbles; 15,000 INR per acre, 60,000 INR per acre, 30,000 INR per acre and 5,000 INR per acre.

The farmers viewed the HS technology as an alternative to stubble burning. Further, if burning was an issue it was considered that this technology may be a useful alternative to burning crop residues, though the majority of farmers had not seen the machine operate. As one farmer lamented,

'we have to burn because we are not left with any choices'.

Local farmer leadership

Good local farmer leadership was considered to be an important asset within local village communities. In contrast to NW India, most participants were able to identify good local leaders. It was viewed by some groups that a local farmer committee within a village community was an important asset that all farmers and village members could benefit from.

The characteristics of good leadership included the having an in-depth knowledge about agriculture and farming practices. Local farmer leaders were also considered to be responsible for teaching other farmers new practices, and to assist in introducing new change (and reforming outdated practices such as excessive cultivation).

6.2.4 WEST BENGAL SUMMARY OF FOCUS GROUP DISCUSSIONS

General conclusions

- Farmers considered that a field free of any stubble residues with clear sowing lines and a fine soil tilth was more desirable than a field characterised by excessive crop stubbles that had just been sown by a HS.
- There was a perception that the ZT seed-drills could sow wheat only and no other crop type. This is not the case, since the ZT seed-drills can virtually sow most types of field crops and so it is important to correct this common misconception amongst many farmers in the region.
- A lack of availability of ZT during the sowing season was considered to be a major barrier to the wider uptake and adoption of ZT.
- Some of the farmer groups engaged in the focus group discussions were considering purchasing a ZT seed-drill themselves as a means of overcoming the shortage of ZT seed-drills within their own local farming communities.
- Farmers were often dissatisfied by the effectiveness of the seeding operation associated with the ZT seed drills. This was in some situations considered to be having an impact on the wider adoption of the technology. Therefore, it is important that steps are taken to address such concerns, and in particular introduce additional field training for technicians and operators of the ZT seed-drills.

Detailed Summary

Ability to identify a well sown wheat crop

A well-sown crop was considered to be one that resulted in a dense stand of seedlings, and was of deep green in colour. The majority of farmers preferred to see a cleanly sown field (photo B), as opposed to a field characterised by a large bulk of crop residue (photo A) that also portrayed a wheat crop being sown into a standing rice stubble with a HS.

It was noted by one group that stubble residues were removed from the field prior to the ZT seed-drills being used. This practice needs to be further investigated, to see how widespread the actions might be. The question remains whether farmers are using the ZT seed-drill in a CA based system (maximising stubble and plant residue retention), or are they removing the plant residues and using it more in sync with a traditional crop establishment system (including reduced tillage).

Awareness of ZT technologies

Group awareness of ZT generally ranged between 60 and 90% of those attending the focus group discussions. Extension officers have been proactive working with a number of farmer groups in an effort to introduce ZT technologies. Outside of these groups, there was less awareness of the technologies particularly amongst smallholder farmers since larger farmers tend to be targeted. There was no promotion of the ZT seed-drills through the media. It was considered that this is a valuable avenue to create awareness and promote the technologies amongst farmers.

Negative aspects

There was a perception amongst some farmers that the ZT seed-drills could only be used for sowing wheat, and they were unaware that such seed-drills could be used to sow other grains successfully. This illustrates the need to provide improved awareness raising in an effort to provide technically correct information and guidance in relation to the sue of the ZT seed-drills.

A lack of machine availability was considered to be a major constraint to the uptake of the technology by many of the farmer groups interviewed. The effectiveness of the seeding operation provided by the ZT seed-drills is sometimes questioned. The main issues relate to blockages in the seed delivery of the seed-drill (resulting in missed rows).

Positive aspects

Farmers were aware of the positive aspects associated with the adoption of ZT; including the timeliness of the seeding operation, the ability to maintain if not exceed crop yield, and importantly the cost savings that were apparent with a ZT seeding system (reduced tillage costs) along with improved seed placement and labour savings.

The decision to trial the technology

The main influencing factor that encouraged farmers to trial the ZT technology was the result of the extensive range of demonstrations that the agricultural extension officers provided to farmers within specific village locations. There was the expectation that farmers would have their entire fields sown, as opposed to just a few demonstration strips. Often in the first year farmers would only have a proportion of their farm sown (20%). However, once the technology was proven to them, in the following years farmers were prepared to have larger areas of crop sown using the ZT seed-drills.

Farmers having larger areas of land tended to be targeted by the extension officers for conducting on-farm demonstrations of ZT. As a result, the small landholder farmer missed out on being engaged in such field demonstrations, and it was a natural expectation that they would have a much lower level of awareness.

Availability and interest in accessing the technology

Smallholder farmers suggested that the ZT seed-drills were not suited to their farm size. They considered that ZT seed-drills that could be fitted to 2 wheel tractors would be more suited to their farm size and scale of operation.

The technology had largely been introduced to farmers through local extension officers on a trial basis. Last season was plagued by devastating floods, and in some instances crops were destroyed, so for farmers using ZT for the first time they were not able to draw any particular conclusive results.

Interest and ability to own ZT seed-drills

Tractor ownership by farmers was uncommon, making it unviable for farmers to even consider purchasing ZT seed-drills. This was considered to be a major barrier to the uptake of ZT technologies.

One farmer group noted that a number of participants were contemplating the purchase of a ZT seed-drill. However, there were no local agents available who sold the seed-drills. As a result, they had lost interest in purchasing the seed-drill. In this particular group some 50% of participants accessed the seed-drill from the local agricultural office and were convinced that it was a good method of sowing crops.

The cost of purchasing a ZT seed-drill, combined with a new tractor (of sufficient power) was estimated by one group to cost in the order of 350,000 INR. This was considered to be out of the reach of all farmers in this particular group.

Relationships with custom service hire providers

For many of the farmers interviewed, they considered that they had difficulty accessing ZT seed-drills through CHC businesses. Some smallholder farmers, having small areas of cropping land, considered that their fields were too small for the seed-drills to operate effectively, and as such the ZT mechanisation was not suited to their particular situation. Such farmers often sowed their seeds manually by hand broadcasting.

The agricultural extension officers were active in working with the farmer groups that were involved in the focus group studies. In effect, the extension service was providing a CHC service 'free of charge' to the farmer participants, with few farmers (if any) indicating that they regularly utilised custom hiring providers for accessing ZT seed-drills.

Access to tractors

There were only a small number of farmers attending the focus group discussions who indicated that they owned a tractor (3 persons). The tractors were generally of low horsepower capacity, and it was felt that these tractors were underpowered when it came to successfully operating the ZT seed-drills. Therefore, if farmers wanted to purchase ZT seed-drills they would also need to upgrade their tractors to a larger power capacity. Farmers under these circumstances indicated that such a requirement was way beyond their financial capacity.

Development of Business Models

A number of groups were not aware of the benefits that could be gained through collective ownership of ZT seed-drills, with the majority not at all interested in purchasing ZT seed-drills on this basis. It is evident that the lack of awareness (or knowledge) is detrimental towards the farmers developing services within their local farming communities, contrary to many of the SRFSI groups where there is a strong determination by many farmer groups to establish such services within their local village communities.

Access to finance

Access to finance was considered to be a constraint for many group participants. Sources of finance included cooperative societies, with loans from Samabava often difficult to access according to one of the focus groups.

Extension Services

Whilst extension services were focused on conducting on-farm demonstrations of the ZT technologies (targeting the larger farmers), the smaller farmers often missed out on these valuable experiences. One group considered that there was often some political interference where the trials were conducted, often favouring party leaders or those associated with party leaders.

There is little publicity or promotion of the ZT seed-drills, and little effort to promote such on farm demonstrations. It was often the smaller farmers who missed out being informed by such field demonstrations and field day activities that were directed towards the larger farmers. Where extension officers were actively involved in demonstrating and trialling ZT seed-drills in local village communities, between 40 to 60% of farmers were readily adopting the technology.

It was also noted that many of the extension offices only had the single ZT seed-drill. As a result, there was a huge demand for such seed-drills to the point where farmers would give up trying to access the seed-drills due to the prolonged delays, and the fact that when the seed-drill was available the optimal time of seeding had long since passed.

Recommended Government Intervention

Government subsidies were considered to provide an incentive to purchase the HS, with many considering that a 50-60% of subsidy as sufficient. Whilst farmers appreciated the efforts that the Government were making in demonstrating the ZT technologies, a lack of custom service hire providers in the open market made access difficult. The need for Government to provide incentives for such businesses to become established was seen as a critical step in popularising the technology.

Local farm leadership

Some groups did not recognise the value of good local farmer leadership. Instead that they considered that farmer leaders within their communities tended to be the larger landholders. These farmers however tended to be the source of information and knowledge, knowing what the best crops were to grow and source of seeds.

6.2.5 BANGLADESH SUMMARY OF FOCUS GROUP DISCUSSIONS

General Conclusions

- Overall, there is widespread acceptance of ZT seeding systems, with farmers clearly aware of the benefits of the technology in terms of timely sowing, reduced costs of crop establishment and improvements in crop yields.
- Performance of ZT seed-drills was less then optimal, there is an urgent need to improve the effectiveness of the seeding operation, as this was considered to be a constraint to increased adoption of the technology.
- There was the need to integrate all agronomic practices into the ZT seeding system, including pest and weed control, disease management, plant nutrition and irrigation management.
- Farmers lacked the availability to finance the purchase of ZT seed-drills. The farmer groups involved in the study (who were established through the SRFSI project as Innovation Platform (InP) groups recognised the value of the ZT seed-drills. Many were actively finding ways of buying ZT seed-drills themselves, so that they could meet local farmer demands for using the seed-drills.
- Training in machine operation and maintenance is seen as an urgent priority across all of the focus discussion groups.
- Farmers considered that a well sown crop was characterised by clear lines of sowing, with the soil free of plant residues and stubble. Well sown crops also achieved good germination, with no gaps along sown rows.
- Farmers recognised the importance of incorporating stubble residues into the soil to assist in improving soil organic matter and general soil health.
- It was considered that traditional crop establishment systems characterised by excessive cultivation and removal of crop residues were detrimental to soil quality, increased the risk of soil erosion and in general were unsustainable.

Detailed Summary

Awareness of ZT technologies

Farmers largely have become aware of the ZT seed-drills through their engagement in the SRFSI project. Groups had been established as Innovation Platform (InP) groups as part of this project. Farmers valued the activities associated with this project, since there was a large on-farm component relating to on-farm demonstrations of the ZT techniques. Some of the farmer groups had also been exposed to the HS in local on-farm demonstrations. They were largely disappointed with the HS, considering that the machine was inefficient in terms of the sowing operations.

Negative aspects

Farmers held several negative perspectives relating to ZT practices, these relating to unevenness in the seed sowing depth (and seed flow coming from the seeding tube/boots of the equipment), and the machine performing poorly on uneven ground (laser levelled land being the most suitable). There were also issues reported of poor weed control (often farmers having a poor understanding of weed control using herbicides).

Some farmers were dissatisfied in relation to the working rates of the ZT seed-drills, reporting in some instances fewer than 2 acres per day could be sown with the equipment (this low work rate threatened the economic viability of such practices). Under these situations farmers were referring to the 2 wheel tractor models. This reinforces the need to adopt a whole of cropping systems approach to ZT technology, taking into consideration all of the key elements of best practice agronomic techniques.

There were also some concerns in relation to the rate of sowing, one machine could not cover large areas due to the time taken to sow crops. There were numerous issues identified relating to the availability of spare parts and access to skilled technicians for the servicing of equipment. The price of the ZT machines was also considered to be a major constraint to ownership.

Positive aspects

Overall, farmers were more than satisfied with the performance of the ZT seed-drills, and recognised the many benefits in terms of timely sowing (when equipment is available), reducing the arduous task of sowing crops manually (mainly by women), less water required under irrigated cropping situations, reduced crop establishment costs and often higher crop yields.

One group in particular recognised the benefits of adopting ZT from the perspective that under conventional cropping systems they would have to wait for the soil to wet up (particularly on heavy soils); this would often lead to delayed sowing. Under ZT seeding could commence much earlier, resulting in higher yields being achieved.

The decision to trial the technology

The decision to trial the ZT technology had for the majority of the groups been facilitated through the SRFSI project, with farmers engaged in group based learning environments through the InP groups established as part of the project activities. Where demonstration trials had been conducted in local villages, there was strong evidence to suggest that the incidence of stubble burning had reduced as more farmers had increasingly adopted the technology.

Central to farmers deciding to adopt the technology had been their ability to view first hand on-farm demonstrations of the ZT seed-drills. Supported through group activities, farmers were introduced to the technologies in group learning environments characteristic of the InP's. The InP's also aimed to engage with other service providers, agribusiness input suppliers, NGO's and other stakeholders.

Availability and interest in accessing the technology

Access to ZT and HS technologies is limited amongst the farmer groups. No farmers actually owned tractors suitable for using the seed-drills, and so were reliant upon accessing seed-drills either through the SRFSI project or in some instances in the few custom hiring service centres that existed.

Some farmers were able to access ZT seed-drills from adjoining villages, where they operating a custom hiring service. It was also noted that there was strong demand for the seed-drills, and as such farmers often found it difficult to access them during the height of the sowing season. There were also additional challenges in terms of those groups who had planned to purchase the ZT seed-drills often found it difficult to source such equipment locally, as it was often difficult to find agents representing the Indian manufacturers of the ZT seed-drills.

Farmers have been exposed to ZT seed-drills under two systems of operation; 2 wheel tractors (the operator walks behind the self-propelled tractors) and 4 wheel tractors. The 2 wheel tractors are more cumbersome and require more physical effort than is the case with the 4 wheel tractors, but are much cheaper to purchase in the first instance. Much of the efforts through the SRFSI project had been directed at promoting ZT with the use of the 4 wheel tractors, and ZT seed-drills that had been sourced for manufacturers in India. In the case of the 2 wheel tractors these have generally been imported from China, with a number of local Bangladeshi engineering companies manufacturing seed-drills to match.

Relationships with custom service hire providers

There were not any specific custom hiring service centres in operation. ZT seed-drills were accessed through farmer groups (such as the InP groups associated with the SRFSI project).

Development of Business Models

Some of the groups interviewed, being part of the InP groups linked to the SRFSI project, were in the process or purchasing the ZT seed-drills themselves. They were convinced that the technology worked within their own village communities and were keen to adopt the ZT seeding systems across all of their available farm land. Due to the limited availability of the ZT seed-drill through the project, the only option available to them was to purchase such equipment collectively through their local groups.

There were some gaps identified in the provision of the ZT as a service. These related to the availability of trained technicians to maintain and service the equipment and the effectiveness of the seeding operation. It was important to have trained operators of the ZT seed-drills since often the seeding operation was poor – reflected in variable seeding depth and missing seed along sown rows (due to blockages in the seeding tube and sowing boots). This latter problem was more of an issue with maize crops compare with sown wheat crops.

Access to finance

It was observed in general that there was very limited access to finance to purchase the seed-drills. Whilst providing a subsidy could help with the issue of affordability, some farmers considered that it would be necessary to obtain finance for the equipment with regular scheduled payment plans.

Extension Services

For many of the groups, support in the trialling and adaptation of ZT technologies was provided through the SRFSI project. Additional support such as skills training, assistance with field demonstrations was also provided by the local Department of Agricultural Extension officers, NGO's such as RDRS, ORFD and the Bangladesh Agricultural Research Institute (BARI). Many groups considered that it was important to provide an integrated approach towards supporting farmers, that ideally included a range of activities and support mechanisms, such as well managed technology field demonstrations, skills training and support, regular field activities (including farmer group visits to field demonstrations and training workshops), in addition to training on equipment use and maintenance. A number of training priorities were identified by some of the groups. These included providing training to machinery operators particularly on calibration and maintenance.

Recommended Government Intervention

Groups considered that a 50% subsidy (should it be offered by Government) would be a worthwhile incentive to purchasing such equipment, since all groups considered that the machine was very costly to purchase. There was an absence of local manufacturers of the ZT seed-drills, with the majority of seed-drills being imported from neighbouring India. This added to the cost of the equipment, making the machine even more unaffordable compared with farmers from India.

HS as an option to stubble burning

The burning of stubble residues at present is not an issue in norther Bangladesh. Stubble residues are considered to be an important source of roughage and forage for livestock that form an important component in local farmer's livelihoods. Stubbles resides were also used as a cooking fuel source.

Local farmer leadership

Farmer leadership is considered to be an important attribute in supporting the adoption of new farming practices such as ZT. Having local farmer leaders was considered important, in terms of them acting as advocates for new farming practices and having the skills to interact with farmers on a technical and social basis. There were also the broader issues of providing and supporting social services within local farming communities that was also recognised as a positive attribute of good local leadership qualities.

6.3 Farmer Survey results

As discussed above, in NW India the HS technology has some traction with farmers and farmer groups; but in the NE of India and Bangladesh ZT technology is more well-known and used (Figure 30). This reflects some of the differences between 2-wheel and 4-wheel tractor operations, plot-size differentials, and the research and extension efforts since there has not been the same need for the HS in the NE region of India and Bangladesh, given the lower stubble residue levels following harvest in comparison to NW India.

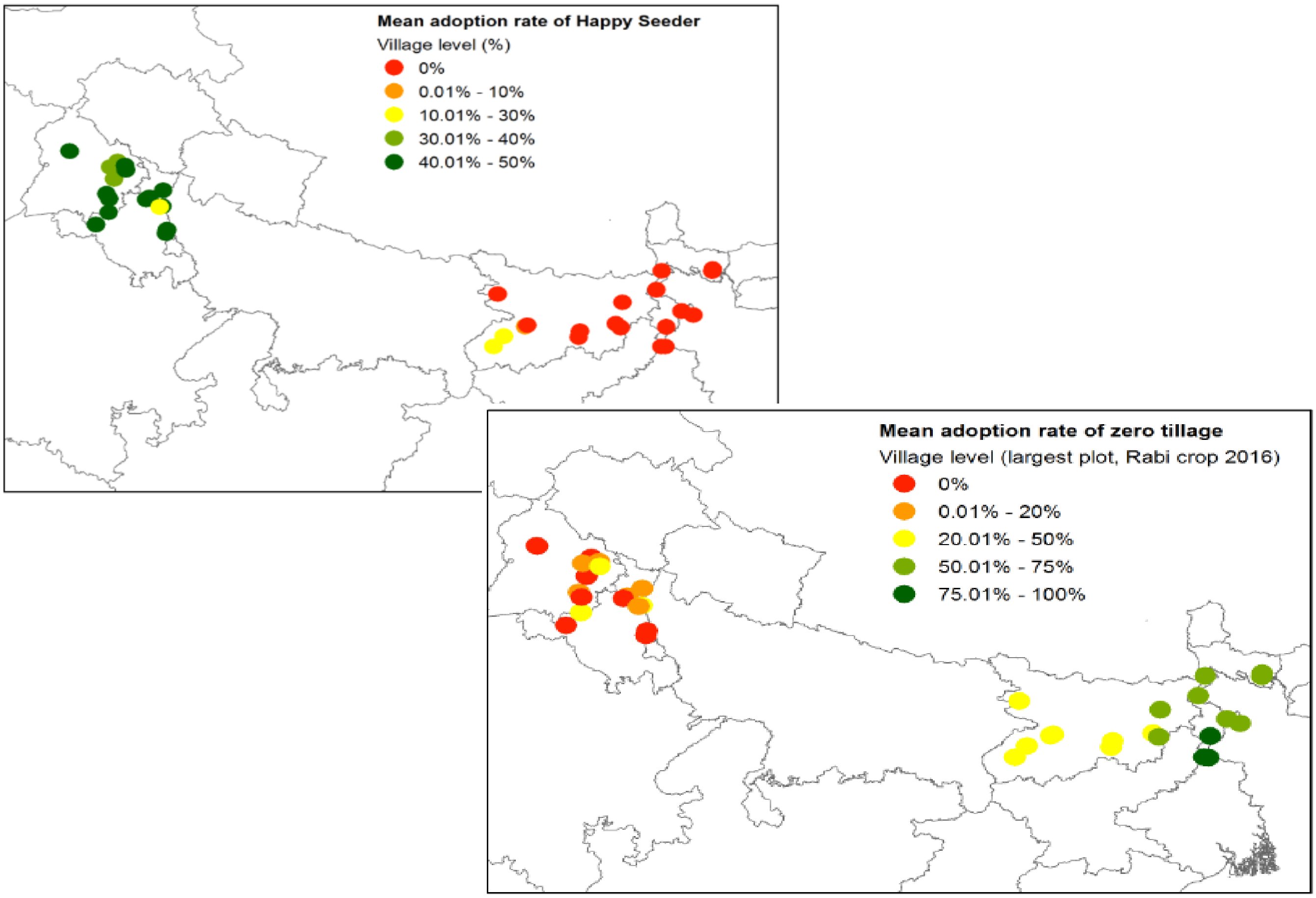


Figure 30: Spatial distributions of HS and ZT technology, IGP

The farmer survey gathered data on a range of issues falling into: i) farm/farmer characteristics; ii) HS/ZT technology adoption drivers; and iii) attitudinal drivers of farmer behaviour and decision-making. The results for these issues are detailed below.

6.3.1 Farm/farmer characteristics

Occupation

Household heads were asked to identify their main occupation (Figure 31), followed by a secondary and a tertiary occupation if they were involved in more than one form of employment. The results indicate that majority of the respondents in both India and Bangladesh were involved in self-employed farming as their primary occupation. On an average across the two countries, farmers had 24 years of farming experience, ranging from nil experience to 65 years.

Around 67% of the respondents did not have any secondary occupation; those that were employed elsewhere reported working as a livestock herder (21%), trader (12%), or food seller/shop owner (9%).

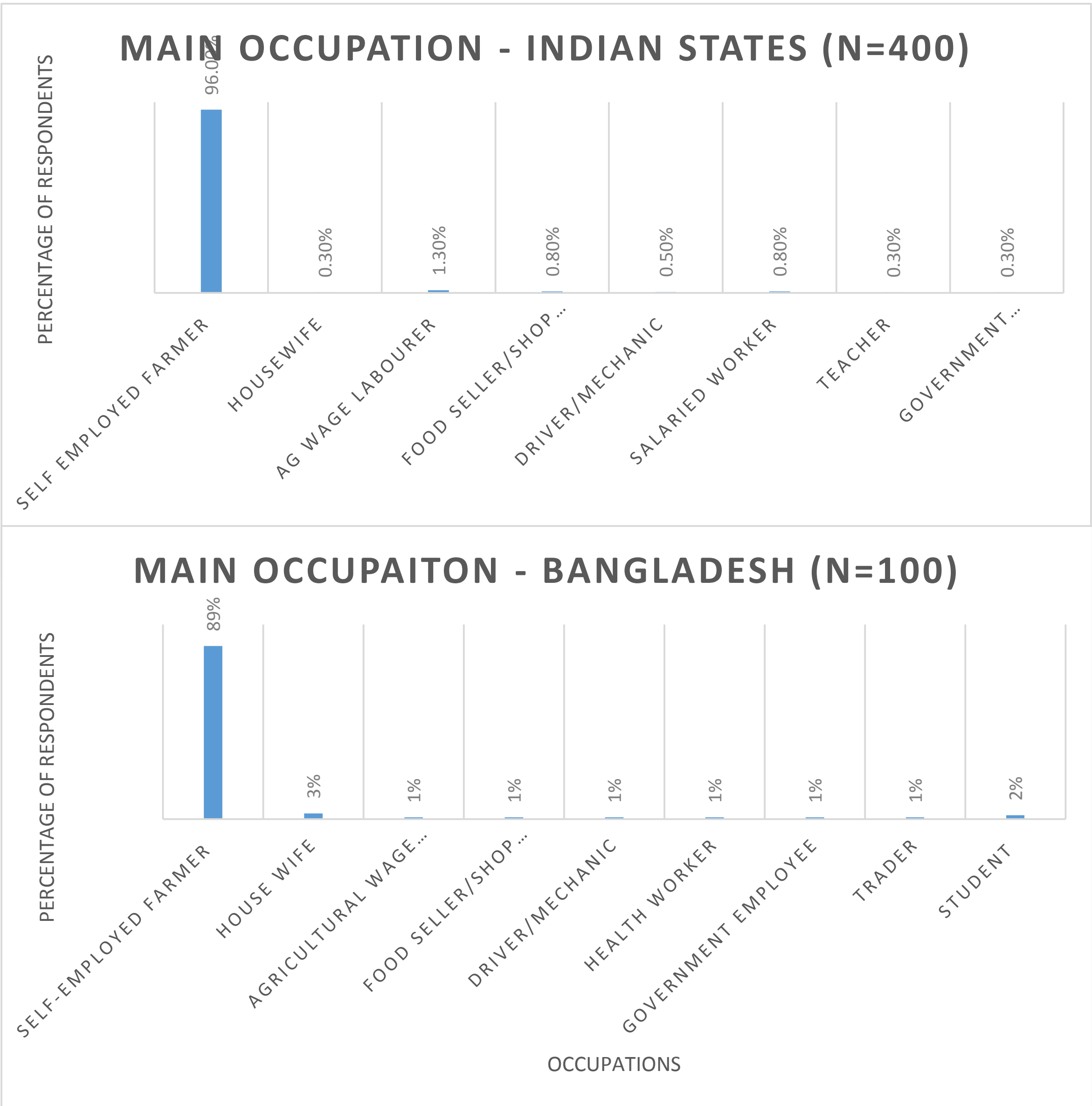
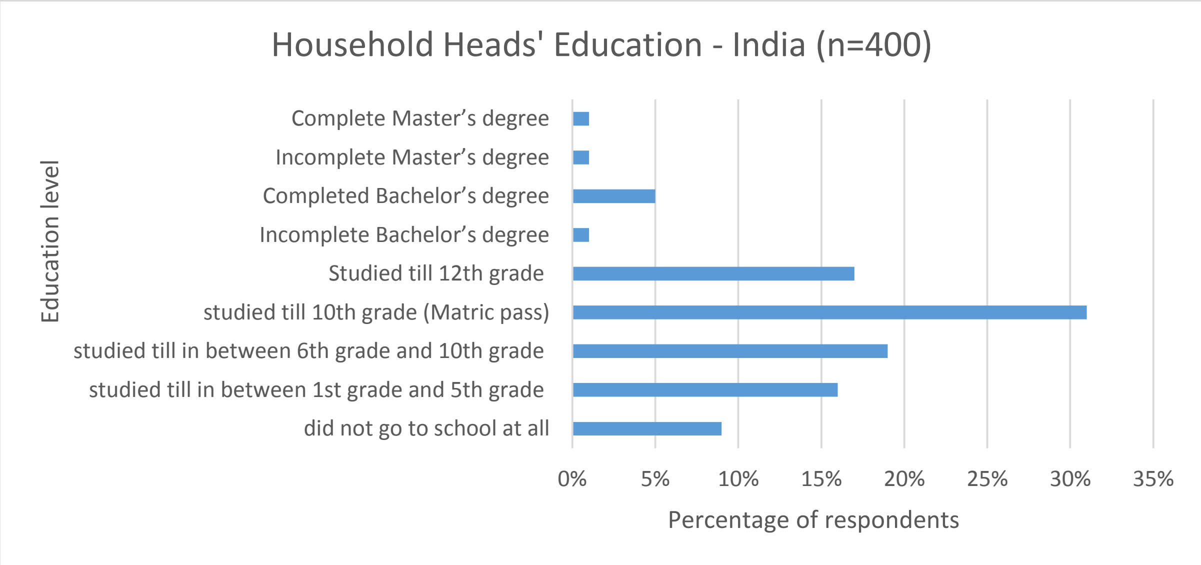


Figure 31: Main Occupation of Household head, India and Bangladesh

Education

The household head was asked to indicate their highest level of education achieved. For India, 31% of household heads reported completing their Matric pass, which means they have completed the basic 10 years of schooling until age 16 as per the Indian education system. Around 5% have a Bachelor's degree, while 1% have completed a Master's degree qualification. For Bangladesh around 35% of farmers reported having had no formal education at all. About 16% of farmers had completed their Matric pass, whilst around 12% had completed Year 12 studies (

Figure **32**).



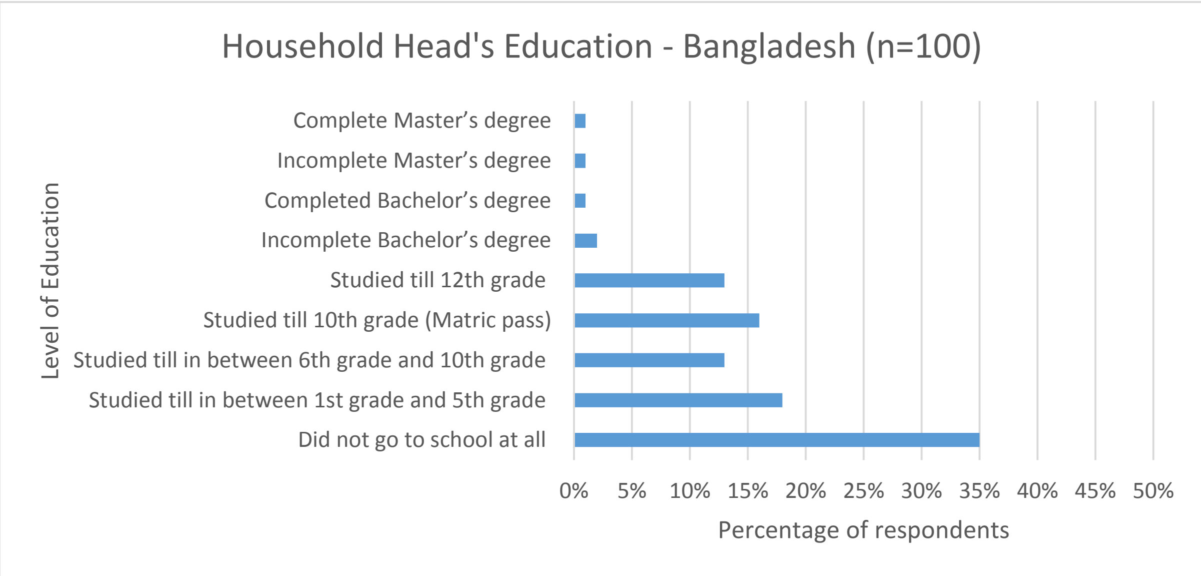


Figure 32: Household head's level of education

Labour

Labour was identified as one of the most critical inputs for agricultural production where mechanisation remained limited. The farmer survey gave some insight into sources of farm labour, and ease of access to farm labour where family members are insufficient to meet labour requirements. For India, 53% of household heads indicated that they hired some labour on the farm, while 42% indicated that they themselves do all the work related to farming in their household (Figure 33).

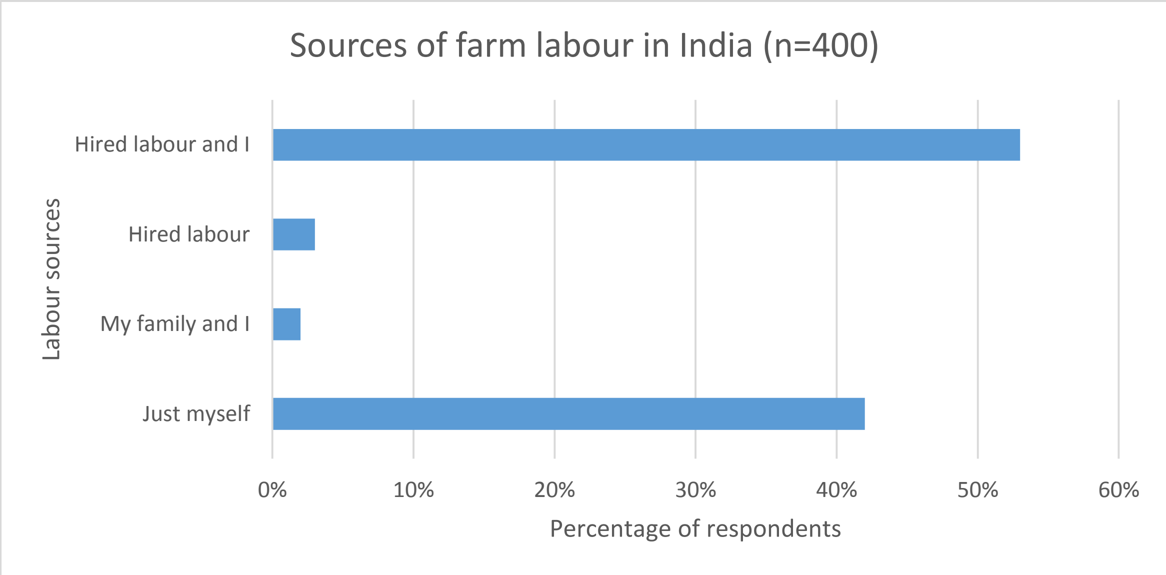


Figure 33*:* Sources of farm labour, India

Farmers having easy access to labour during peak cropping season is very important when there is a short period of time for sowing after the harvest of the previous crop, and so respondents were asked to rate the level of difficulty in finding/accessing farm labour when needed. The majority of Indian farmers revealed that they found it very difficult (32%), difficult (16%), or somewhat difficult (44%) to access labour with only 9% reporting that they found it easy to locate necessary labour inputs (Figure 34).

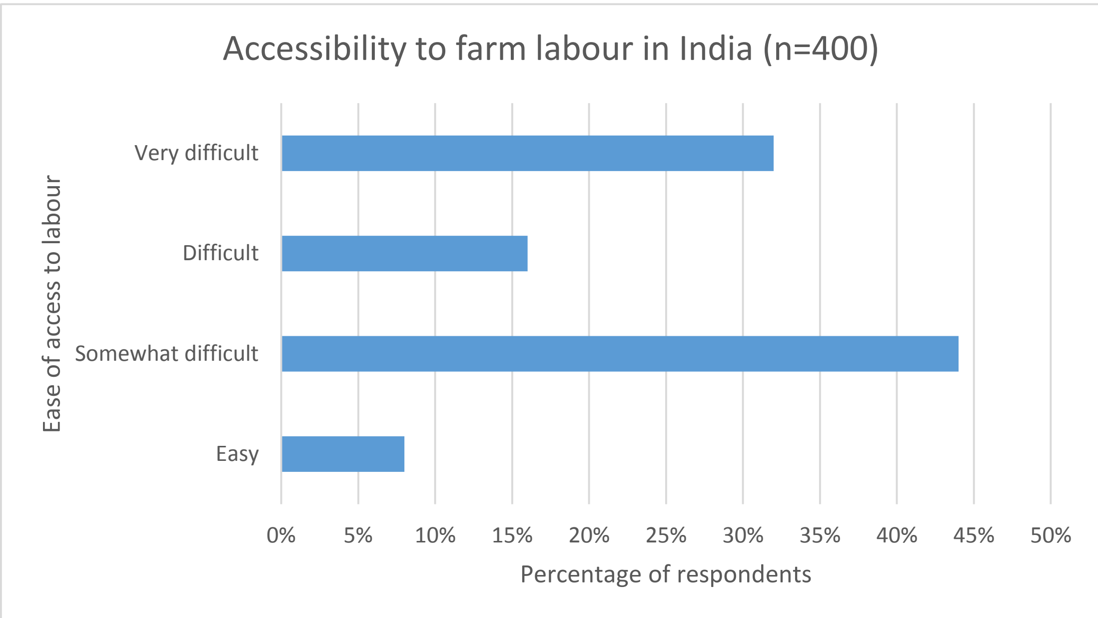


Figure 34: Accessibility of farm labour, India

Further questions were asked in the survey about the number of hours spent doing different activities on-farm by members of the household (and by any hired labour). The results for India (Table 8) and Bangladesh (Table 9) indicate that a significant number of work-hours are dedicated to field preparation and sowing seed.

Table 8: India - Labour Inputs

Daily Activities	Family labour (total working hours/day)			Hired Labour Daily hours and # hired workers	
	Male	Female	*Children	Hours/day	# hired workers
Field Preparation	4	0.4	0.2	6	2.6
Sowing seed	3.6	0.6	0.1	5.6	8.7
Irrigating fields	3.3	0.1	0.1	4.4	1.7
Fertilising	2.8	0.2	0.1	3.8	5.4
Weeding	2.8	0.8	0.1	4.8	7.1
Pest control	2.3	0.1	0.1	3.7	2.2
Maintaining machinery/infrastructure	2.2	0.3	0	2.4	0.8
Harvesting	2.8	0.8	0.2	5	2.6

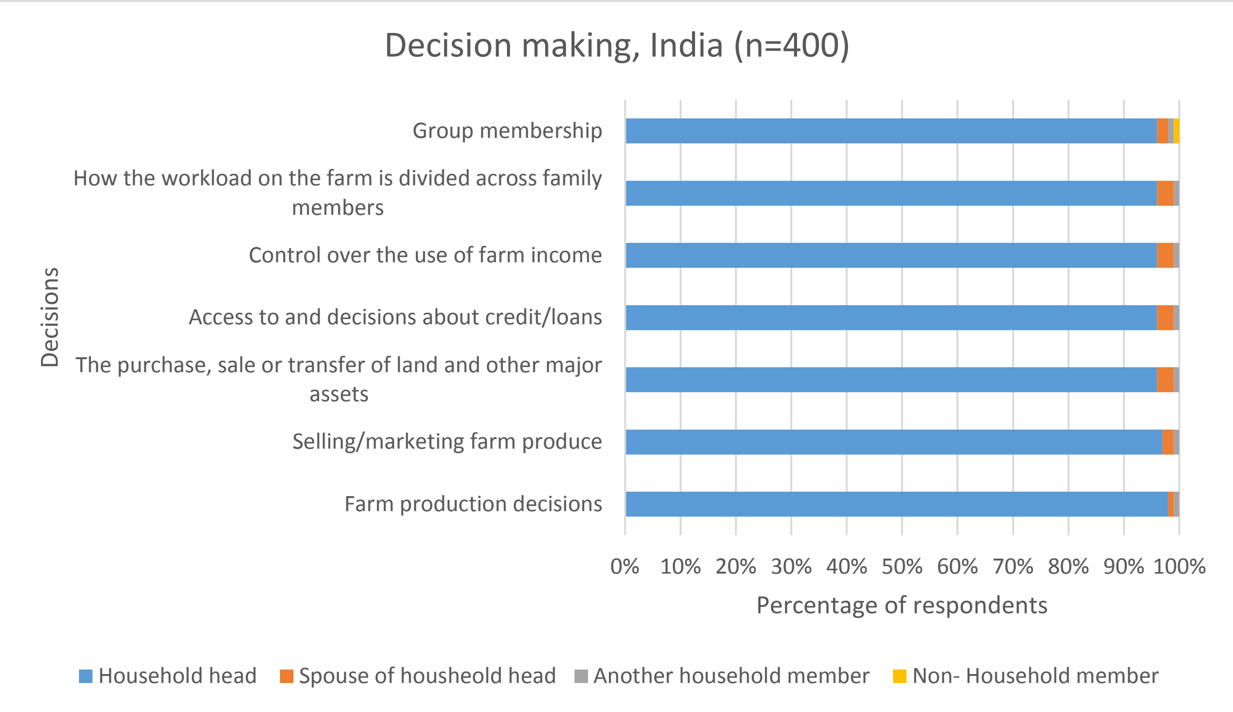
Table 9 Bangladesh - Labour inputs

Daily Activities	Family labour (total working hours/day)			Hired Labour Daily hours and # hired workers	
	Male	Female	*Children	Hours/day	# hired workers
Field Preparation	3.1	0.2	0	2.5	0.6
Sowing seed	5.1	0.5	0.2	8.3	1.9
Irrigating fields	2.3	0.1	0	0.2	0.06
Fertilising	2.5	0.1	0	0.2	0.08
Weeding	5.6	0.8	0.1	8.7	3.3
Pest control	2.2	0	0	0.4	0.2
Maintaining machinery/infrastructure	0.4	0	0	1.1	0.5

Harvesting	7.2	1.3	0	12.1	3.9

Farm Decision Making

Respondents were asked to identify "who makes the important decisions regarding farming practices and issues". In the Indian states surveyed, the majority of farm decisions were considered the responsibility of the household head, while in Bangladesh both the household head and the spouse of the household head made shared decisions. Figure 35 provides further insights.



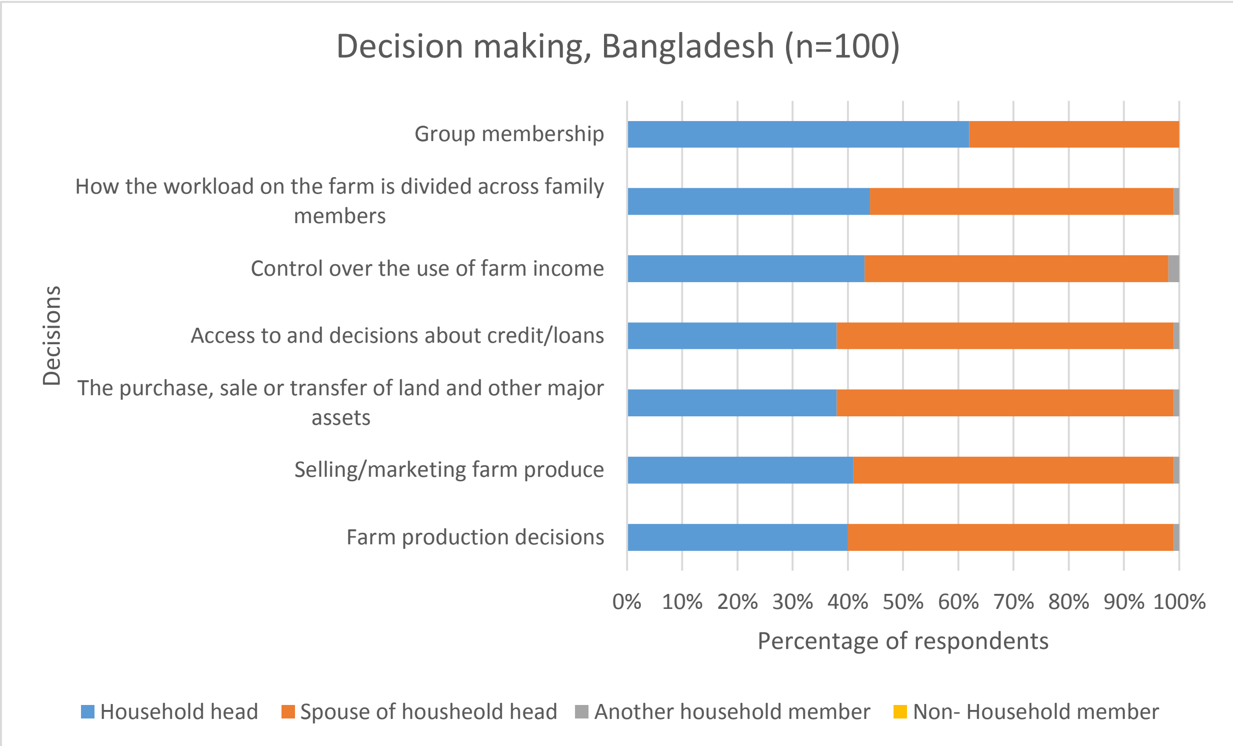


Figure 35: Farm decision-making roles

This indicates very large differences between the two countries, reflected in the more important and influential role that women have to play in farming in Bangladesh. Therefore, policy decisions in that country should take into account this role and its usefulness for adoption outcomes.

Group Membership

Being member of a social group helps farmers in getting information on new technologies, and understanding improved methods of farming; respondents were asked to indicate if they were members of any groups. The Bangladesh response was poor for this question and so is not reported here. For India, 40% of farmers indicated that they belonged to a religious group, while 39% indicated being members of women's union. Some farmers also belonged to youth unions (25%) and/or technology improvement groups (21%), but overall the majority of farmers have limited associations with groups.

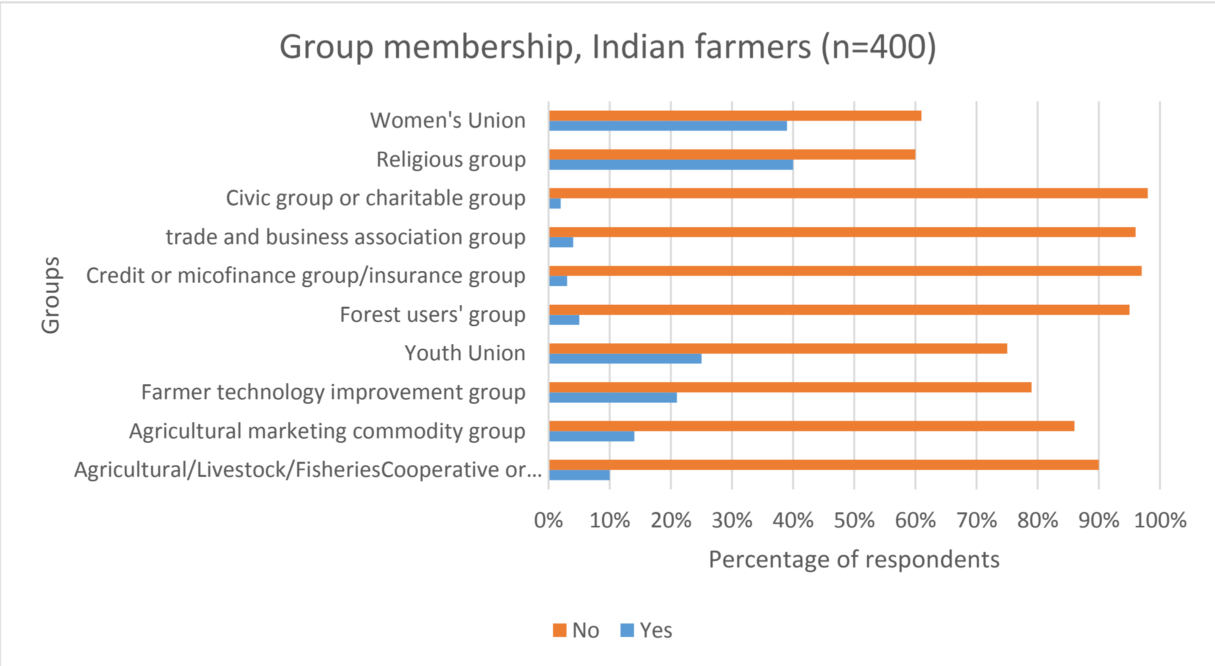


Figure 36: Group Membership, India

Willingness to pay for increased CASI awareness

As discussed above, limited change has occurred to date with respect to HS and/or ZT adoption, as well as the increased awareness of CASI practices and their recognised need across the IGP. To create increased awareness and dissemination of conservation agriculture technologies, our farm household heads were asked if they would be willing to pay a certain fixed amount of money for a legislated fund requiring every farming household to contribute monthly. It is important to note that the respondents were reminded that this money could potentially be used on other goods and services of their personal choice.

In India, 78% of the respondents indicated that they were not willing to contribute to this fund (Figure 37). The respondents were then asked to provide reasons why they would not be willing to contribute to this fund. The two main reasons were that they could not afford to pay, and that they believed it was the Government's responsibility to provide these services without farmers needing paying for it (Figure 38).

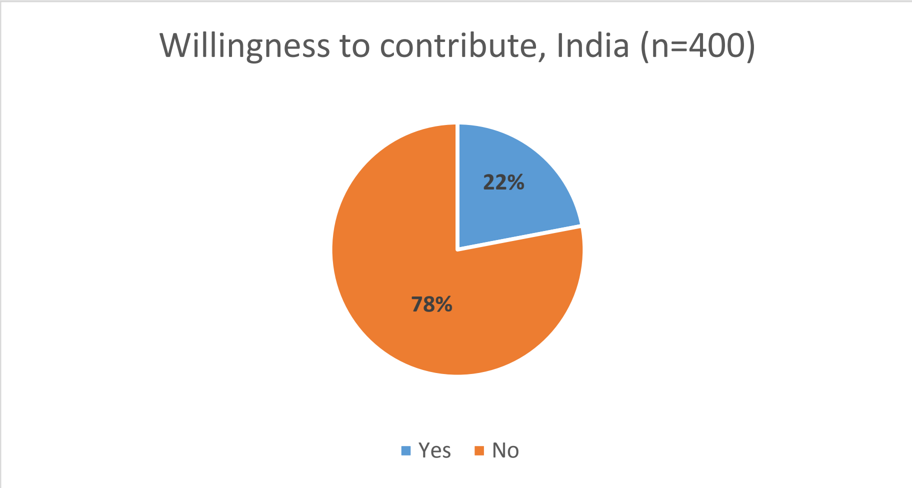


Figure 37*:* Willingness to contribute to increased CASI awareness fund

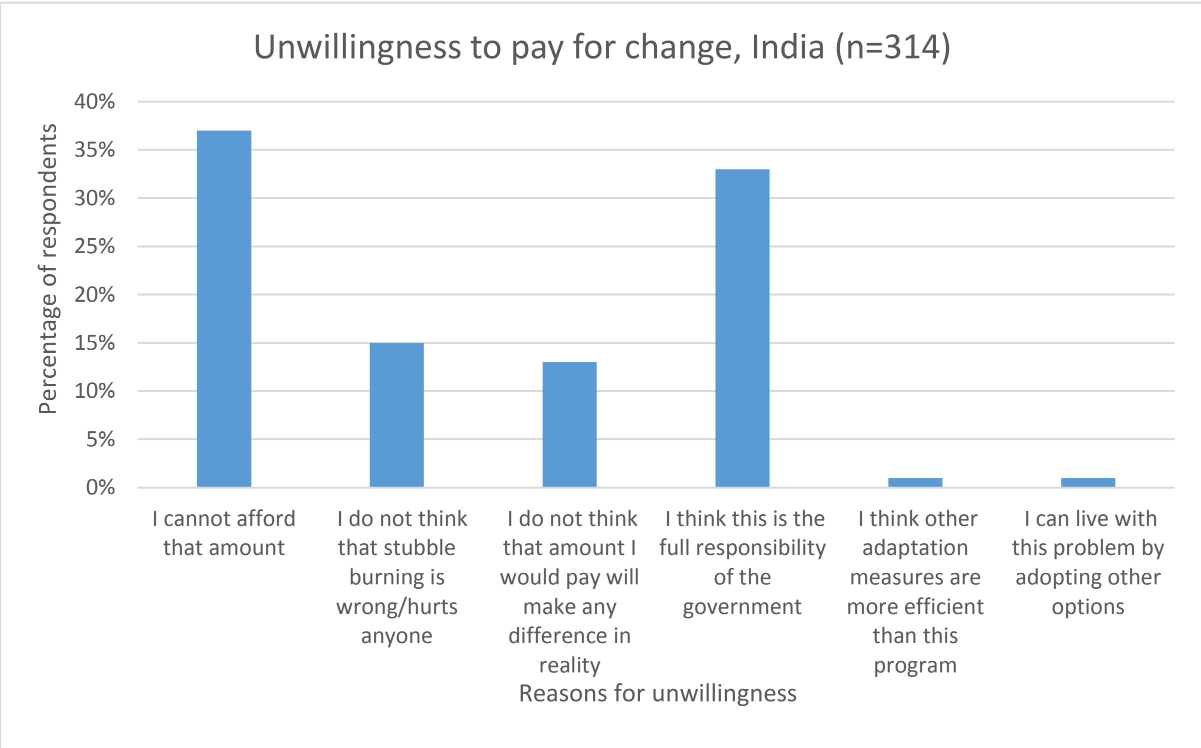


Figure 38*:* Reasons for unwillingness to pay for change

Sources of funding

The household heads were then asked to indicate the main source of capital funding for their farm businesses. The responses to this question in the Indian states were quite low (approximately a quarter of those surveyed). Of those, 82% of respondents indicated that their main source of capital funding was from cooperatives (

Figure **39**), which tied to our interviews with finance providers in India. The financiers told us that they preferred not to lend to individuals; instead feeling more comfortable lending to cooperatives or farmer groups since it was easier to obtain repayments and security with less loan defaults.

Credit is another critical aspect of farming where it is used to pay for inputs ahead of the receipt of annual income. However, access to credit is often a challenge for small and marginal landholders. In our survey farm respondents were asked if they borrowed money on credit for input purchases, sources of credit and ease of access to various credit sources. Some 97% of respondents indicated that the main purpose of credit was to purchase inputs like fertilizers, seeds or pesticides. The majority of the respondents also felt that it was very difficult to borrow from sources like public sector banks, private banks and even primary agriculture cooperative societies. On the other hand, sources like informal moneylenders, friends or relatives were considered to be easily accessible for credit. A significant number of respondents indicated 'Don't know' as their answer, which implies they had never attempted to borrow from those sources, and hence were unable to comment. Overall, it seems that sources of credit may not be important.

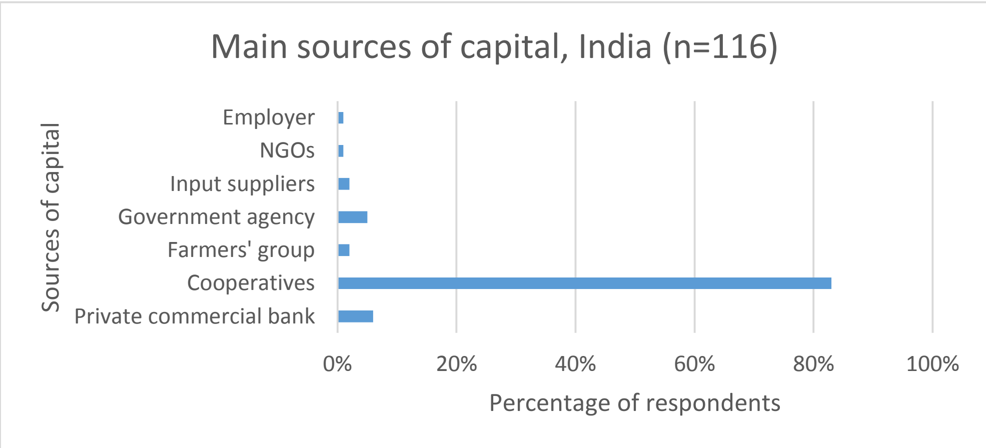


Figure 39: Main source of capital, India

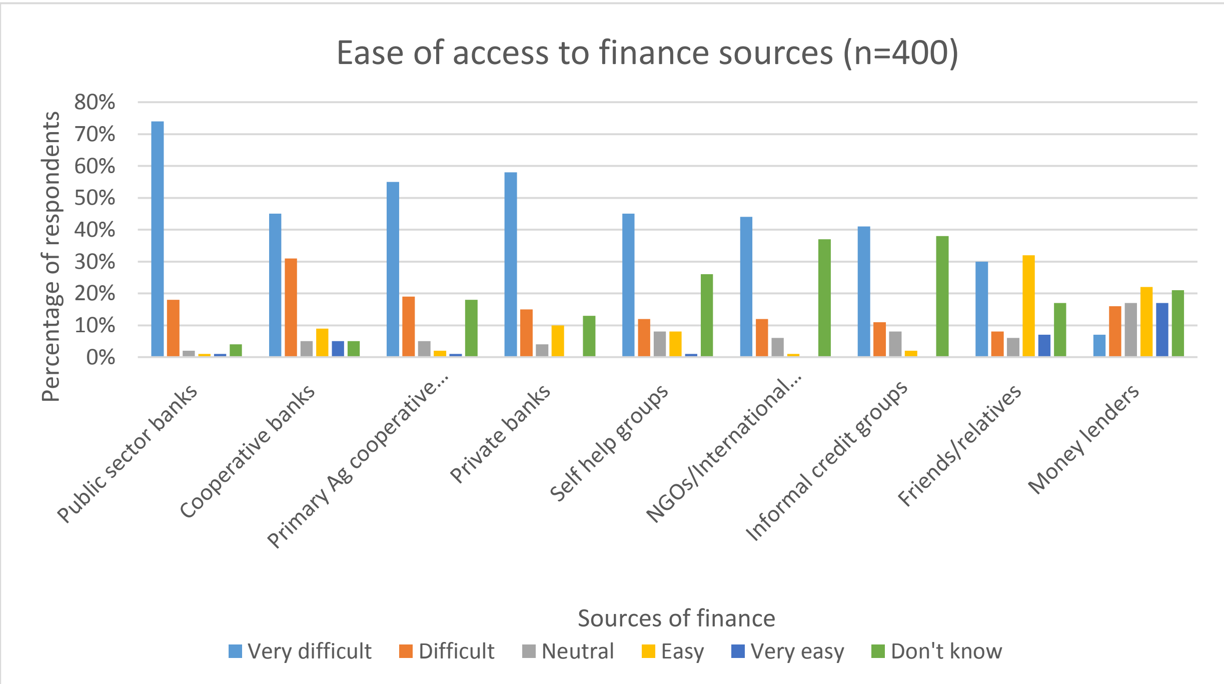


Figure 40: Ease of access to finance sources

6.3.2 Adoption of HS or ZT Technology

In this section results from the survey questions related to technology adoption and crop sowing practices are presented.

Sources of Information

To enhance adoption it is important to identify the sources of information farmers use to learn about new technologies, and how awareness is achieved. The survey data response from Bangladesh was poor due to low responses recorded. However, for India, where farmers reported awareness of HS/ZT technologies, respondents were asked to identify the various sources of information that they used. Some of the most commonly used sources were KVKs (extension officers), Kissan Call Centre (Farmer's call centre-helpline), and state agricultural universities (

Figure **41**).

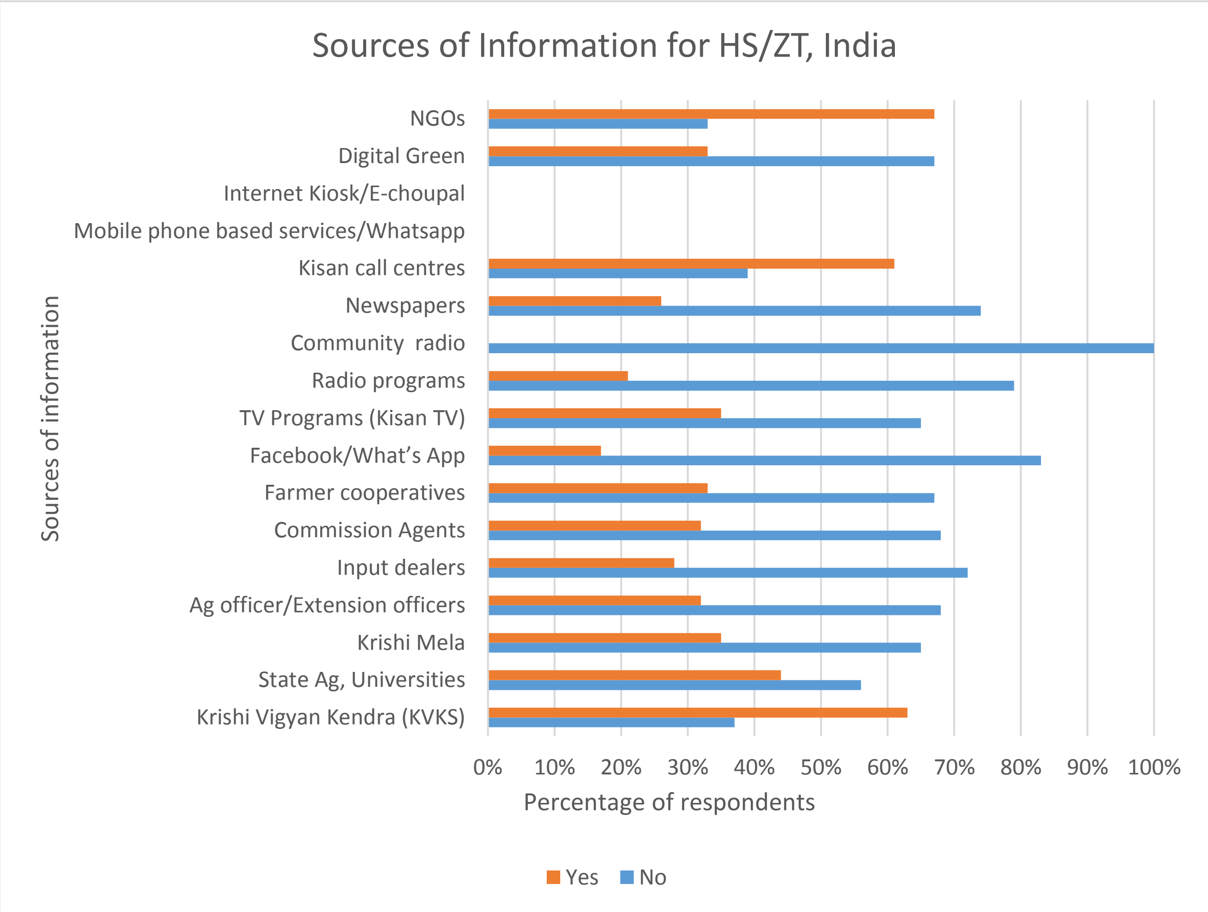


Figure 41*:* Sources of information for HS/ZT

Respondents were also asked to rate their perceived level of credibility of the information sources. Responses indicate that state agricultural universities, extension officers, farmer cooperatives, newspapers and Kissan call centres were considered to be highly credible sources of information for new technologies (Figure 42).

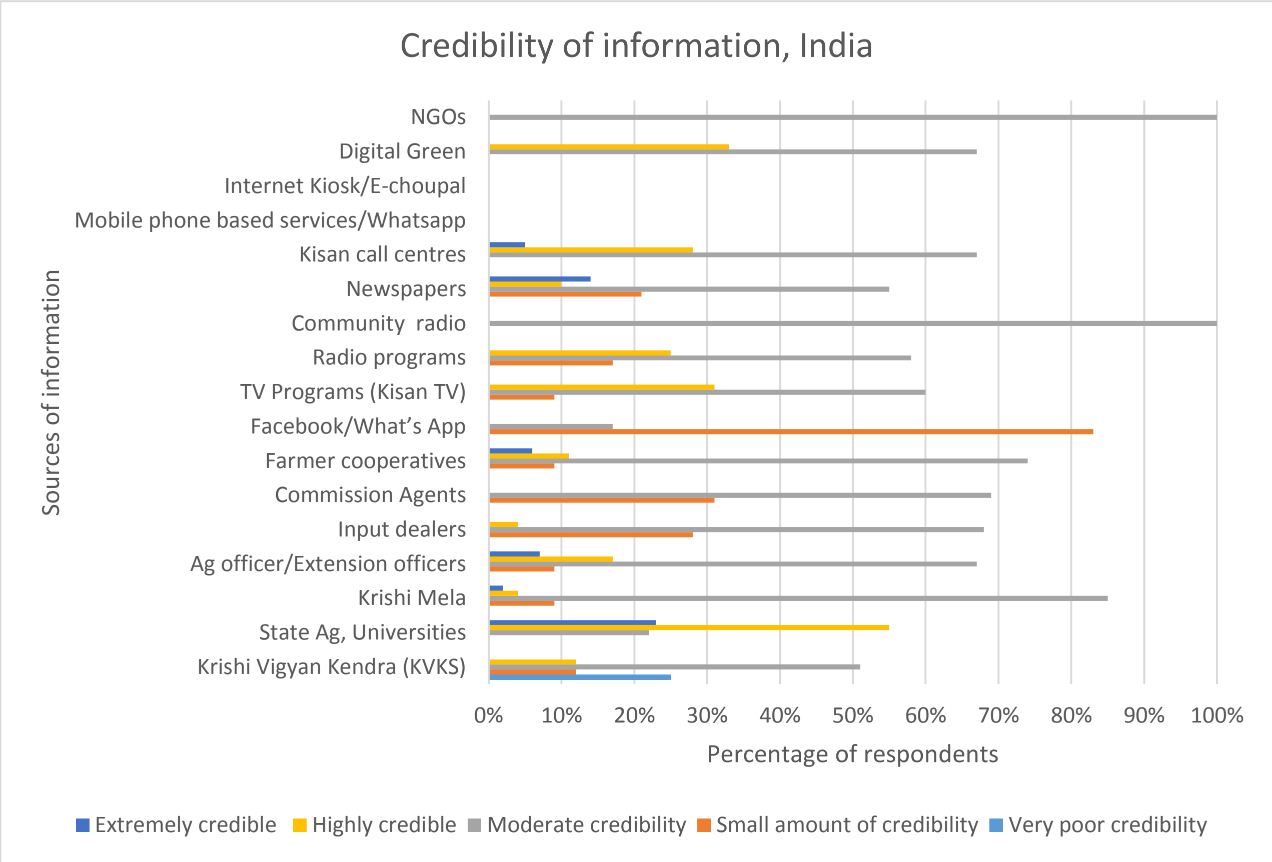


Figure 42*:* Credibility of information

Happy Seeder awareness and adoption drivers

Since the focus of the survey was on identifying lessons learned from existing adopters of the HS (and how these experiences could provide insights into how adoption could be accelerated across the IGP), the questionnaire included detailed questions relating to the adoption characteristics.

Of those surveyed, 40% were aware of the technology (Figure 43), which may considered disappointing since the HS technology has been available for more than 10 years.

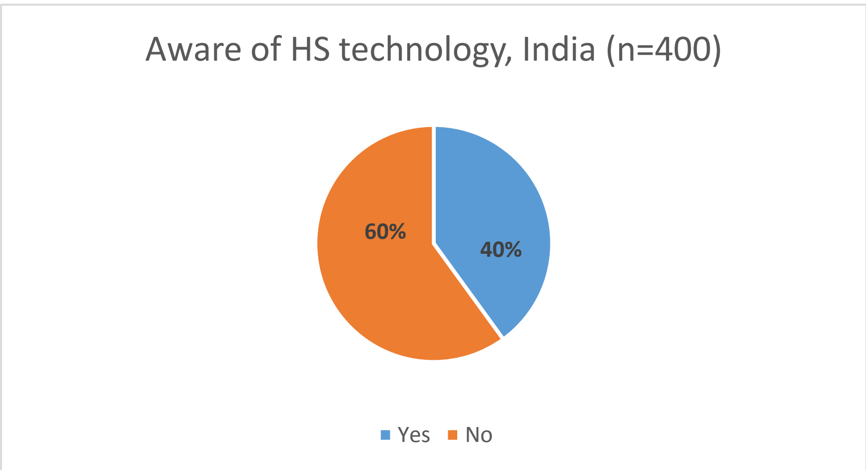


Figure 43*:* Awareness about HS technology, India

Those farmers that were aware of the HS technology were then asked to identify from where they had first heard of the technology. The most common information sources nominated were Krishi Melas (agricultural exhibitions) other farmers and input dealers. Awareness raising sources such as on-farm demonstrations, agricultural extension officers, KVKs) did not feature high on the list (Figure 44).

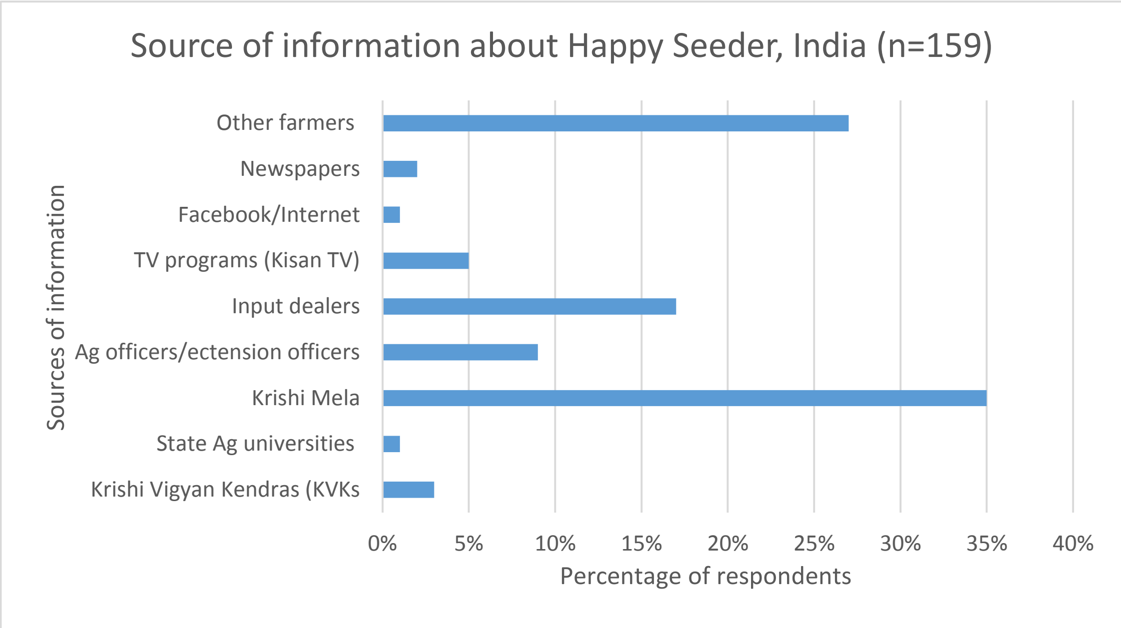


Figure 44: Sources of information about Happy Seeder

To obtain further insights into HS adoption, respondents were asked if they had ever used the machine. Only 25% of the respondents had direct experience in using the HS seed drill, and of those the majority had only recent experience (from 2014 onwards (Figure 45)), indicating that the main factor adoption related to the opportunity to increase crop yield (Figure 46).

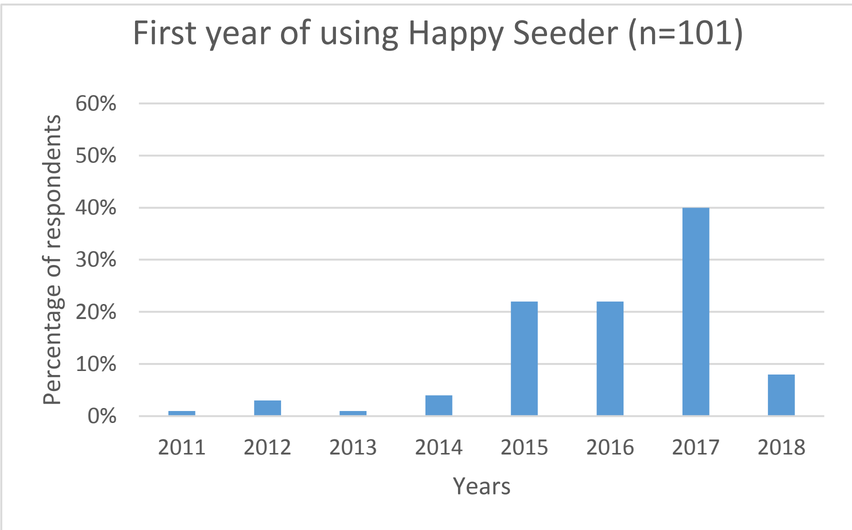


Figure 45: First year of Happy Seeder adoption

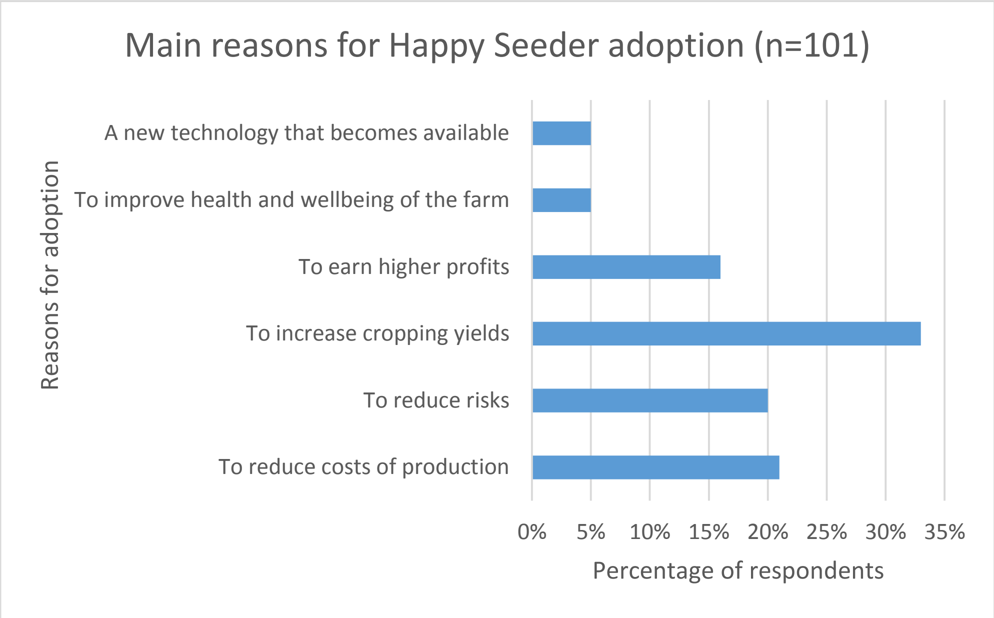


Figure 46: Main reasons for adopting Happy Seeder technology

Around 48% of the non-adopters of HS had not adopted the technology because they considered that they did not have enough information on which to make a decision. Other reasons include high cost of adoption, increased risk and recommendations from other farmers to stop using, and being happy with the status quo (Figure 47).

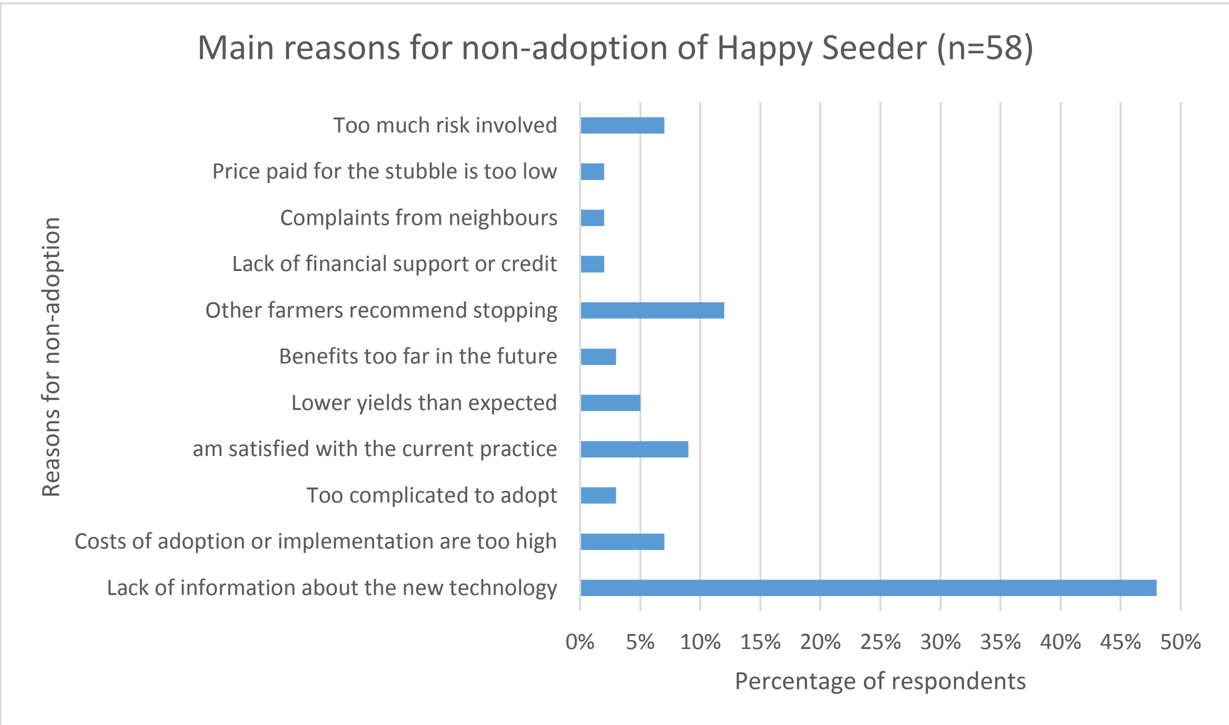
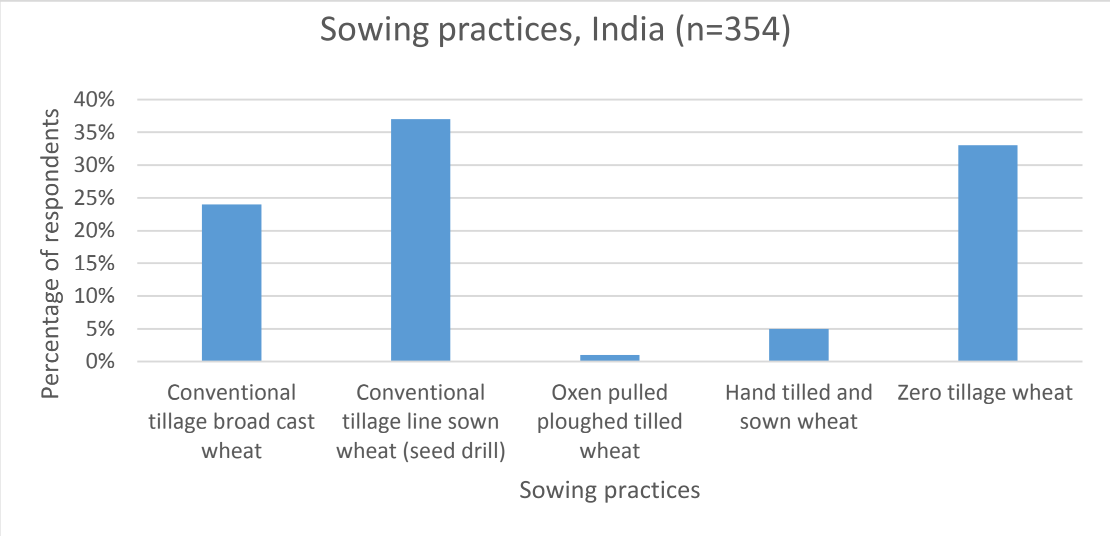


Figure 47: Main reasons for non-adoption of Happy Seeder

Crop Sowing Practices and HS Adoption

The characteristics of the crop production systems (and associated farming practices) were then sought to help identify if there were any relationships to HS technology adoption factors. The majority of the farmers in the NW Gangetic Plains (Haryana and Punjab) follow a rice-wheat-rice cropping pattern. In the EGP region whilst rice is common in the survey areas there is greater diversity in the kharif crops grown (influenced by emerging disease pressures in wheat) and potentially higher returns from maize and other crops.

The majority of the farmers in the EGP region of Bangladesh follow a rice-wheat or rice-maize crop rotation. Conventional tillage line sowing was the most common method of sowing both the winter and summer crops.



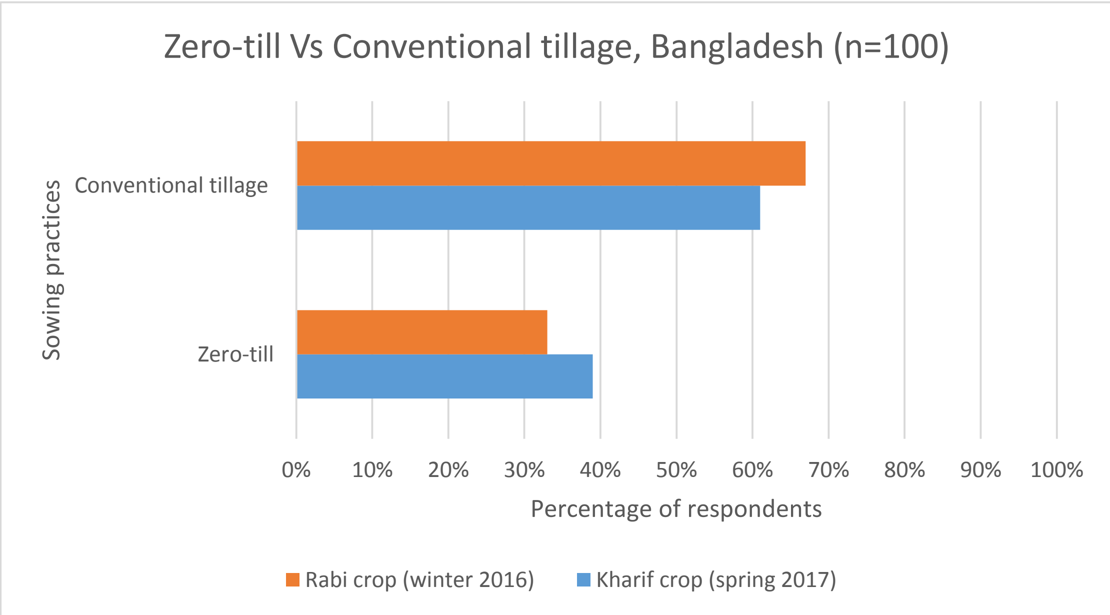


Figure 48*:* Sowing practices for Rabi crop in India and Rabi and Kharif crop for Bangladesh

Residue Management

As previously outlined, the stubble residues from wheat and rice crops can result in a high level of crop residue (or stubble) after harvest in machine harvested crops; that then can prove difficult if the following crop is to be direct sown into the standing stubble without either removing or burning the previous crop’s stubble.

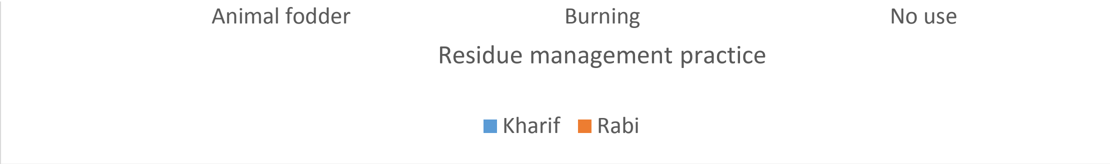


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Figure **49** shows the rice residue management methods that farmers use in both HS/ZT sown versus conventional line sown crops in India. The results indicate that a larger percent of residues from conventional line sown rice can be subject to burning post-harvest. This draws a useful correlation between the adoption of HS/ZT technologies and reductions in stubble or residue burning, further evidencing the need for these technologies to be more widely adopted.

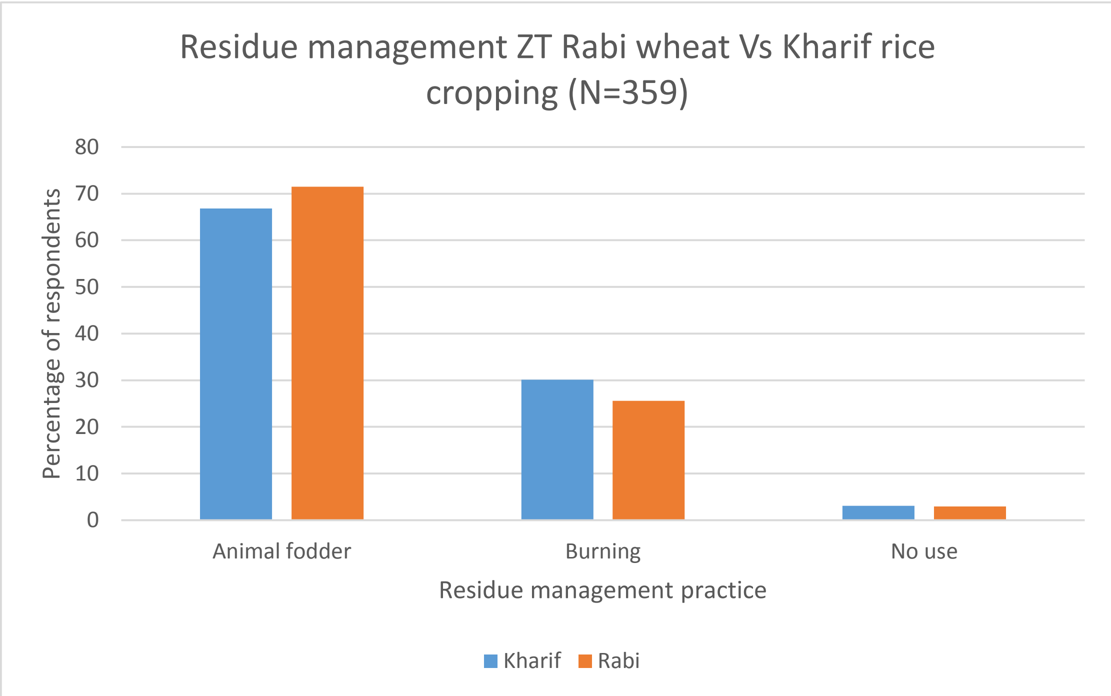


Figure 49*:* Residue Management for wheat (Rabi) versus rice (Kharif), India

It is also important to look at the average yield of wheat from both conventional and ZT methods, to reflect on the potential volumes of residue under each system. Survey data collected provided some estimates for this issue from farmers and is summarised below:

- ZT sown wheat (n=115); 4927.15 kg per Ha
- Conventional tillage line sown wheat (n=216); 5295.91 kg per Ha

It is noted that the ZT sown crop produces slightly lower residue levels following harvest, providing some management benefits—albeit small in relative size.

Accessibility to HS/ZT Technology

In the survey sample only 4% of farmers reporting owning a HS machine, with most adopters access the technology via CHC providers. The average cost of hire services was reportedly INR 1418.18/acre.

To help identify pathways to enhance adoption of CA technologies such as ZT, it is important to identify the ease of access to custom hire services and therefore respondents were asked of this. It was found that 28% of Bangladesh farmers indicated that it was difficult, whilst a majority (56%) remained neutral or report positive accessibility.

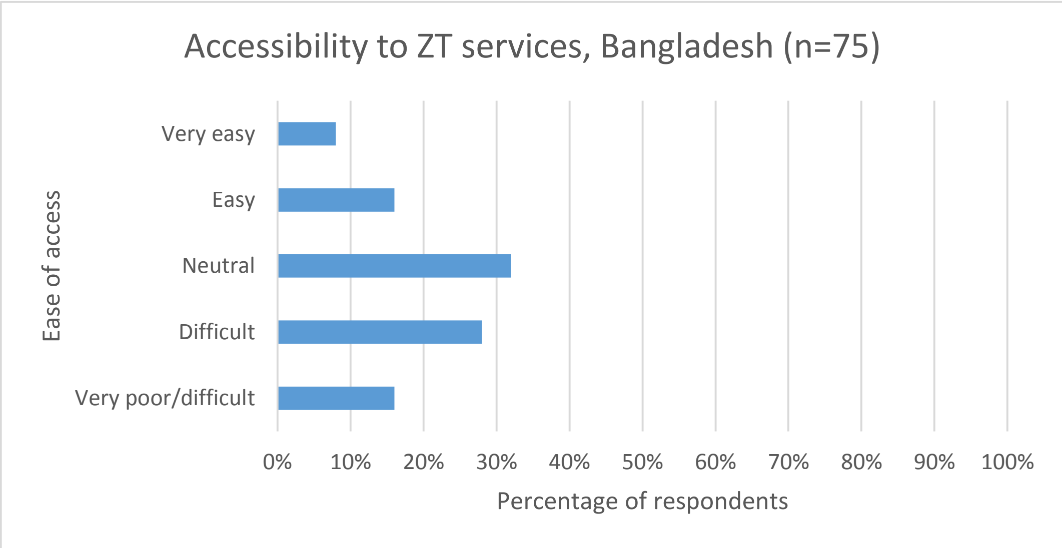


Figure 50: Accessibility to ZT hire services, Bangladesh

Farm Profitability by Production System

Farm household heads were asked to identify the top five income sources that contributed to farm income. The gross revenue and total costs were also recorded to identify the level of profitability from the top five income sources. The results for India are shown in Table 10, while the Bangladesh results appear in Table 11. Rice production has the highest profitability with an average profit of INR 85,474 per year.

Table 10: Level of farm household income and profit, India

Income sources (production type)	**Gross revenue (INR)**	**Total cost (INR)**	**Total profit (INR)**
Rice (n= 367)	161000.0	75806.3	**85474.0**
Wheat (n=363)	125000.0	57207.2	**68087.2**
Mustard (n=106)	26607.6	10530.2	**16077.4**
Vegetable (n=60)	75825.0	44293.3	**31531.7**
Animal fodder (n=115)	13069.6	5305.2	**7764.4**

Table 11: Level of profitability, Bangladesh

Income sources (production type)	Gross revenue (BDT)	Total cost (BDT)	Total profit (BDT)
Rice (n= 99)	43745.96	21862.63	**21883.33**
Wheat (n=99)	11322.50	3982.14	**7340.35**
Maize (n=99)	34590.54	13347.30	**21243.24**

These figures are averages of the revenue/cost categories reported in the survey instrument. They depict the expected crop selection similarities (i.e. rice) and differences (i.e. wheat versus maize) across the IGP region, as well as significant differences in profit between Indian and Bangladesh farmers (taking currency exchange rates into account). The survey data can also be used to extrapolate some differences by state for wheat production, as detailed in the following section.

Cost of production

The following tables present the costs of production for producing wheat using HS, ZT and conventional line sown wheat. The costs of production in each state are presented in Table 12.

Table 12: Cost of production of per ton of wheat by Indian state (n=325)

Input cost (INR)	Punjab (n=97)	Haryana (n=86)	West Bengal (n=56)	Bihar (INR) (n=86)
Fertilizer	479	664	1529	1573
Herbicide	95	79	392	356
Insecticide	212	243	183	187
Fungicide	50	40	62	48
Machinery capital	473	750	52	399
Seed	611	482	353	666
Water, energy, harvest, transport and storage	5365	5873	3219	3068

Some of these cost differences can be explained by the state by state nature of farm input subsidies across India (e.g. there may be lower fertiliser subsidies in West Bengal, Bihar, which are relatively poorer states). Further, the relatively wet, humid and tropical conditions of NE India and Bangladesh would require additional costs for fungicide, herbicide and insecticide applications, and irrigation can be relatively more expensive resulting in farmers avoiding such costs. However, a more useful comparison is that of conventional cropping systems to HS or ZT cropping systems. These production cost comparisons are presented in Table 13 and Table 14 below. Data are derived from the relevant survey responses (e.g. those who reported ZT or HS sowing practices, versus those participating in conventional practices).

Table 13: Cost of production comparison (ZT vs. conventional wheat)

Input costs	Zero-till wheat (n=107)	Conventionally sown wheat (n=218)	Mean T-test Significance
Fertilizer	1333	834	^***
Herbicide	326	130	^***
Insecticide	179	223	#**
Fungicide	56	45	NS
Machinery capital	324	515	#***
Seed cost	503	566	NS
Water, energy, harvest, transport and storage	2923	5289	#***
Total cost	**6799**	**5107**	**NS**

^ mean values of HS adopters (ZT practice adopters) are significantly higher than those of HS non-adopters (ZT practice non-adopters).

mean values of HS adopters (ZT practice adopters) are significantly lower than those of HS non-adopters (ZT practice non-adopters).

*** < 0.01; **<0 .05; * < 0.1, >; Ns= Not Significant (>0.1)

Values do not sum – some non-production costs omitted

Table 14: Cost of production comparison (HS vs. conventional sown wheat)

Input costs	Happy Seeder wheat (n=88)	Conventionally sown wheat (n=95)	Mean T-test Significance
Fertilizer	524.16	604.48	NS
Herbicide	74.24	99.93	#*
Insecticide	204.04	266.15	#**
Fungicide	41.06	48.82	NS
Machinery capital	594.73	684.77	NS
Seed	509.58	587.85	NS
Water, energy, harvest, transport and storage	5653.99	6316.19	NS
Total cost	**7601.79**	**8608.21**	**NS**

^ mean values of HS adopters (ZT practice adopters) are significantly higher than those of HS non-adopters (ZT practice non-adopters).

mean values of HS adopters (ZT practice adopters) are significantly lower than those of HS non-adopters (ZT practice non-adopters).

*** < 0.01; **<0 .05; * < 0.1, >; Ns= Not Significant (>0.1)

Values do not sum – some non-production costs omitted

As shown, in the case of ZT sowing practices, farmers generally reported lower individual input costs and total system costs; except for fertiliser, herbicide and fungicide input costs in the NE of India and Bangladesh. One possible reason for this discrepancy has been explained above, but further work may be required to confirm that reasoning. HS users reported lower costs across all categories.

Finally gross margins were calculated to provide comparisons for the whole survey sample, where the HS/ZT adoption had occurred. These were then set against the gross margin calculations for non-adopters in both cases. As shown in Table 15, adopters of the HS technology (predominantly in NW India) reported that their gross margin was about 4.5% larger than those using conventional sowing systems; and this difference was statistically different at the 5% level. However, adopters of the ZT technology (predominantly NE India and Bangladesh) reported slightly lower gross margins (about 0.5%) than their conventional counterparts; and without any statistical difference (Table 16).

Table 15*:* Cost of production comparison (HS vs. conventional sown wheat)

Percent of Gross Margin for Happy Seeder adopters and non-adopters	Happy Seeder adopters (95)	Happy Seeder non-adopters (104)	Mean T-test Significance
Gross Margin (%)	59.60%	55.10%	^**

^ mean values of HS adopters (ZT practice adopters) are significantly higher than those of HS non-adopters (ZT practice non-adopters).

mean values of HS adopters (ZT practice adopters) are significantly lower than those of HS non-adopters (ZT practice non-adopters).

*** < 0.01; **<0 .05; * < 0.1, >; Ns= Not Significant (>0.1)

Table 16*:* Cost of production comparison (ZT vs. conventional sown wheat)

Percent of Gross Margin for Zero-till adopters and non-adopters	Zero-till adopters (114)	Zero-till non-adopters (245)	Mean T-test Significance
Gross Margin (%)	55.60%	56.08%	NS

^ mean values of HS adopters (ZT practice adopters) are significantly higher than those of HS non-adopters (ZT practice non-adopters).

mean values of HS adopters (ZT practice adopters) are significantly lower than those of HS non-adopters (ZT practice non-adopters).

*** < 0.01; **<0 .05; * < 0.1, >; Ns= Not Significant (>0.1)

6.3.3 Attitudinal drivers of decision-making

In the last major section of the survey farmers were asked a wide range of attitudinal and behavioural questions. These were aimed for later use in the cluster analysis and/or factor analysis to determine if any meaningful groups of farmers among adopters/non-adopters with shared characteristics could be identified.

In the first instance, some of these questions were spatially mapped (using GIS software) to help illustrate the different drivers of decision-making among farmers. For example, Government subsidies on HS technology, ZT technology and other machinery were an important decision driver for farmers in NW India, while access to the sowing technology at critical times was important across the entire IGP (Figure 51). Similarly, there appear to be shared attitudes across the IGP with regard to the need for sufficient information before making decisions, farmer preferences to view technology in the field before adopting, and an appreciation of training and skills before operating machinery such as HS/ZT drills (Figure 52).

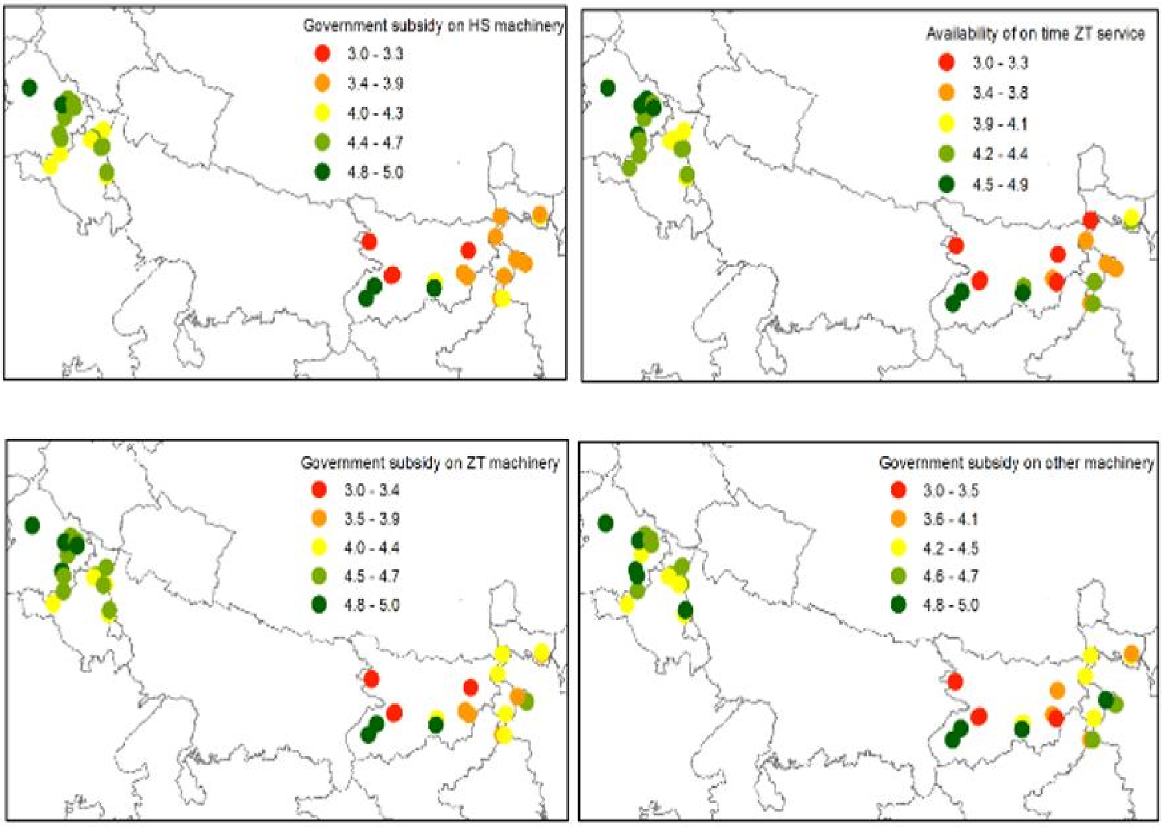
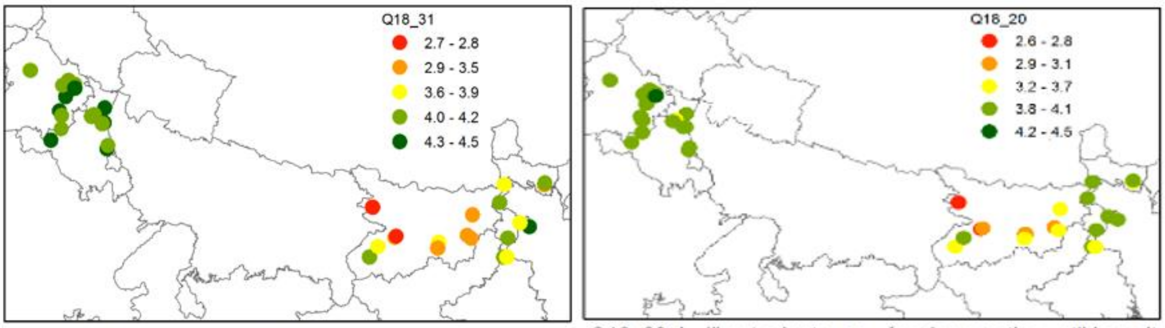
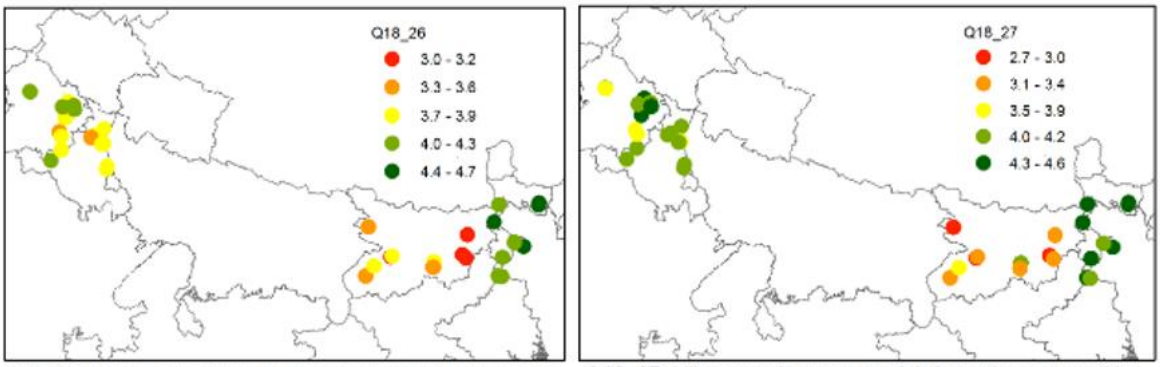


Figure 51*:* Drivers of decision-making, India



Q18_31: The impacts of stubble burning on people are overstated

Q18_20: I will not adopt a new farming practice until I see it working successfully on other farms in my district.



Q18_26: There is a lack the skills to properly maintain agricultural machinery such as tractors and implements in my district.

Q18_27: I like to seek out as much information as possible relating to a new farming practice

Figure 52*:* Drivers of decision-making, India

Latent Class (LC) Cluster Modelling Results

To test for further drivers of farmer adoption from the survey data a series of latent class cluster models were estimated. Results of the LC cluster analysis are presented in Table 17. Cluster 1 has the highest number of observations (66%), followed by Cluster 2 (19%) and 3 (15%). In Cluster 1 farmers were more likely to be either “unsure” about given decision factors for crop sowing/management practices, or found them to be “somewhat important”. Farmers in Cluster 2 found the decision factors important, whereas farmers in Cluster 3 found them not important at all. Table 17 also shows the mean scores for each decision factor (from not important at all (1) to very important (5)) in the respective clusters.

In the cluster analysis there was a focus on crop sowing and management practice decisions (that are considered to affect adoption of HS/ZT technology). The results can broadly be sorted into three decision-drivers: farming costs, timing issues, and biophysical concerns. High costs, concerns about availability of ZT seeding, and agronomic issues may see up to 19% of the population adopt the technology in future, while the majority of farmers would still not be motivated enough by these issues to change their practices.

Table 17: Mean scores for HS/ZT adoption decision factors, by LC Clusters

	Cluster 1 "Unsure" to "Somewhat important"	Cluster 2 "Somewhat important" to "Very Important"	Cluster 3 "Not Important"	Sig
Cluster Size	66%	19%	15%	
Observations	262	76	62	
Indicators (means):				
Cost of HS machinery (farming cost)	3.64	4.20	1.96	***
Herbicide expenses (farming cost)	3.64	4.81	2.40	***
Availability of HS service (timing)	3.73	4.30	2.17	***
Late harvest (timing)	3.66	4.69	2.01	***
Lodging risk (biophysical)	3.57	4.93	2.92	***
Rodent/pest infestations (biophysical)	3.65	4.78	2.05	***
Log Likelihood	-2,496			
R^2	0.89			
Degrees of freedom	357			
Number of parameters	43			
Classification errors	0.037			

Note: Means are statistically significant across clusters (one-way ANOVA and post-hoc Tukey test).

Table 18 reports associations of adopter/non-adopter of HS and ZT practices with relevant Clusters. Interestingly, there are notable differences between adopters of the two practices. Adopters of HS were more likely to find selected decision factors on crop sowing/management practices not important (Cluster 3), whereas adopters of ZT were more likely to consider them important (Cluster 2).

Table 18: Adopter/non-adopter of HS and ZT practices per Cluster

	Cluster 1	Cluster 2	Cluster 3
	"Unsure" to "Somewhat important"	"Somewhat important" to "Very Important"	"Not Important"
Happy Seeder Adoption	23%	14%	**48%**
Zero Tillage Adoption (Rabi)	34%	**54%**	2%

Regression modelling results

Once again, to explore the drivers of technology adoption further probit and bivariate probit regression analysis were performed to check for statistical relationships between adoption/non-adoption decisions and a variety of potential drivers.

The probit regression models for India for HS and ZT adoption are presented in Table 19. Factors significantly associated with HS (for Punjab and Haryana only) and ZT adoption (for all four state) vary greatly. For example, HS adoption was strongly associated with larger land sizes, but only until a certain threshold land size, as shown by the squared term (i.e. as land sizes increase the effect of land size on HS adoption is lessened).

Furthermore, farmers adopting HS were more likely to have a successor in place and have used input dealers (e.g. fertilizers, chemicals, etc.) as an information source. It was also found that farmers adopting ZT were more likely to have future farm plans, were less likely to use KVKs as an information source, and were less likely to be late adopters of new or emerging technologies. ZT adoption was also strongly associated with the eastern states of Bihar and West Bengal. Although included in the modelling, the farmer attitudinal and decision-making factors did not have a significant effect on either HS or ZT adoption.

Overall then, the probit regression analysis did not provide any further novel or helpful insights about farmer adoption/non-adoption outcomes for Indian farmers, besides what have been uncovered from the qualitative results. However, it is suggestive that in the main Indian farmers are not taken with either technology, and/or that the necessary drivers of change are not sufficiently important to factor in their decision-making. We explore these issues further in the discussion section below.

Table 19: HS and ZT adoption regression modelling results, India

		Happy Seeder adoption		Zero Tillage adoption (Rabi crop)	
		Coefficients	Marginal Effects	Coefficients	Marginal Effects
Age		-0.009	-0.003	0.009	0.002
Education	(years)	-0.017	-0.005	0.007	0.001
Land size	(ha)	0.406***	0.043	-0.049	-0.009
Land size squared		-0.040***			
Succession	(1=Yes; 0=Otherwise)	0.609**	0.196	0.15	0.028
Future farm plans		0.084	0.027	1.210***	0.228
Income	(log)	0.193	0.062	-0.040	-0.007
Labour hire	(1=Difficult; 0=Otherwise)	-0.147	-0.047	0.188	0.035
Info source Krishi	(1=Yes; 0=Otherwise)	0.023	0.008	-0.458**	-0.086
Info source Ag/Ext officer		-0.443	-0.142	0.099	0.019
Info source Input dealers		0.566*	0.182	-0.399	-0.075
Info source Farmer coop		-0.299	-0.096	0.072	0.014
Info source TV Programs		-0.153	-0.049	-0.252	-0.048
Very late adopter		-0.312	-0.100	-1.877***	-0.354
Burning fine	(from 1=Not important at all to 5=Very important)	0.156	0.050	-0.058	-0.011
Cost factors for decisions on crop sowing/management practices		0.376	0.121	-0.160	-0.030
Timing factors for decisions on crop sowing/management practices		-0.167	-0.054	0.160	0.030
Biophysical factors for decisions on crop sowing/management practices		0.013	0.004	0.004	0.001
Traditional attitudes	(from 1=Strongly disagree to 5=Strongly agree)	-0.663	-0.213	-0.114	-0.021
Environmental attitudes		-0.180	-0.058	-0.066	-0.013
Health attitudes		0.468	0.150	-0.278	-0.052
Constraints attitudes		0.686	0.220	-0.259	-0.049
Punjab		-0.266	-0.085	-1.421***	-0.268
Haryana				-1.775***	-0.334
Constant		-4.788		3.540	
Observations		200		360	
Log pseudolikelihood		-113.34		-122.91	
Pseudo R2		0.18		0.46	
Wald chi2		43.41***		145.65***	

Notes: * p<0.10, ** p<0.05, and *** p<0.01 indicate significance at the 10%, 5%, and 1% levels, respectively. No marginal effects are reported for non-linear variables, instead the marginal effects at the mean value are reported for the linear term.

The bivariate probit regression models for ZT adoption in Bangladesh are presented in Table 20, and provide some useful results. Unlike to the Indian ZT adoption model, land size has a strong positive effect on ZT adoption in Bangladesh. Additionally, farmers experiencing difficulties with hiring labour and rating cost decision factors (regarding crop sowing/management practices) as important are associated with ZT adoption.

Farmers adopting ZT during the Kharif season were also more likely to have a higher income, were less likely to rate biophysical decision factors (regarding crop sowing/management practices) as important, and were less likely to agree to traditional farming attitudes. It was found that farmers adopting ZT during the Rabi season were more likely to be younger, less educated, have future farm plans in place, were more likely to agree to environmental attitudes, and have health concerns regarding stubble burning.

Table 20: ZT adoption regression modelling results, Bangladesh

		Kharif		Rabi	
		Coefficients	**Marginal effects**	**Coefficients**	**Marginal effects**
Age		-0.015	-0.004	-0.029**	-0.006
Education	(years)	0.008	0.002	-0.069*	-0.015
Land size	(ha)	0.417***	0.100	1.385**	0.294
Succession	(1=Yes; 0=Otherwise)	0.304	0.073	0.056	0.012
Future farm plans		0.267	0.064	1.089**	0.231
Income	(log)	0.871***	0.209	-0.032	-0.007
Labour hire	(1=Difficult; 0=Otherwise)	0.618*	0.148	1.333***	0.282
Burning fine	(from 1=Not important at all to 5=Very important)	-0.010	-0.002	-0.124	-0.026
Cost decision factors on crop sowing/management practices		1.774***	0.426	2.091***	0.443
Timing decision factors on crop sowing/management practices		0.115	0.028	0.360	0.076
Biophysical decision factors on crop sowing/management practices		-2.190*	-0.526	-1.636	-0.347
Traditional attitudes	(from 1=Strongly disagree to 5=Strongly agree)	-0.850**	-0.204	-0.483	-0.102
Environmental attitudes		-0.080	0.019	0.965*	0.205
Health attitudes		0.282	0.068	2.269***	0.481
Constraints attitudes		0.452	0.109	-0.473	-0.100
Rangpur		0.020	0.005	-0.367	-0.078
Constant		-7.057		-8.286	
athrho Constant		14.42***			
Observations		98			
Log pseudolikelihood		-61.50			
Wald test of rho=0		754.43***			

Notes: * p<0.10, ** p<0.05, and *** p<0.01 indicate significance at the 10%, 5%, and 1% levels, respectively.

Crop management and sowing considerations and Behavioural Characteristics

Finally the factors farmers considered important or unimportant while deciding about crop sowing and management and farmers' behavioural and attitudinal statements were analysed by the adopter and non-adopter groups of HS and ZT, respectively.

These drivers will be expanded upon in the discussion section to follow, but as a summary of important factors that were revealed through these survey questions by technology type the following observations were reached (see Table 21 and Table 22 for details):

Drivers of HS technology adoption

- Government subsidies on other machines (e.g. harvesters) drive positive HS adoption.
- The precision that can be achieved with the technology is a positive factor in farmer decision-making to adopt, but non-adopters worry about the seed rates possible when using HS machinery.
- Fines for burning residue do not appear to influence adoption decisions very much.
- Non-adopters of HS (and ZT non-adopters as well) worry about the need to cultivate the soil ahead of sowing, do not consider it necessary to worry about future generations, require adequate training or skills before feeling comfortable operating the technology, and yield penalties if they sow their wheat too late.
- HS adopters are increasingly using social media to learn things about new technology and innovations in agriculture.

Drivers of ZT technology adoption

- The high cost of HS technology drives farmers toward ZT adoption; as does the fact that HS machines are largely unavailable in the Eastern IGP.
- A lack of subsidy support for HS purchases, and access to the technology as needed, also drives farmers to adopt ZT technology. However, subsidies on ZT technology did not create positive adoption outcomes, which may indicate issues with the scheme.
- ZT adopters value labour-replacement benefits as well as soil fertility, capacity to cope with late-harvested/early-sown cropping needs, and decreased lodging risk in rice crops.
- ZT adopters also appreciate the precision sowing benefits from the technology, but must be able to experience this first-hand to be convinced.
- Concerns about rodent issues, herbicide expenses, residue volume after harvest and post-harvest spreading issues all encourage increased ZT adoption.
- ZT adopters are not concerned about tractor power requirements to operate the technology. There is some scope as such to combine zero-till technologies to increased uses of versatile multi-crop planters (VMP – ACIAR project LWR/2005/001) as a potential solution, where the combined technologies may have significant benefits for users in the NE.
- Stubble burning fines appear to have a slightly more important role to play in ZT technology adoption than HS.
- ZT adopters have positive perceptions about the future of their farms, cite yield increases as a decision-driver, learn from other farmers, and emphasise the relevance of rice stubble for livestock as a need to adopt ZT (they cannot afford to cultivate it back in, so harvest, collect residue (takes time), and then use ZT to cultivate quickly after that).
- ZT non-adopters are also concerned about the possible yield lowering effects of shifting away from conventional practices; highlighting the risk-averse nature of farmers generally.

Table 21*:* Decision on crop sowing and management practices

Decisions about crop sowing and management	By HS adoption (Punjab and Haryana only)			By ZT practice Rabi Crop 2016 on largest plot			By state/Bangladesh				
	HS adopters (n=95)	**HS non-adopters (n=105)**	**Mean t-test significance**	**ZT practice (n=115)**	**No ZT practice (n=245)**	**Mean t-test significance**	**Punjab (n=100)**	**Haryana (n=100)**	**West Bengal (n=100)**	**Bihar (n=100)**	**Bangladesh (n=100)**
14.1 Cost of HS machinery or service	3.2	3.1	NS	3.7	3.2	^***	3.3	2.9	3.7	3.8	2.8
14.2 Availability of on time HS service	3.3	3.3	NS	3.7	3.4	^***	3.4	3.1	3.8	3.8	2.8
14.3 Government subsidy on HS machinery	4.4	4.4	NS	3.8	4.3	#***	4.6	4.3	3.8	3.9	2.8
14.4 Availability of on time ZT service	4.3	4.3	NS	3.8	4.2	#***	4.5	4.1	3.8	3.8	3.9
14.5 Government subsidy on ZT machinery	4.6	4.5	NS	4.0	4.4	#***	4.7	4.4	4.1	3.9	4
14.6 Government subsidy on other machinery	4.7	4.5	^**	4.2	4.4	#***	4.7	4.5	4.4	3.9	4.7
14.7 Labour input	3.8	3.7	NS	4.0	3.8	^***	4.0	3.6	4.2	3.8	4.8
14.8 Soil moisture	4.5	4.5	NS	4.0	4.4	#***	4.6	4.4	3.9	4.0	4.8
14.9 Soil fertility	3.9	4.0	NS	4.4	4.0	^***	4.0	3.9	4.6	4.1	4.9
14.10 Late harvest of crops	3.1	3.0	NS	4.1	3.2	^***	3.2	2.9	4.2	3.9	3.5
14.11 Being able to sow early	3.2	3.1	NS	4.0	3.3	^***	3.3	3.0	4.1	3.9	4.6
14.12 Lodging risk for rice/wheat crops	3.5	3.5	NS	3.9	3.6	^***	3.8	3.3	3.9	3.7	4.9
14.13 Precise placement of seed and fertilizer	3.8	3.6	^***	4.2	3.7	^***	3.8	3.6	4.3	4.0	4.9
14.14 Seed rate	4.2	4.4	#**	4.2	4.3	NS	4.4	4.2	4.4	4.0	4.9

14.15 Yield	4.4	4.5	NS	4.2	4.3	NS	4.6	4.3	4.4	4.0	4.9
14.16 Weed infestation	3.9	3.8	NS	3.9	3.9	NS	4.0	3.7	4	3.9	4.9
14.17 Rodent or pest infestations	3.0	2.9		4.1	3.1	^***	3.0	2.8	4.6	3.8	4.9
14.18 Herbicides expenses	3.2	3.1	NS	4.1	3.3	^***	3.3	3.0	4.5	3.8	4.9
14.19 Volume of crop straw residue	3.6	3.6	NS	4.1	3.7	^***	3.8	3.4	4.3	3.9	4.3
14.20 Tractor capacity	4.5	4.6	NS	4.1	4.4	#***	4.5	4.5	4.2	3.9	4.5
14.21 Poor spreading of residue during harvest	3.7	3.8	NS	4.0	3.8	^***	3.9	3.6	4.3	3.8	4.1
14.22 Prior experience with machinery/practices	4.2	4.2	NS	4.0	4.1	#**	4.3	4.2	4.3	3.6	4.8
14.23 Threat of fines for burning crop residues by government officials	3.6	3.4	^*	3.6	3.4	^**	3.6	3.3	4.3	2.9	3.6
14.24 Differentiate between HS and ZT seed drills	4.3	4.2	^*	3.9	4.0	#*	4.4	4.0	4.0	3.4	3.3

^ mean values of HS adopters (ZT practice adopters) are significantly higher than those of HS non-adopters (ZT practice non-adopters).

mean values of HS adopters (ZT practice adopters) are significantly lower than those of HS non-adopters (ZT practice non-adopters).

*** < 0.01; **<0 .05; * < 0.1, >; Ns= Not Significant (>0.1)

Table 22: Farmer Behavioural Characteristics

	By HS adoption			By ZT practice Rabi Crop 2016 on largest plot			By state/Bangladesh				
A+A2:L37ATTITUDINAL STATEMENT+A2:L37	HS adopters (n=95)	HS non-adopters (n=105)	mean t-test significance	ZT practice (n=115)	No ZT practice (n=245)	mean t-test significance	**Punjab (n=100)**	**Haryana (n=100)**	**West Bengal (n=100)**	**Bihar (n=100)**	**Bangladesh (n=100)**
Q18.1b I consider myself a traditional farmer.	4.0	4.0	NS	3.7	3.8	NS	4.0	4.0	4.1	3.4	4.0
Q18.2 As long as I can grow enough farm produce to feed my family that is all that matters to me as a farmer.	3.8	3.8	NS	3.9	3.8	^*	3.9	3.8	4.4	3.6	4.0
Q18.3 There is a positive future for farming in my village.	3.0	3.0	NS	3.3	3.0	^**	3.1	3.0	4.1	2.7	4.0
Q18.4 Not having enough spare money prevents me from adopting new technologies on my farm.	3.8	3.8	NS	3.3	3.7	#***	3.8	3.8	3.6	3.0	3.9
Q18.5 Labour shortages during crop sowing and harvest limits farm productivity in my village area.	3.6	3.7	NS	3.7	3.6	NS	3.6	3.7	4.2	3.4	3.8
Q18.6 There is a good opportunity for me to increase crop yields on my farm through adopting new and improved farming practices.	3.7	3.7	NS	3.8	3.6	^**	3.8	3.6	4.1	3.4	3.9
Q18.7 Custom hiring services for machinery such as ZT seed drills are readily available in my district.	3.3	3.2	NS	3.5	3.2	^**	3.2	3.2	4.1	2.8	2.8
Q18.8 It is not possible to sow wheat without first cultivating the soil.	3.6	3.8	#***	3.5	3.7	#**	3.7	3.8	4.3	3.0	3.1
Q18.9 I would like my children to one day be farmers just like me.	3.3	3.2	NS	3.1	3.2	NS	3.2	3.3	4.1	2.4	2.0

Q18.10 I am concerned about depleting groundwater reserves in my district.	3.9	4.0	NS	3.5	3.8	#***	3.9	4.0	3.9	3.1	3.7
Q18.11 Learning from other farmers is one of the best ways to learn and adopt a new farming practice.	3.7	3.7	NS	3.8	3.6	^**	3.7	3.7	4.4	3.1	3.9
Q18.12 There is little incentive to improve crop yields because of the lack of markets for my crops.	3.8	3.8	NS	3.9	3.7	^**	3.8	3.8	4.3	3.4	3.6
Q18.13 I am happy with my life as a farmer.	3.8	3.8	NS	3.2	3.6	#***	3.7	3.9	4.1	2.5	3.8
Q18.14 It is important to have a rice-straw (stubble) free fields prior to sowing a wheat crop.	3.7	3.7	NS	3.8	3.7	^*	3.6	3.8	3.8	3.6	3.2
Q18.15 A large proportion of my income from crops is used to pay off debt/loans to money lenders.	3.7	3.8	NS	3.7	3.7	NS	3.8	3.8	4.2	3.2	3.7
Q18.16 I like to be one of the first in my village to try growing a new crop variety.	3.7	3.8	NS	3.7	3.7	NS	3.7	3.8	4.3	3.1	3.8
Q18.17 Farmers have no choice but to burn their rice straw stubbles prior to sowing their wheat crops.	3.4	3.6	#**	3.4	3.5	NS	3.5	3.6	4.3	2.7	3.2
Q18.18 The Government should pay farmers to adopt conservation agriculture related farming practices.	3.7	3.8	NS	3.9	3.7	^**	3.8	3.7	4.3	3.4	4.0
Q18.19 The Rotavator helps to improve soil health by mixing the soil together.	4.0	4.0	NS	3.8	3.8	NS	4.0	3.9	4.2	3.2	3.0
Q18.20 I will not adopt a new farming practice until I see it working successfully on other farms in my district.	3.9	3.9	NS	3.6	3.7	#*	4.0	3.8	3.9	3.2	2.9
Q18.21 Increasingly, I am finding out more valuable information about farming through Facebook and/or What's app.	2.8	2.5	^**	3.3	2.8	^***	2.6	2.7	4.5	2.7	3.4

Q18.22 I am concerned about the impact of climate change and the ability to maintain crop yields into the future.	3.8	3.8	NS	3.8	3.7	NS	3.8	3.8	4.4	3.3	3.8
Q18.23 It is important to leave the condition of my farm's soil health in better condition for the future generations of farmers.	3.8	3.9	#*	3.7	3.8	NS	3.9	3.9	4.1	3.3	4.0
Q18.24 Rice stubble residues are an important source of feed for livestock.	3.8	3.8	NS	4.0	3.8	^***	3.8	3.9	4.3	3.7	4.0
Q18.25 I will not adopt a new farming practice until I am convinced that it is risk free.	3.7	3.8	NS	3.8	3.7	^**	3.8	3.7	4.4	3.3	4.1
Q18.26 There is a lack the skills to properly maintain agricultural machinery such as tractors and implements in my district.	3.8	3.9	#*	3.9	3.8	NS	3.9	3.8	4.3	3.3	3.9
Q18.27 I like to seek out as much information as possible relating to a new farming practice	4.0	4.0	NS	3.8	3.9	NS	4.1	4.0	4.3	3.2	4.0
Q18.28 The yield penalty from late sown wheat can be very high	3.8	4.0	#**	3.9	3.9	NS	3.9	3.9	4.3	3.5	2.9
Q18.29 I am concerned about personal health impacts from stubble burning	4.0	4.0	NS	3.8	3.9	NS	4.0	4.0	4.3	3.4	3.6
Q18.30 I think that stubble burning causes severe health problems for other areas (e.g. Delhi)	3.9	4.0	NS	3.9	3.8	^*	4.0	3.9	4.2	3.5	3.5
Q18.31 The impacts of stubble burning on people are overstated	4.1	4.2	NS	3.8	4.0	#***	4.2	4.2	3.9	3.3	3.7

^ mean values of HS adopters (ZT practice adopters) are significantly higher than those of HS non-adopters (ZT practice non-adopters).

mean values of HS adopters (ZT practice adopters) are significantly lower than those of HS non-adopters (ZT practice non-adopters).

*** < 0.01; **<0 .05; * < 0.1, >; Ns= Not Significant (>0.1)

6.4 Outcomes of Consultation Workshops (including Regional Collaborative Platform)

6.4.1 Project inception workshops

The project inception workshops (conducted in Chandigarh (December 2017), Siliguri and Rangpur (February 2018)) achieved a range of positive outcomes that contributed towards gathering valid field based intelligence relating to the challenges and constraints associated with the adoption of the ZT and HS seed drills. A brief summary of the workshop discussions and outcomes are presented below:

- A series of informative presentations from key technical representatives were included. Presenting organisations included ICAR, IFPRI, ACIAR, BISA, CYMMIT, PAU, UBKV, KVK's, BARI, RDRS, machinery manufacturers and agents, custom hire operators and a number of farmer associations and groups. These talks highlighted the background to HS/ZT adoption and considered views on the drivers of and barriers to achieving accelerated adoption of the technologies.
- Discussions with a large number of innovative farmers provided the opportunity to hear first-hand of their experiences and challenges they currently face in using the technology and spreading awareness about it. Importantly, such feedback helped shape the research questionnaires and discussion points for the focus group studies that were to follow in the study.
- A synthesis of the views obtained from the participants emerged during the course of the workshops, and centred around seven key themes (with a focus on addressing on-farm risk, agronomic issues, and economic costs). This helped to draw out both the challenges/issues related to HS adoption, and possible solutions that may lead to accelerated adoption outcomes.
- Facilitated discussion in relation to how value chain associated stakeholders can best engage with the project and contribute to the outcomes through the provision of advice, services, data and/or knowledge during the planned field data collection activities. This process helped to widen the research team with partnering organisations, and build collective ownership for the project.
- Discussions with key stakeholders in relation to project objectives and aims, and how the ACIAR project will provide significant 'value-add' to better understanding the drivers of adoption and change at the farmer level, and how best government policy can be influenced in an effort to accelerate adoption were also undertaken.

6.4.2 Policy Briefing Workshop

At the Policy Briefing Workshop (held at the Australian High Commission in Delhi in May 2018) the key findings arising from the three data analysis approaches performed in this research study (comprising the value chain analysis (VCA), farmer household surveys (FHS) and focus group discussions (FGD)) were presented to the appointed working group. The working group comprised carefully selected lead technical and policy development experts, along with recognised senior officials from research, extension/education and policy implementation. Their active engagement helped provide valuable contributions towards the shaping of the policy briefing paper that was subsequently developed by the project team targeting government decision-makers across the IGP.

The workshop set the scene in terms of emphasising the imperative across the IGP to address the following challenges:

- Addressing the impact of stubble burning and its serious impacts on human health.
- Depleting natural resources (soil and water) as a result of unsustainable farming practices.

- A stalling (or plateau) of yield gains that have to date largely been growing as a result of the Green Revolution.
- The challenges of maintaining future food and water security for the region.

The workshop conducted a series of ‘think tank sessions’ that involved time-bound group discussions where each session addressed specific themes that included the following:

- The role of government policy/investments and private sector involvement for creating opportunities for accelerated HS/ZT adoption.
- Opportunities for improving the efficiency of the seed drill value chains.
- Improving farmer access to HS/ZT technologies and achieving accelerated adoption.
- Addressing the issues of machinery subsidies and identifying how best government investment could best bring about practice change.

Participants provided enthusiastic contributions and openly shared a wide range of ideas and experiences. Group brainstorming activities identified a range of innovative and novel ideas that largely addressed the system constraints identified through the field data collection activities.

Workshop participants deliberated, discussed and debated the potential policy options and solutions, and came up with several novel ideas that were included in the policy briefing documentation. The challenge for the project team was to maintain an overall strategic focus for the policy recommendations identified through the workshopping process, whilst not losing site of the practical activities that could be integrated into future ‘on the ground’ interventions aimed at accelerating adoption of the Hs and ZT technologies. Following the workshop, project team members addressed a range of recommendations relating to further data interrogation, the inclusion of additional GIS mapping of results, and succinct editing (and updating) of the draft policy document that also incorporated the range of practical suggestions identified through the workshop process.

6.4.3 ZT Summit Workshops

Following the Policy Briefing Workshop, an updated draft Policy Briefing paper was prepared for presentation and discussion at the four ZT Summit Workshops (conducted in June 2018 and held in Delhi (Haryana and Punjab), Patna (Bihar and West Bengal) and Rangpur (Bangladesh). Each of the three workshops were attended by senior government officials engaged in both technical research and policy formulation (relating to CASI) in addition to selected stakeholders associated with the HS/ZT value chains.

A series of presentations provided participants with an introduction to the findings from the field studies and an overview of the key recommendations contained in the policy briefing paper. A series of small group ‘break out sessions’ were conducted that provided the various stakeholder groups the opportunity to discuss, debate and provide further suggestions in terms of how the policy recommendations could be shaped. An objective was to shape recommendation in such a manner to provide governments with more practical and workable solutions in support of accelerating the adoption of HS/ZT technologies from a policy formulation and implementation perspective.

In terms of capturing the regional characteristics (and implementation considerations) the following observations were made:

Bangladesh

- Labour shortages and transferring needed information to farmers are key problems in Bangladesh. Key messages were thought to be ‘we must go for this technology’ and to transition farmers to being self-sufficient in their quest to access and adopt CASI technologies.

- Subsidies were considered to create second-class machines for farmers, and so they must value this technology and have access to capital to secure it financially.
- Addressing the needs of farmers should be the number one policy priority for Bangladesh to help ensure that policy services the needs of farmers (as being the central benefactor).
- The threat of machinery provided by various projects being rapidly dis-adopted by farmers is a real risk, unless it is proven to work in a practical manner in the field. Consideration about how to perfect the technology, including addressing agronomic concerns such as seed placement and successful germination under field conditions, needs to be integrated into extension efforts, with ZT/HS adoption policy linked to the provision of a sufficient level of resourcing to achieve these outcomes.
- The development of sound policy relating to CASI and the adoption of the HS/ZT also needs to complement the Prime Minister of Bangladesh's priority for developing water saving technologies and practices as part of an integrated approach to farming systems improvement.

Eastern Gangetic Plains (Bihar and West Bengal states)

- The major on-farm system constraints in the EGP relate to labour shortages, the fragmented nature of land-holdings and smallholder farmers having an inability to afford the technology through outright equipment purchase. To address these major constraints it was considered critical that CHC operators (managers and technical operators) were adequately trained and acquired skills to successfully demonstrate the technology (and help convince farmers of the success of the practices to achieve ambitious out scaling targets).
- Properly resourced and trained CHC's were considered central to accelerating adoption amongst extreme resource poor farmers, with an identified need to provide in-field and 'hands-on training' to avoid dis-adoption. In particular, it was considered that additional efforts (and resources) must be devoted towards supporting farming women in raising an awareness and technical understanding of CASI technologies; particularly amongst those working in isolation and having the responsibility of managing the land whilst the male members of the household were working off-farm.
- Practical agronomic based research was considered a priority to further adapt and perfect the ZT technologies (in terms of achieving optimal plant germination, successful crop establishment for wheat and other crops), and in particular address other system constraints, and the integration of best management practices such as the use of chemical weed control in developing CASI systems.
- Whilst there is some local manufacturing capacity across the region, quality of machines is often poor. Quality machines, whilst being available in NW India, are not readily available locally. Hence, there is the need to consider offering support and financial incentives for manufacturers to establish local manufacturing capacity in the EGP. Once this is established, it is believed that the efficiency and effectiveness of the HS/ZT value chains will follow.
- Access to expertise for the servicing, maintenance and repairs of machines in the EGP at times is very difficult, as is the availability for equipment spare parts. Incentives should be offered to manufacturers to improve local availability of spare parts through an expanded network of service centres and retail outlets.
- In relation to the contentious issue of subsidies, participants were of the opinion that the provision of subsidies would be better targeted towards CHC's, and could be operated on an area basis linked to those farmers embracing the initial adoption of CASI systems. It was thought that any financial support in the form of subsidies was best short-lived, with the view of transitioning support towards the provision of low-interest loans over time.

- It is considered important that further studies were conducted in relation to assessing and understanding the differences (and benefits) between two-wheel and four-wheel tractor economics; an issue of considerable concern to farmers in the EGP. Evidence of savings, benefits, adoption outcomes, profitability, and awareness over time was required to clearly support any policy recommendations put forward to policy decision-makers.
- The issue of farmers burning stubble residues, whilst not seen as a significant problem at this stage, was likely to increase into the future as more rice crops were being harvested mechanically (leaving more stubble residues in the field). It was recognised that farmers in the EGP valued the stubble residues more highly as a source of animal feed in comparison to NW India, and so stubble residues were also removed manually negating the need for excessive stubble burning practices.

NW India (Haryana and Punjab states)

The final workshop conducted in Delhi for NW India echoed many of the previous observations, comments and feedback provided above. There were however a number of specific noteworthy outcomes:

- There was an identified need to actively develop relationships between various stakeholders associated with the HS/ZT value chains. Specific examples provided included the engagement of financial institutions (for example NABARD) for supporting access to finance and building the business management skills of operators, and machinery manufacturers to help build skills in operating and maintaining equipment.
- There is a need to better inform and brief policy makers in relation to CASI technologies, such as the use of the ZT and HS seed drills, by arranging field visits and discussions with farmers and other stakeholders associated with the value chains. There is also the need to address inconsistencies in policy relating to machinery subsidies, such as subsidising the rotavator (that goes against principles of CA systems).
- There is the need to overhaul the provision of subsidies for the purchase of equipment, as such systems were considered to be inefficient and open to mismanagement. Alternative suggestions included the Government providing first-use loan guarantees to CHCs as an incentive to accelerate uptake and the provision of locally available services to smallholder farmers.
- There was concern raised in relation to the need to provide training to CHC operators, in the area of operational business management and the technical operation of the equipment in the field.

6.4.4 Regional Collaborative Platform Workshop

The final workshop activity conducted as part of the project related to a workshop dedicated towards the formation of a Regional Collaborative Platform (RCP), held in Kathmandu from 22-23 July 2018. Whilst the field research study was confined to India and Bangladesh, representation at the final workshop was expanded to include other countries comprising the geographical footprint of the IGP, namely Pakistan and Nepal. As indicated previously, key project objectives were to develop a range of policy driven options to accelerate on-farm adoption of CASI practices (such as the HS/ZT seed drills). A secondary objective was to explore the opportunity to establish a regional collaborative platform (RCP) capable of championing policy recommendations to decision-makers and to serve as a catalyst to achieve practice change on-farm across the IGP.

Attending the workshop were senior level government representatives from Bangladesh, India, Nepal and Pakistan. This activity served two purposes. The first purpose was to present the draft Policy Brief associated with the project, in an attempt to inform and influence future policy decisions by Governments in relation to providing an enabling environment to help accelerate the adoption of the Happy Seeder and ZT seed drills (see Appendix 11.4 for the final Policy Brief document).

The second purpose was to reach agreement from the senior National Agricultural Research Systems (NARS) representatives to form a continuing RCP, in addition to agreeing on the general purpose, operational structure and responsibilities of such a platform group. Both activities were achieved with outstanding success, as well as the signing of the Kathmandu Resolution in support of continued effort to promote and accelerate the adoption of conservation agriculture and sustainable farming intensification (CASI) technologies such as ZT and HS.

The NARS representatives collectively drafted the Kathmandu Resolution which clearly stated the importance of CASI for the region, and that achieving the benefits of CASI adoption requires urgent regional action in the form of a *CASI Platform* (CASI-P) for knowledge-sharing, capacity development, research and development partnerships, policy advocacy, and public awareness. Those participants representing the NARS in the region thus agreed to have an effective and functional regional partnership framework established with immediate effect, for which broad objectives and guidelines were discussed, and endorsed in principle. To that end, at the conclusion of the workshop each NARS representative signed the resolution and affirmed their commitment to its associated framework guidelines (which were also drafted at the workshop).

The Kathmandu Resolution (as signed off by the NARS partners) was worded as follows:

> We, the participants of the Regional Collaborative Platform on Conservation Agriculture for Sustainable Intensification Workshop, held in Kathmandu on the 22-23 July 2018, reviewed the evidence and information, progress and achievements made to date on conservation agriculture and sustainable intensification (CASI) across the Indo Gangetic Plain region.
>
> This information highlighted the value of facilitated and accelerated adoption of CASI sustainable agricultural practices to boost farmers' income, enhance farmers' and custom service provider livelihoods, improve soil health and increase the efficient use of inputs (e.g. water). It was recognised that achieving the benefits of CASI adoption requires urgent regional action in the form of a CASI Platform (CASI-P) for knowledge-sharing, capacity development, research and development partnerships, po9licy advocacy, and public awareness.
>
> We recognise that a sustainable CASI-P initiative will primarily be propelled by regional partnerships of NARDS in collaboration with other International Centres of Excellence in Agricultural Research, extension and development organisations – including private sector engagement. We further recognise that fostering such partnerships will be critical for the success of this initiative, and also for delivering regional public goods with cross-country benefit for South Asia.
>
> To achieve this partnership, those participants representing the NARS in the region agree to have an effective and functional regional partnership framework established with immediate effect, for which broad objectives and guidelines have been discussed, and endorsed in principle. We the undersigned therefore jointly undertake to submit this resolution for further approval with our respective NARS organisations in order to nurture effectively this crucial initiative for the sustainable future of the region.
>
> Signed on this date by the NARS representatives in the Kathmandu workshop.

The NARS representatives signing off on the resolution were Dr Wais Kabir (Bangladesh), Dr AK Singh (India), Dr Yubak Dhoj G.C. (Nepal) and Dr Yusduf Zafar (Pakistan). The inaugural Chair for the RCP was also chosen as Dr Baidha Nath Mahato, The Executive Director of the Nepal Agricultural Research Council.

His Excellency, Mr Peter Budd, the Australian Ambassador to Nepal, provided the closing remarks for the workshop and again highlighted the close ties that Australia has with the countries of the project, and how much Australia values the work that it does in the region through ACIAR and its partners.

Whilst the formation of the RCP involving Bangladesh, India, Nepal and Pakistan is an achievement in itself, the findings of this study also demonstrate the high level of complexity (and reluctance by farmers) to adopt CASI farming systems in a resource-limited environment. Further to this, the Policy Document involves a series of actions that need to be considered within the context of environmental resource declines in the respective countries and regions, to ensure that practical adoption initiatives are introduced and promoted by governments.

7 Discussion

The following matrix provides a synthesise all of the data results from the previous results section. It lists the issues raised within the project, and a score based on how many times a positive or negative adoption outcome was raised, categorised by methodology:

Raised issues for discussion	***Sign***	***VCA***	***FGD***	***Survey***
Positive issues:				
HS/ZT technology saves farming inputs (e.g. labour, time),	**+2**	✓		✓
HS/ZT adoption improves/meets existing yields, and/or lowers farm costs (mixed for gross margin)	**+2**	✓		✓
ZT technology is affordable and well-serviced across most areas of the IGP	**+2**	✓		✓
Gender differences in decision-making between Western IGP and Eastern IGP; may provide opportunity for engagement	**+1**			✓
ZT technology has a positive image in the Eastern IGP areas	**+1**	✓		
Negative issues:				
High cost of purchasing HS technology, and low demand for the technology by farmers	**-3**	✓	✓	✓
Seed germination, weed/pests controls concerns, or general agronomic worries	**-3**	✓	✓	✓
Flawed subsidy policy in the past, and no evidence collected in support of positive adoption outcomes	**-3**	✓	✓	✓
Low levels of awareness persist, and farmers need information or first-hand experience before they will adopt (e.g. in-field demonstrations and time-lapse evidence)	**-3**	✓	✓	✓
Low farmers access to finance if not in a co-operative or group (but may be improved for CHC's)	**-3**	✓	✓	✓
Farmers' still perceive need for 'clean' fields ahead of next sowing operation	**-3**	✓	✓	✓
Poor knowledge transfers via extension or other official sources (with some low credibility issues)	**-3**	✓	✓	✓
Limited economic window for operation of HS/ZT technology between sowing periods	**-3**	✓	✓	✓
Precision operation, while appreciated as a benefit, requires skilled training and capable operators	**-3**	✓	✓	✓
Higher tractor power is critical for HS adoption; but may be less of an issue for ZT adoption	**-2**	✓		✓
Ineffective bans of burning of crop residues (where that is an issue)	**-2**	✓		✓
Low access to HS technology outside NW India, as well as low access to parts and service	**-2**	✓		✓
Fragmented and small farms create issues for effective adoption of HS/ZT technology	**-1**	✓		

This matrix clearly shows that there are far more negatives associated with the potential for HS technology adoption than positives. The fact that many of these negative issues also appear across all three methodologies suggests a high-level of triangulation with regard to policy importance.

If next a comparison between the matrix above to the one developed following the literature review is made it is then possible to identify a number of persistent issues related to the ongoing low levels of HS technology adoption:

Adoption Problems:	Previous studies	Current Project
Short operating time frames	✓	✓
Unenforced bans on burning	✓	✓
Subsidies in farm inputs	✓	
Cost of HS/state tariffs*	✓	✓
Risk aversion by farmers	✓	✓
Yield increase uncertainty	✓	✓
Manufacturing capacity*	✓	✓
'Clean field' perceptions	✓	✓
Operational training needs	✓	✓
Seed germination/quality*	✓	✓
Adoption Solutions:		
Demonstrations/champions	✓	✓
Purchase subsidies*	✓	✓
Increased awareness	✓	✓
Enforcement of laws*	✓	✓
Reduced operating costs	✓	✓
Remove input subsidies	✓	
Extend operational window	✓	✓
Entrepreneurial businesses	✓	✓
Training capacity scaling	✓	✓
Local manufacture*	✓	✓
Ex-post analysis needed	✓	✓
Including women in process*	✓	✓
Value chain analysis*	✓	

Note there are two exceptions between the previous and current studies: i) the removal of input subsidies was not raised in the current project, although it may still provide some confusion in the subsidy policy; and ii) value chain analysis does not appear as a requirement because the current project undertook a VCA as part of the evidence-collection process.

This comparison of past and present issues can now be used to structure the discussion of our findings, beginning first with a consideration of the positive adoption drivers.

7.1 Cost savings and yield improvements

Commonly-claimed benefits from farmer adoption of HS/ZT technology include the potential to achieve savings in terms of labour requirements, crop inputs (fuel savings from less cultivation and water savings from improved irrigation efficiencies) and the capacity to shorten the time required between harvesting of the rice crop and sowing of the subsequent wheat crop. Other claims suggest that the adoption of HS/ZT sowing practices will increase crop yield (and in turn farmer's income). The analysis identified that input costs are lower with both HS and ZT adoption across the survey sample (in comparison to conventional crop sowing), an observation supported by other studies (see for example Bell et al., 2017). However, while these benefits should provide some reasons to adopt, the project results have pointed to a number of issues that must first be addressed:

- Apart from the low levels of awareness of ZT/HS technologies persisting among IGP farmers, the opportunity for yield increases from CASI farming practices remains limited; although such outcomes would be of benefit above sustainable practices and increased farm incomes under intensified farming systems. A recent meta-analysis of the scientific literature would suggest that in terms of temporal stability (i.e. yield benefits over time), a transition to CASI and ZT practices over conventional agriculture does not affect yield stability (Knapp and van der Heijden, 2018). It is evident that there is a degree of difficulty that extension officers and other supporters of CASI technologies face when attempting to convince farmers of the benefits of CASI and ZT adoption based on the provision of evidence based field research and quantifiable farmer experience.
- Farmers in general are far-removed from the scientific literature and as detailed by the results reported herein, prefer to gather firm 'physical evidence' in the field themselves that clearly demonstrate input savings and yield improvements on their own farms. This is generally near impossible to achieve in the short-term and may be challenging to show even in the longer-term (e.g. soil carbon improvements directly linked to CASI adoption).
- ZT technology in the EGP offers more potential for adoption since farmers in this region generally hold a positive perception towards the ZT technologies, and it is relatively affordable based on using a CHC model of access in West Bengal and Bihar and smallholder farmer ownership and CHC models in Bangladesh (based on imported ZT drills for two wheel tractors). In contrast HS technology in NW India is perceived to be less affordable/accessible amongst those farmers who at least have an awareness of the technology. In the EGP there is not a convincing need for the HS at this point in time, given the dominance of hand harvesting of rice crops (having less stubble residues remaining in the field and the recognised value of the rice stubble for animal feed). And the fact that ZT seed drills provide an adequate result for direct sowing of wheat into remaining rice stubbles. This situation may change as the machine harvesting of crops in the EGP becomes more popularised in the future.
- There has been some mention of the need to include women in technology adoption decisions, which has again been raised in the results from this project. It was not possible to include the full Women's Empowerment in Agriculture Index (WEAI) instrument in our farmer survey, due to its length. The original research intent was to utilise the WEAI but given the significant amount of data required to perform this analysis, unfortunately this had to be relinquished (with the need to explore gender issues related to HS/ZT technology adoption as a future research priority). For the EGP there appears to be good scope for involving women in adoption decisions with positive outcomes in comparison to NW India where the role of women is far less recognised nor accepted socially. In Bihar and West Bengal several examples of progressive change and technology adoption among women-only groups (supporting transformation in local villages) benefiting all farmers involved were observed.

We turn next to a consideration of the negative HS/ZT adoption issues.

7.2 Demand and Supply of HS/ZT technology

Farmers do not display any widespread demand for HS technology across the IGP. This is due to a number of reasons, firstly the lack of awareness of the technology and secondly the fact that the incentives required to increase demand were not sufficient to generate demand. For example:

- Farmers perceived that the purchase price for a HS machine is too high (at the 150,000 INR level). In contrast, the purchase price for ZT machines is lower, making that technology an affordable substitute where the field residue is not too high.
- Both researchers and the manufacturers of the HS technology indicate that it is a far superior technology, and is the only option available to direct sow wheat into rice stubbles. These qualities, and the more complex manufacturing process required to build the machines, are used to justify the higher cost of the equipment. However, there are some disappointing constraints associated with the lack of proper set-up (machine calibration), operational training, on-site support and availability of spare parts outside of NW India (and even within NW India at times), that acts to negates the positive advantages of the technology.
- Demand increase in response to positive outcomes from adopting HS technology (including increased yields, reduced input requirements, timesaving) cannot be fully achieved until farmers have the opportunity to experience these advantages from first-hand experience. This requires time, resources, commitment and planning by a range of stakeholders (manufacturers, extension officials, local farmers, researchers) that has to date only occurred on a limited scale. While that has driven positive adoption outcomes, widespread demand remains low in most areas.
- The current subsidy support scheme (at the time of this study) did not stimulate demand. It is arguable that farmer demand for HS technology across the IGP is relatively elastic (i.e. farmers can easily operate without HS/ZT technology) whilst they have the option of freely burning rice straw stubble residues. While subsidies at the perceived 'fair' market value for HS technology may act to stimulate demand, if the real market price is perceived to be inflated, then they may fail to work (Figure 53).
- A relatively elastic demand suggests that suppliers will enjoy much of the surplus generated from subsidies in the market under a fixed supply curve (S) (Tisdell, 1982). This is because farmers may not view price as a sufficient incentive to increase the quantity purchased in the market; and in this case at the 150,000 INR price (D_1) farmers' perceive that the technology is expensive. While a 50% subsidy (for individual farmers) should stimulate demand by reducing the 'cost' to farmers, it actually only serves to bring the price down to what farmers informed us that they thought was a 'fair' price for the machines; that is, 75,000 INR (represented by the D_2 demand curve). While co-operatives and farmer groups may be able to access an 80% subsidy to purchase a machine for shared use, this comes with practical challenges around how that shared-use will be scheduled, whether the capacity will meet sowing-window limits, etc. Thus, it is highly likely in the eyes of farmers that the subsidy only benefits the manufacturer; while the manufacturer may also be challenged by their dealings with the government. Coupled with the high transaction costs by both parties of accessing the subsidy (e.g. limited subsidy support available, complex application process, state by state differences), the subsidy incentives may not work as a demand-inflating mechanism to the level anticipated by policy makers.

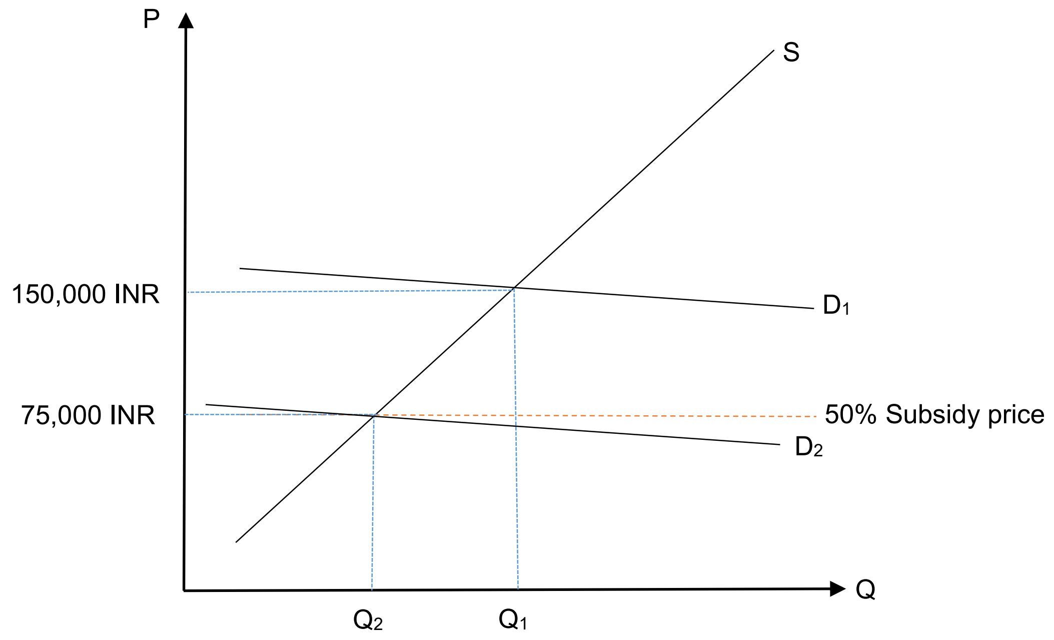


Figure 53: Elastic demand effects on subsidy incentives

- Some barriers to ZT demand in the EGP may be overcome through an existing approach adopted by other machinery suppliers; that is, through developing local manufacturing facilities. If manufacturers were committed to selling their product in these regions, and could benefit financially from doing so, then it would make economic sense for them to establish a presence in those markets. Governments could support early-movers (e.g. clear financial assistance strictly for the first two or three manufacturers) with incentives to expand their operations, while laggard manufacturers could explore this option at their own costs.
- In previous seasons there has been very little incentive for farmers in NW India to stop the practice of rice stubble burning. Whilst legislation has been in place banning the practice and the provision of fines, there has been little enforcement. It is now becoming increasingly evident that this situation is expected to change, with closer monitoring by authorities who have stated in the media (as of September 2018) that individual villages will be monitored by local authorities (both 'on the ground and by satellite imagery) for this coming wheat cropping season. Fines will then be imposed for those farmers having disregard to the law. If this is the end result, then it is expected that there may be increased demand generated for the HS.

7.3 Agronomic concerns

Results from this study clearly illustrate the high degree of risk aversion held by farmers in relation to introducing change on-farm, and the need to provide solid incentives to initiate practice change such as adopting the HS/ZT seeding systems. A revisit of the requirement to achieve Rogers' (2003) innovative transformation to the adoption of the HS/ZT draws several useful agronomic insights for the future:

- **Relative advantage**: *is the HS technology innovation better than what preceded it?* What has preceded this technology is either: i) burning of crop residue to remove heavy straw loads from fields ahead of the next sowing activity, and/or ii) conventional agriculture involving repeated cultivation of the soil to prepare fields prior to crop sowing. As discussed, the cost of adopting HS technology is high for individual farmers. For those considering entrepreneurial business models (discussed below) there is also an element of financial risk even with 80% subsidy support provided by the new *in-situ* arrangements. If the technology fails to deliver in just one season (for example if germination is poor, weeds/pests create additional management problems, the machine is unable to cope with high straw levels etc.)[6], then farmers will quickly lose confidence, returning to conventional methods and leaving the service provider with an unwanted piece of machinery. Since the majority of farmers prefer to see finely tilled soils that are residue free prior to crop sowing (and the fact that burning of stubbles is an accepted practice), there is a significant change in farmer attitude and 'mind set' that is required. This is hampered by the failure in 10 years to adequately 'out scale the technology' since there is very little farmer awareness of the technology and limited demonstrations/practice comparisons that can be used to grow farmers' positive perceptions of the technology. Under assumptions of risk averse attitudes among those in agriculture, the relative advantages are not firmly evidenced enough to incentivise practice changes by users under the current situation. Transformational change by authorities is required.

- **Compatibility**: *is the innovation consistent with existing values, past experience, and needs? Can the innovation fit into existing farm systems?* The complex nature of the farming systems across the IGP poses a challenge in terms of providing alternatives to the current farmer practices that are considered to be compatible to the agro-ecological environment, build on past technological advances and are compatible to farmer values and belief systems. The challenges remain with the HS seed drills in particular associated with the farmer perception that it is simply impossible to sow a crop without removing the prior crop's stubble residues and though repeated cultivation in order to produce a fine soil tilth and seed bed for sowing of the crop. It is evident that more effort is required to address farmer perceptions or 'mind sets' in a well-planned manner if there is to be any particular change of achieving widespread adoption and impact. It is without any doubt that there are immense challenges and pressures being forced onto the current farming systems across the region; thus necessitating the need to take into consideration the dynamic nature of this evolving system. Challenges will continue, be it political, social and community pressure for farmers to address the serious issue of stubble burning, the changing dynamics in rural communities in terms of the availability (or lack) of seasonal labour which is resulting in the need to introduce mechanisation, or consumer concerns in relation to pesticide residues and food safety. The fragmented nature and small farm plot size raises challenges for the efficient use of ZT/HS machinery, which ideally lends itself towards cooperative or custom-hire business models as a solution to proving access to the technology by the smallest of farmers; but this only addresses part of the concerns raised in this project (and many preceding studies). As these business models are examples of new farming systems, that in themselves are still being tested and proved, the context across the IGP is one of an innovative technology being fitted into an innovative farming system, which invariably does not satisfy the compatibility model describes by Rogers.
- **Complexity***: is the innovation relatively difficult to understand and use? Will it require specialised skills or training to operate?* Using the HS/ZT technology in an effective manner takes skill, training and expertise and a commitment over an

[6] Longer-term use of zero-till may result in unanticipated negative outcomes, such as increased pest pressure. For example, in Southern Australia continued use of zero-tillage in broadacre grain cropping has resulted in reduced controls for snail eggs, which used to be broken up during tillage. The area is now subject to a widespread plague of cone-shelled snails, which impact on grain quality and export market returns.

extended period of time to ensure widespread adoption and success of the particular complex crop establishment technique. From experience elsewhere, the development of CASI systems that are based on ZT technologies takes a considerable amount of time to perfect the technologies and factor in the high degree of complexity in the farming system. It is unwise to suggest that adoption of the HS will occur simply by providing farmers with access to highly subsidised machinery. There needs to be the development and extension support provided to accompany the technology, and importantly to support farmer groups and individuals through the adoption process. Without this concentrated support there will be little increase in adoption, as has been the case for the past 10 years in parts of NW India in relation to adoption of the HS. It is necessary that a 'thought out' support plan with training and extension institutions playing a significant role in this process, as discussed further.

Triallability: *how much can the innovation be trialled at small scale? Can we demonstrate the innovation to reduce uncertainty about any changed practices?* Innovation can be undertaken on a small scale with relative ease and has been successfully performed in a large number of on-farm research and demonstration activities in programs such as the SRFSI program conducted in the EGP, KVK CA programs amongst others. At a local level whilst on-farm demonstrations have been successfully conducted, there have however been additional challenges in terms of the out scaling of the technologies and the challenge of meeting farmer demand for access to ZT seed drills. The provision of a single seed drill in a local village community rarely kept up with demand; once farmers had accepted the technology and were convinced that the practice worked on their own farm. Similarly in NW India where the focus of the technology being promoted has been the use of the HS as an alternative to crop residue burning the challenge in this situation is the ability to raise awareness and to trial the technology on-farm given the number of farms and farmers. There is the need to reverse the persistent misconception amongst HS aware technology farmers that the HS can only be used to sow wheat and that it is possible to use the HS to sow crops such as maize, mung bean, fodder crops and others. Whilst there are a number of projects across the IGP currently demonstrating ZT/HS technologies (in addition to local efforts provided by KVK's and Universities), there is no large-scale resourcing that has been committed towards initiating a major program across the IGP. Such a program could provide a strategic and coordinated approach towards correcting and/or upscaling farmer awareness, demonstrating the technology, or showcasing agronomic benefits. The provision of subsidies on ZT/HS seed drills (the level of subsidy determined and implemented on a 'state by state' basis) is questionable in terms of overall effectiveness due to alleged corruptive influences. It is therefore apparent that a coordinated approach is required, and the opportunity to form a regional collaborative platform across the IGP will be a step in the right direction, providing sufficient resources are provided.

Observability: *are the benefits or outcomes of the innovation observable to others? Can these be effectively and convincingly communicated more broadly to users at scale?* This level of observability can detract from the technology, given the traditional perceptions requiring a fine soil tilth free of any plant residues prior to crop sowing. The success of the technology has a high degree of observability, in terms of assessing the success of crop establishment form the germinating crop; either it works or it doesn't. Some other benefits are less observable, such as longer term soil health benefits including increased soil organic matter and biological activity, improved soil structure and water infiltration (improved irrigation efficiency. Such benefits may take years to eventuate and only be measurable via costly testing and analysis. Being able to communicate such benefits to large numbers of farmers may be a difficult process due to the expense and the challenge of communicating complex principles to largely uneducated farmers. For risk-averse farmers who are focussed on short term outcomes (achieving basic farm household food security), the long-term benefits of the technology may not necessarily provide the incentive for immediate uptake. The focus therefore needs to be on those characteristics/benefits of the technology that are easily observable and can be realised in the short-term.

7.4 Institutional issues

Another important group of barriers to increased or accelerated HS/ZT adoption relates to institutional issues. In an effort to understand the process of economic change, Nobel-Prize winner Douglas North spent a lifetime studying institutions, institutional change and associated economic performance. For North, institutions represented the 'rules of the game', while relevant organisations could be thought of as the 'players of the game' (North, 1990). Beyond these two characteristics of the economy, it is also important to consider the resources needed to play the game, and the rewards from playing the game as critical components to analyse. It is in this context that North's institutional framework is used to further discuss the project results.

The players of the game across the IGP have largely been confirmed and captured in the VCA conducted as part of this study. Interviews with VCA stakeholders provided the opportunity to examine in detail how the institutions and resources of the game enabled or provided barriers to HS/ZT technology adoption, and what might be changed to create an adoption-enabling economy. This has raised several key points:

- The rules of the game with regard to effective bans on crop residue burning in the NW IGP have to date failed to create any significant changes in farming practices. Recent controversy reported in the media has certainly raised awareness about the issue with the governments (September 2018) that a much more enforced and disciplined approach will be taken in the 2018 wheat crop preparation season. However, these bans have been argued in the past as being far too drastic if there are few viable alternatives prior to HS technology becoming available. It has also been observed in Haryana (September 2018) that farmers are opting to the cultivation and incorporation of rice stubble residues on early harvested rice crops (with combine harvesters fitted with the straw management system to evenly spread rice straw residues across the field). This practice appears to be adopted with the hope that incorporated residues are able to partially break down over a four week period prior to wheat sowing. This technique, whilst far from being a sound CA practice, is a positive response to farmers finding an alternative to burning the rice straw residues and who are reluctant to (or can not access) the HS.
- In the rice-maize cropping systems of the EGP burning is less of an issue as a consequence of the relatively lower crop residue volumes identified in our results. However, allowing time to reap important livestock feed straw between crops creates time-pressures on farmers which ZT sowing can alleviate where adopted. But there are no clear policy or institutional rules in place to support farmers in these choices, and to take advantage of resource/cost saving opportunities. As such, one of the key outputs from this project is policy advice in support of change.
- Where subsidies are available (mainly in the NW India), they are in conflict with other support-schemes (e.g. similar subsidies on conventional tillage machinery such as the rotovator) or are undermined by continuing input subsidies (whereby there is not the same degree of benefits to be made from subsidies on diesel fuel for example). Thus, the main positive incentives for HS adoption identified above are offset by the Government's current policy, and reliance that what worked before now will be effective in future. This is short-sighted, and completely at odds with the potential for CASI adoption and/or increased farm incomes. Policy decisions and investments

are required now to secure India's future—and the security of the entire IGP region. The cost of decisive policy action today will be far lower than the cost of policy failure in future.

- Many times stakeholders re-enforced the message that seed quality goes hand-in-hand with precision sowing and achieving successful crop germination and establishment. To support either increased CASI adoption or HS/ZT technology across the IGP, institutional focus on the seed quality supply chain (such as seed source of seed, processing, certification and packaging, storage, field use) is required and warrants further VCA of the industry to support final recommendations and policy advice.
- Positive resource changes may also include removing subsidies altogether and instead focusing on encouraging/underwriting private investments by farmers, cooperatives and/or CHC providers. This might be in the form of low-interest loans that incentivise adopters to recognise the economic value of their choices, and the need for longer-term thinking both with respect to financial issues as well as resource sustainability that is consistent with a CASI focus.
- Alternatively, if wider CASI farming practices were a chosen policy objective, then additional institutional changes could include removing GST taxes on CASI technology at both state and national levels of Government. This would send clear signals of the Government's commitment to this idea, and reduce total costs of investment for adopters.
- A further area of clear resource requirement is that of skills training and knowledge transfer. Results from this this study revealed that farmers perceive the standard channels of communication and knowledge transfer (such as extension officers, KVKs) as being considered moderately credible sources of information; while the State Agricultural Universities scored relatively well. This should be a concern, and suggests that either i) new sources of information with higher credibility among farmers are used to raise awareness and promote the benefits of adoption or ii) Governments undertake to properly inform and resource extension/KVK officers with the requisite knowledge, HS/ZT demonstration machines, and schedule of interaction with farmers across the IGP to improve that perception and accelerate change among farmers.
- In support of this, Governments must also structure and resource the collection of data in evidence of positive outcomes from their policy and program choices, whatever they may be. Without the capacity to monitor what is happening on the ground, link those changes to the policy/program choices made, and identify what is/is not working successfully then the current level of non-adoption will continue into the future. Only if Governments can clearly identify that change is occurring on farms will they be able to evaluate the policy choices made.
- In an ideal world, there would be no requirement for Governments to subsidise farmer investment in this technology, if it in fact proved beneficial for users to do so. The private gains of the investment would offset the machinery costs, and on balance farmers would be better off and incentivised to adopt. The cost of the technology would still require access to finance, and results from this study reveal the difficulty that farmers experience in accessing finance. Formal lenders (banks) favour business models such as farmer groups, cooperatives and/or CHC providers when lending against capital investments such as machinery. The lenders view these business models as being more secure in terms of repayment reliability than individual farmers, who are perceived as having a high default risk. This helps to explain some of the results in this study, where the survey respondents did not seem to express much concern about access to finance. For individual farmers, they may already be resigned to poor access, and see formal lending as irrelevant. However,

farmer groups and cooperatives seeking financial assistance to invest in machinery have likely found it relatively easy to do so, perceiving no issues of access to fiancé as a consequence. Overall, this suggests the importance of appropriate business models for costly HS/ZT technology investments where a significant deposit ahead of a subsidy grant may also be required. This leads us to some further consideration of HS/ZT adoption business models in the final discussion section below.

7.5 Business Models

In this project as in previous studies, there has been much mention of the limited time-frame in which ZT can be undertaken between crops. Similarly, the fragmented and relatively small land size of most individual farms in the IGP make it challenging to adopt mechanised innovations and expensive capital investments. Finally, opinion is divided regarding the relevance of tractors in this context, particularly with regard to whether two-wheeled options in Bangladesh are more appropriate for ZT technology in that context, or whether four-wheel tractors should be increasingly explored. Four-wheeled tractors may have greater capacity to more easily accommodate HS technology power requirements as the use of the HS over the ZT becomes more important as the cropping systems transition to mechanised harvesting particularly in the EGP region.

The need to provide smallholder farmers with access to ZT/HS seed drills that otherwise are unaffordable to them presents the opportunity to develop sustainable and profitable business models that offer coordinated services to access the innovative technology as part of introducing a broader CASI based farming system across the IGP.

As discussed traditional finance providers such as banks have expressed a positive willingness to lend to farmer groups, cooperatives and CHC providers, since the capacity of such business models to provide a credible business case in support of the loan and to meet repayments was favoured instead of lending to individual farmers. While CHC providers were previously excluded from subsidy the support programs in India, the recent *in-situ* subsidy scheme includes CHC providers and raises the level of subsidy support available to 80% (as opposed to the 50% subsidy available for individual farmers). This should provide adequate incentives for such business models to invest in innovative technology such as the HS, grow their customer base over time and to endure past their entrepreneurial roots into thriving local agricultural businesses. To successfully achieve this outcome it is important that the CHC businesses (that are largely run by farmers) are provided with adequate financial and business planning skills in order to ensure that they are able to undertake profitable operations for the long term. Poorly managed businesses would be a disastrous outcome if there is not adequate training and support provided to them.

One of the fundamental barriers to increased adoption of HS/ZT technology at present can be summarised by adopting a classic cost-benefit analysis (CBA) approach. For any innovation to be successfully adopted, the benefits of doing so must clearly outweigh the costs. The typical CBA will enable a business decision maker to identify, calculate and report on the costs and benefits of any choice set in dollar terms. For an investment with long time-frames, as in the case of machinery investments, an appropriate discount rate can allow us to determine if the ratio of discounted benefits over time outweigh the discounted costs in real terms. Finally, the internal rate of return also allows us to determine the discount rate at which the ratio of benefits to costs will be zero; effectively identifying the rate at which it is wise to invest.

If we consider a stylised CBA for HS adoption, we can see some of the risks associated with that proposition. For example, a typical CBA cash-flow (or the movement of flows from negative to positive over time) will appear as an s-curve similar to that shown below (e.g. the *private investment* line in Figure 54).

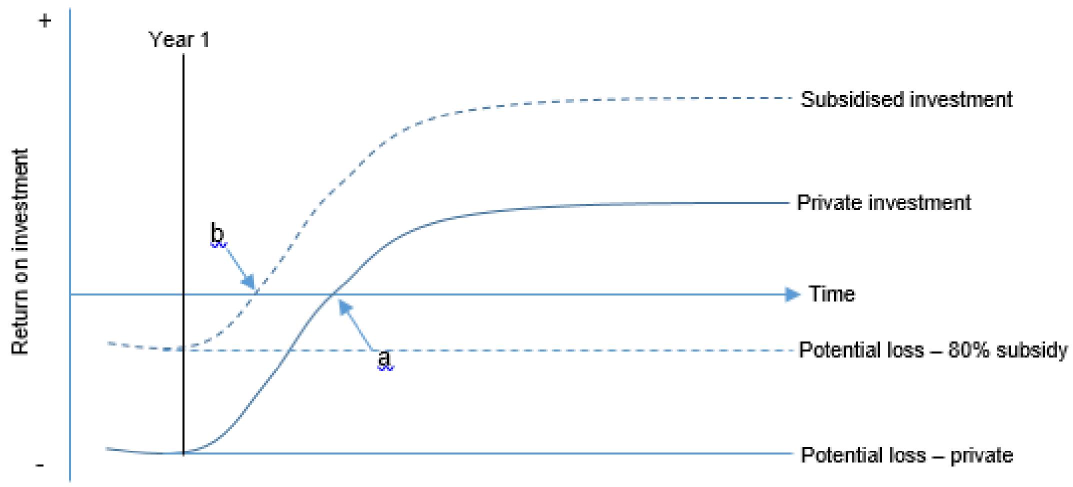


Figure 54: Stylised CBA for HS adoption

What this shows is that any private investor would normally expect the costs of their investment outweigh the benefits for a period (up to about year three in this example). At that period (a), the discounted cash flows from the investment should turn positive over the remainder of the life of the project, effectively making it a worthwhile choice. For a subsidised CHC business which, for example can access and benefit from 80% subsidies under India's current *in-situ* support arrangements, the s-curve remains the same but the positive cash-flow benefits would accrue sooner (b), and the total benefits would be higher than for that of the individual farmer investor.

The agronomic risk remains high as previously discussed. If either the individual farmer investor or the subsidised business experience poor outcomes in any of these early periods (poor agronomic performance of the technology or inability to introduce the ZT/HS technologies into the specific farming systems, lower crop yields and/or low operational efficiencies of the HS in the field including breakdowns), then they and/or their business service users may elect to not utilise the technology in future. This would drive the returns on the investment along a straight negative path for the remainder of the machinery life, with potential losses.

Consider the likelihood of any of those poor agronomic outcomes in the space of a production season. The probability of any one of those outcomes is high, let alone the probability of a combination of them—which suggests far greater costs of adoption when compared against the (often disputed or at best uncertain) yield benefits of adoption. If a high discount rate is also factored in (which would be common in developing countries), then it may be challenging for any decision maker; individual farmer, cooperative group, or CHC provider alike to justify adoption of HS/ZT technology under a CBA approach.

It is therefore unlikely that subsidy support alone will be sufficient to encourage entrepreneurial business people to adopt HS/ZT technologies into their existing (or proposed) mix or farm services. Larger coordinated policy approaches that include:

- a focus on skills training and knowledge transfers
- awareness-raising among customers and supported trials of the innovation
- on-going annual investments in local showcase plots or field days for up to a minimum of five years to develop a local understanding and appreciation of the risks and benefits of zero-tillage practices, and
- local collection, analysis and dissemination of comparative field data, cost savings, and yield outcomes between conventional versus HS/ZT sowing practices will be

need to make the case for wider HS/ZT technology adoption, and to support the growth of farmer groups, local cooperatives and/or CHC providers in the area.

7.6 Operating the HS as part of an efficient Custom Hiring Centre business operation

Finally, there are a range of costs incurred in operating a HS in the field situation that CHCs should be aware of in order to help ensure that their operations are profitable both in the short and long term. An exercise was conducted with a recently established CHC that was operating in Haryana, as an exercise to identify all of the relevant costs of the operation and to determine the expected margins to be generated from providing such services.

A comprehensive spreadsheet was used to help calculate the results. Comparisons are made between nil subsidy, a 50% subsidy (available to individual farmers), and an 80% subsidy (available to Farmer Producer Organisations). A range of scenarios were used to describe the operational costs for each model. The results indicate that the provision of subsidies reduces the overall cost of providing services, as does a high work rate and an increasing number of acres serviced by the HS in any one season. This information is presented graphically in **Figure** 55.

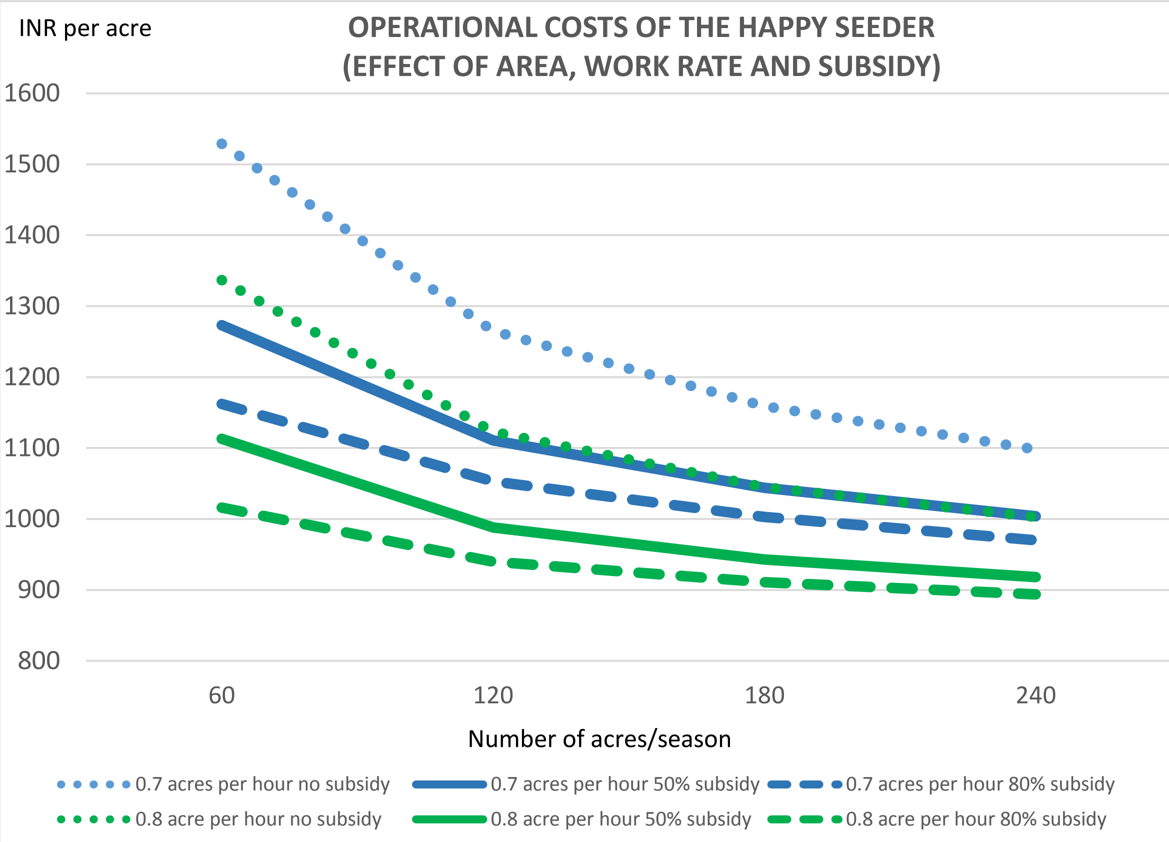


Figure 55: Impact of the provision of a subsidy, work rate and seasonal area (of operation) on the operating costs of a Happy Seeder.

The Government of Haryana have set a maximum contracting price charged to farmers for the HS at 1500 INR per acre. Comparisons helped to identify the cost of delivering a custom hire service for the HS machine under different operating scenarios. Results indicate the cost of operating a HS in the majority of cases is less than 1500 INR per acre.

The provision of subsidies does reduce the overall cost of operating a HS, and so does improving the efficiency of operation. A highly efficient operation (0.71 acres per hour without any subsidy) will actually cost less to operate than a moderately efficient operation (0.56 acres per hour with a 50% subsidy). This is an extremely important point, in that to maximise subsidies on machinery it is also important that the CHC are efficiently operated and coordinated. That is, a poorly managed operation will negate any of the government's investment in relation to the subsidy.

It is therefore important that Governments simply not just focus on handing out subsidised equipment. It is also important that CHC operators receive training and capacity building support in order to maximise their efficiency of delivery and long term business sustainability. There are two areas of priority, these being the field efficiency of the operation (technical operations, machinery maintenance and coordination of field activities) and the financial and business management operations.

It is important that the field efficiency is maximised, in terms of minimising 'down time' moving equipment between farmer fields, coordinating field operations for different farmers who are located close to one another, ensuring that the machinery is properly maintained (including performing maintenance out of hours) and importantly how the equipment is used (training of the operators/tractor drivers.

CHC operators will also require sound business management skills, need a full understanding and ability to calculate the cost of operations, annual depreciation costs and strategies for self-replacement of equipment, customer liaison, managing employees, financial book keeping, and so on. It has been reported that to date little training and capacity building has been provided to FPO's/CHC operators, with many of them facing difficulty in providing efficient and effective services based on sound financial and business management skills.

Figure 56 provides an indication of the number of days that the HS will need to operate to sow a range of different crop areas, at a moderately efficient and highly efficient work rate. If a wheat crop sowing window of 30 days is considered to be acceptable (sowing beyond a 30 day time frame will significantly reduce crop yield), then it becomes apparent that at a HS with moderate efficiency will be capable of sowing around 178.5 acres and a highly efficient HS will be able to sow 204 acres of crop.

It is possible to calculate the number of HS machines that farmers will need to access, if adoption of the HS is to take place by the majority. Such data will be of value to Governments to assist in calculating the number of HS that are required. Once again, this information highlights the need to ensure that CHC operations are efficient and effective, in order to ensure that as many farmers as possible have access to the machinery in as tighter 'sowing window' as possible. A slight reduction in the level of efficiency impacts upon the area that can be sown in a short time period, with any significant delays in sowing reducing the crop yield potential.

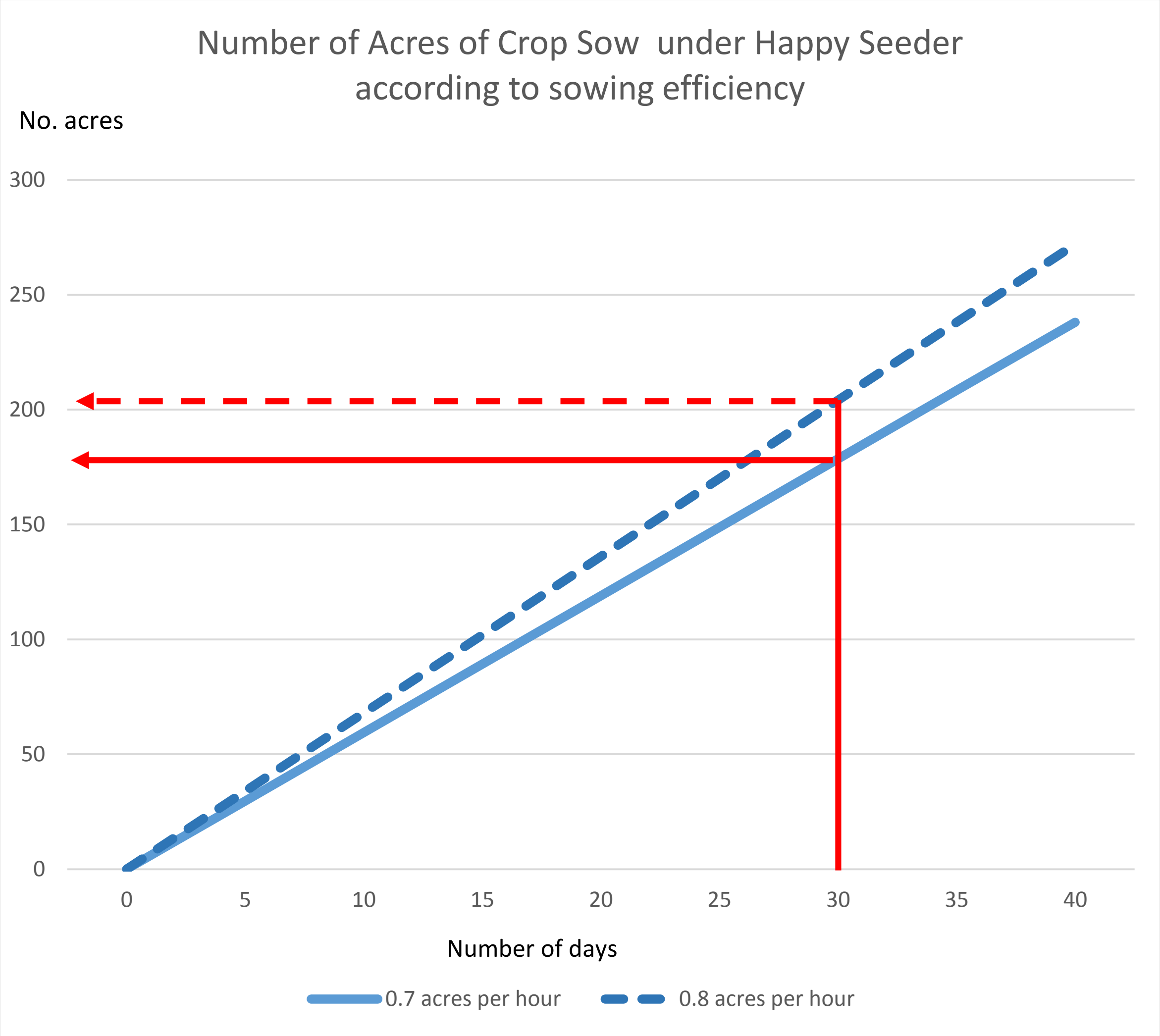
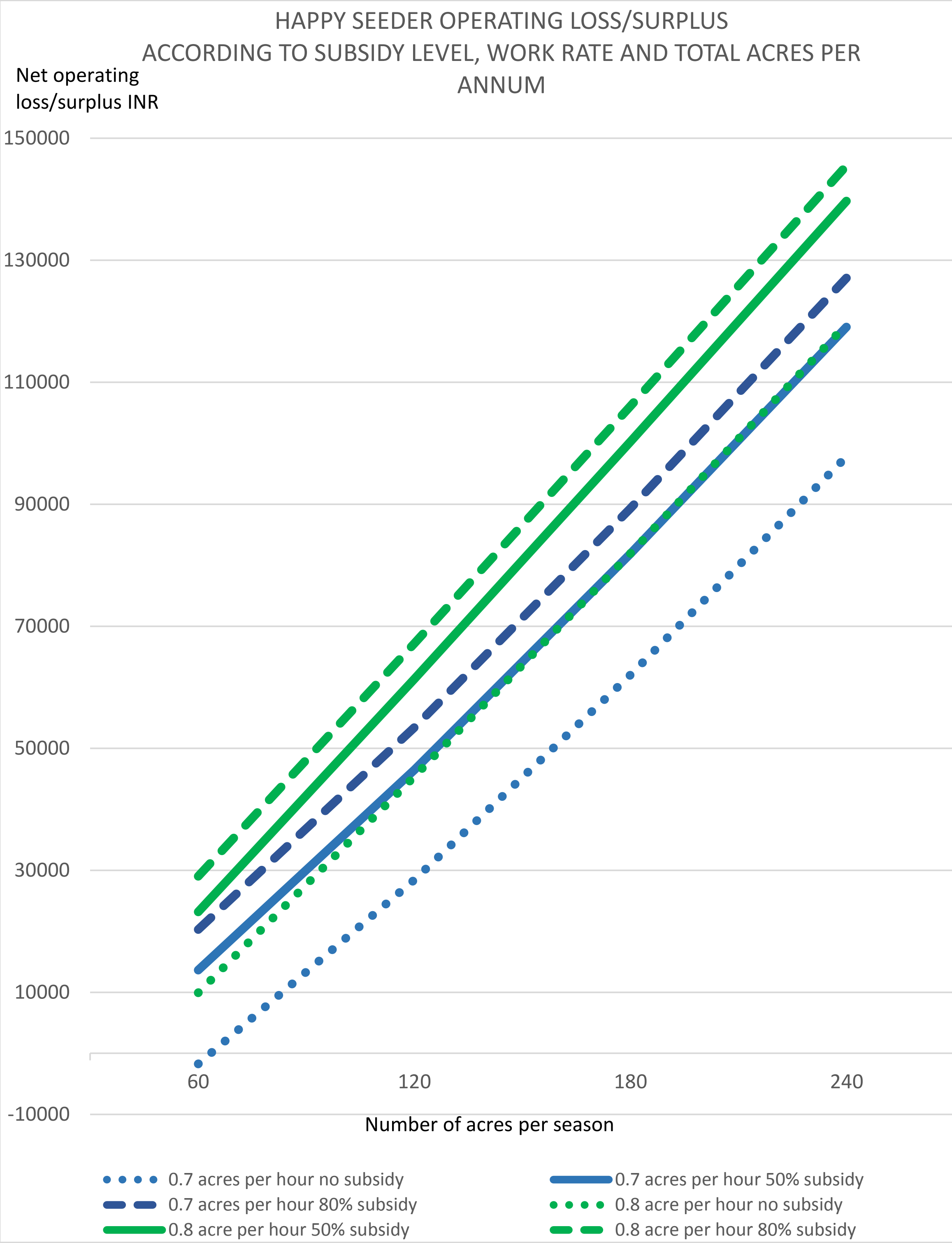


Figure 56: Number of days that the HS will need to operate to sow a range of different crop areas

It is also valuable to examine the potential loss or surplus that is generated from the provision of the CHC's, based on the level of subsidy provided and the overall field efficiency of operations. Figure 57 provides detailed information in relation to this. As previously indicated, the graph highlights that a HS (without any subsidies) operating at a higher field efficiency (0.8 acres per hour) will achieve the same level of profitability as a 50% subsidised HS working at a lower rate of 0.7 acres per hour, negating the Government investment in a 50% net subsidy.

The maximum operating surplus possible under the different scenarios can be compared, based on the number of acres sown over a 30-day period according to the work rate. Sowing at the less efficient rate of 0.7 acres per hour will sow 178.5 acres and generate an operating surplus of around 80,000 INR (50% subsidy) and 85,000 INR (80% HS subsidy). Sowing at a rate of 0.8 acres per hour over a total of 204 acres will generate an operating surplus of around of 122,000 INR (50% subsidy) whilst an 80% subsidy will generate a surplus of around 127,000 INR.

Figure 57: The impact of the Happy Seeder subsidy in relation to the operating surplus



(net profit/loss) after all of the operating costs have been deducted.

This analysis highlights the need to ensure that CHC operations are run in a highly efficient manner. There is the opportunity for the services to generate a modest operating surplus, to assist in covering some of the additional costs such as managing the CHC business operations. Importantly, in the financial calculations, depreciation of the HS and tractors have been factored into the fixed costs. Therefore the CHC operator should be in a position to replace the equipment at the end of its deemed 'useful life' (10 year period with the equipment housed in a suitable machinery shed/building) with funds that have been set aside for the cost of the depreciation.

Specific assumptions used in the financial calculations included:

- Comparisons between Happy Seeder subsidy at 50% and 80%, with a 40% subsidy on the tractor as standard for both. For the 'No subsidy' scenario, no subsidies are applied to the HS or the tractor.
- Estimated useful life of the machinery (tractor and HS) is 10 years.
- Both fixed (registration, insurance, storage of equipment in a weather proof building, depreciation) and variable costs (repairs and maintenance, fuel, labour) are factored into the calculations, with variable costs and depreciation (represented by residual value of the equipment at the end of the 10 year period) adjusted to the number of hours of usage of the equipment.
- An opportunity cost of the investment of capital into the equipment purchase is calculated at 8% per annum for a similar cash investment.
- Number of hours operation per work per day is 8.5 hours (assuming some transit to and from the field takes place before conditions are considered suitable for operating the HS due to moisture on the stubble). We further assume two working rates of either 0.7 acres per hour (moderate efficiency) or 0.8 acres per hour (high efficiency) forming the basis of the two work rate scenarios.

7.7 Extension systems

One of the outcomes from the project was to identify suitable policy interventions that would support the introduction of improved extension approaches that governments and the private sector could adopt to assist in the accelerated adoption of CASI technologies such as the HS and ZT seed drills. Significant challenges remain in terms of developing cost-effective strategies that support the out scaling of the technologies in resource limited environments.

The ultimate goal from this part of the study was to provide advice to governments in relation to how public-private partnerships can be created that help create an enabling environment that assists in the rapid adoption of CASI technologies, particularly the HS/ZT seed drills, in addition to improving farming systems. Improving the farming systems through the adoption of CASI technologies leads to sustained and improved food and water security that in turn contributes to improved profits and livelihoods for smallholder farmers.

The study identified four key characteristics that are required to create an enabling environment for achieving accelerated adoption of CASI technologies;

1. The need to address farmer perceptions, adoption constraints and farmer behaviour
2. The opportunity for farmers to be able to access technology through efficient value chains.
3. The need to provide an enabling environment for growth of entrepreneurial CHC's.
4. The opportunity to support the development of Innovation Platforms at the local farmer group level to support on-farm adoption.

Within the above four characteristics there are a large number of specific requirements identified from this study that need to be addressed (or a suitable environment created). These are presented in Figure 58, and illustrate the high degree of complexity and the need to address all of the issues simultaneously due to the interdependence associated with all of the elements.

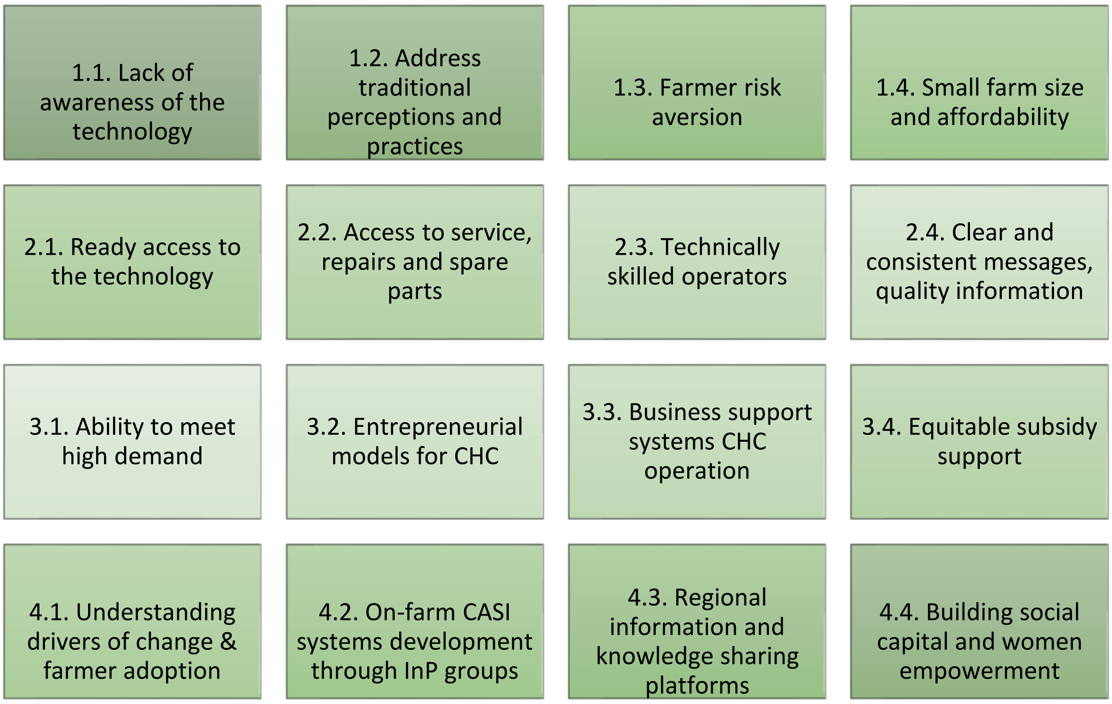


Figure 58: Summary of the required characteristics required for the creation of an enabling environment necessary for the accelerated adoption of CASI technologies such as HS and ZT seeding systems.

7.7.1 Developing successful extension approaches

We conducted an examination of the relative success of the Innovation Platform (InP) farmer groups associated with the current SRFSI project that is being delivered in the EGP (and focuses on the out scaling of CASI technologies including the ZT seed drills). This process provides a practical example of how new technologies can be successfully introduced to farmer groups in partnership with a wide range of stakeholders associated with the agricultural input value chains. An examination of the InP groups has identified a number if critical success factors and outcomes and include the following:

- Opportunity to share practical farmer experiences and knowledge as part of local self-help approaches.
- Strong and effective local leadership (farmers).
- Development of inclusive and trusting partnerships.
- Entrepreneurial service provision (largely through CHC that may include supply of inputs) within local farming communities.
- Open sharing of knowledge and information by all stakeholders.

The environment for extension needs to be supportive and structured. Figure 59 provides an overview of the extension process that incorporates the process of creating awareness, alignment with farmer needs (and perceptions), market opportunities, ensuring that farmer groups have sufficient capacity (and capability) to evaluate, adapt and in turn adopt the innovation. It is important that these key elements are incorporated into any extension environment that is initiated to support the accelerated adoption of ZT/HS technologies.

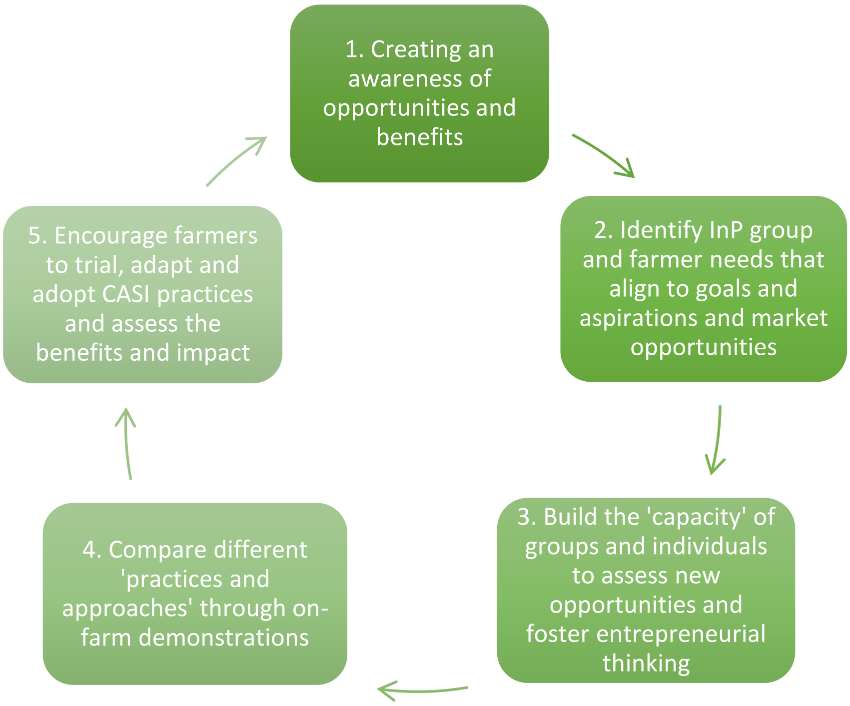


Figure 59: overview of the steps required by farmers to successfully adopt CASI technologies such as the HS/ZT seed drills.

7.7.2 Developing a pathway for accelerate adoption; an integrated InP-CHC model

It is critical that significant steps are taken to provide a far better enabling and supportive environment to achieve accelerated adoption of the HS/ZT technologies. Integrating Innovation Platforms with the provision of CHC's will help to ensure that there is an environment of innovation that is developed whist ensuring that the farmer groups have access to the ZT/HS technologies and quality cropping inputs. Important elements are summarised;

1. Formation of InP-CHC's need to be linked to FPO networks and other existing networks. This helps to ensure that there are elements of existing structure and basic leadership in place. It is also important to be able to identify both the poor and high performing groups, and provide the appropriate level of support to ensure successful outcomes.
2. InP-CHC business models should also include the opportunity for the retailing of farm inputs and other value-add services such as assistance in the pooling and marketing of produce (connecting farmers to markets), as a means of developing on-farm extension and technical related services in the longer term. A staged approach is required, and needs to be upon sound financial management and business planning principles.
3. Adopting an InP approach will help to ensure that multiple stakeholders from local knowledge networks and across farm input value chains are engaged and contribute towards supporting the farmer groups. This also needs to include stakeholders from

the finance sector, as well as encouraging participation from youth and women. A 'value proposition' needs to be developed that summarises what specific value the InP-CHC brings to its members and stakeholders.

4. Business management and entrepreneurial training of farmers and CHC operators (including Farmer Producer Organisations FPO's) as well as leadership and governance training is required to support the development of the InP-CHC entrepreneurial model.
5. The impact and benefits associated with the activities and outputs from the InP-CHC's needs to be closely monitored and reviewed on a regular basis, with opportunities for improved efficiencies identified and implemented.
6. A 'pathway to success' for each of the InP-CHC's needs to be developed, with both short term and long term goals set. The pathway is a 'learning journey' as outlined in Figure 60.

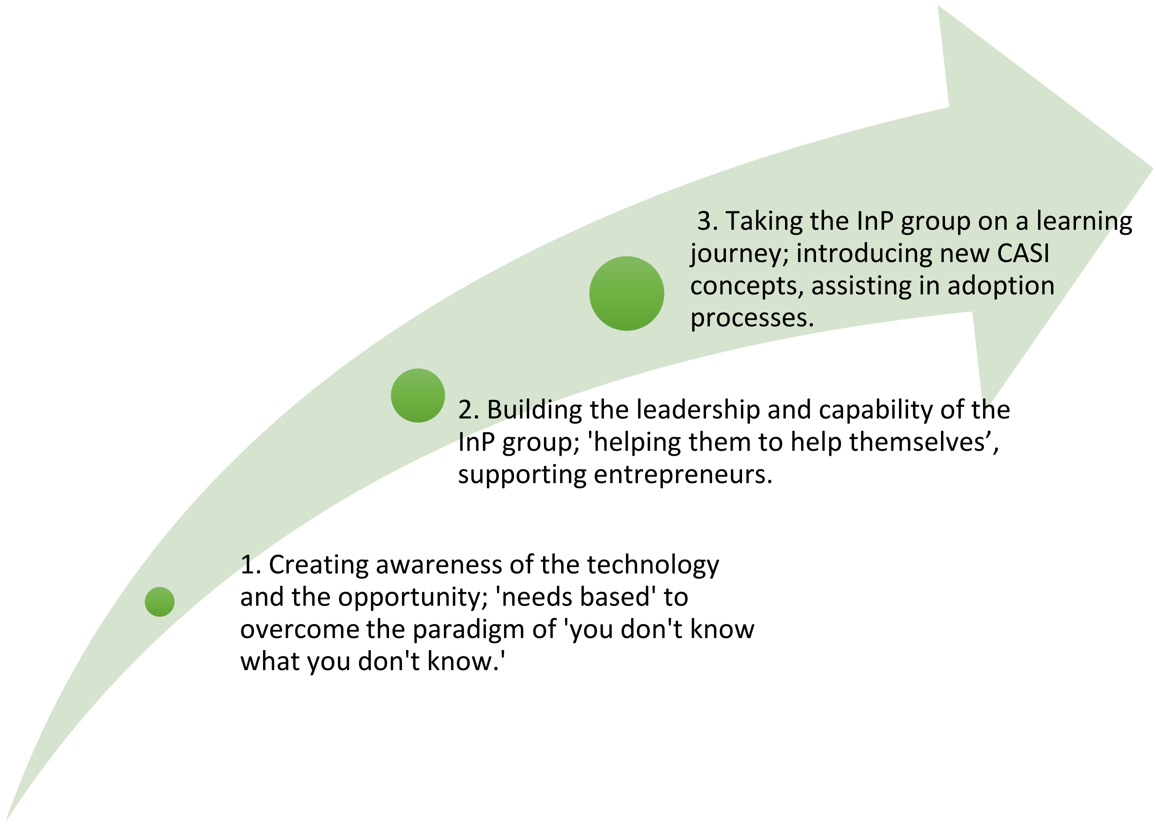


Figure 60: An overview of the 'pathway to success' for achieving successful adoption through establishing and building high performing InP-CHC.

7.7.3 Adopter and non-adopter characteristics

Table 23 provides a summary of observations from focus group discussions and elements from the survey data analysis relating to some of the distinguishing characteristics between both adopters and non-adopters of the HS and ZT technologies. This information can be used to help plan and design suitable interventions to help achieve accelerated adoption of CASI technologies such as the HS and ZT seed drills by understanding the main distinguishing characteristics between the two groups.

Table 23: Summary of observations from focus group discussions and elements from the survey data analysis

Characteristics	Adopters	Non-adopters
Group participation and engagement	Actively involved in local farmer groups and networks.	Limited engagement with farmer groups and networks.
Attitude to risk	Moderately risk averse; will trial new practices and technologies after they have obtained the required information. High level of understanding of the economic benefits to be obtained from adopting ZT/HS practices.	Highly risk-averse; reluctant to trial new practices and technologies as there is a high level of concern in relation to the threat of reduced crop yields when 'moving away' from traditional farming practices.
Crop diversity	Will grow a range of crop types linked to market opportunities. Cropping systems likely to be more intensive.	Likely to maintain a relatively simple cropping system with little crop diversity such as a rice-wheat rotation
Primary sources of information	Will have a diverse range of information sources and actively seek out information. Multiple sources including direct relationships with research and extension organisations, input suppliers, participation in farmer field days, other farmers, actively engaged in social media, printed and electronic media.	Will have limited information sources and not actively seek out information. Primary sources include other farmers, printed media, engagement in farmer field days and printed and electronic media.
Understanding and attitude to HS/ZT technologies	High awareness and positive outlook relating to HS/ZT technologies. Understanding of the benefits and the need to adopt CASI farming practices, acceptance of sowing crops into high residue stubble retained field conditions. Awareness of the savings from adoption in terms of labour, input costs.	Low level of awareness of HS/ZT technologies, limited exposure to such practices. Traditional perceptions towards the need to have a well-tilled soil and prepared seedbed free of stubble residues.
Size and scale of farming operations	NW India: larger land holdings, high level of tractor ownership (large HP) EGP: small to modest land holdings, low level of tractor ownership (low HP capacity), access to mechanisation through CHC, diverse range of crops produced.	NW India; small to medium sized landholdings, high level of tractor ownership (low HP) EGP: small landholdings, very low levels tractor ownership (low HP capacity), limited access to mechanisation through CHC, limited crop diversity, higher manual labour inputs.

Characteristics (continued)	**Adopters**	**Non-adopters**
Attitudinal responses (Bangladesh farmers)	Adopters more likely to be younger, positive attitudes to the environmental benefits of ZT and understanding of the negative impacts of stubble burning, greater awareness of the cost savings associated with ZT.	Non-adopters slightly higher level of education, had less positive attitudes towards environmental benefits of ZT.
Outlook on farming	Positive attitudes towards the future opportunities of their farming operations, tend to have a succession plan in place for the next generation of farmers in the family. Opportunities to increase crop yield a motivating influence on decision making to adopt new technologies.	Less positive outlook in relation to future opportunities in farming, little long term planning or vision. Less inclined to recognise any significant improvements or opportunities into the future.
Roger's Adoption framework • Relative Advantage • Compatibility • Complexity • Trialability • Observability	Greater awareness of the advantage (benefits). Willingness to integrate practices within existing farming system to ensure compatibility, (though recognised challenges). Comprehensive understanding of the complexity. Actively engaged in trials to adapt practices to suit local farming conditions (both trialability and observability a critical step in the adoption cycle).	A low level of awareness that a problem exists and such a technology is available translates to a limited understanding or appreciation of the relative advantage of the technology. Therefore, there is not a willingness to explore the compatibility or other steps involved in the adoption process.
Bennet's Hierarchy for adoption (KASAP) • Knowledge • Attitudes • Skills • Aspirations • Practice Change	High level of knowledge of the problem and the available technology. A positive attitude to addressing such an issue, highly skilled (or willingness to access and gain such skills). Positive future aspirations in relation to farming ambitions and future plans. Demonstrated practice change evolves after experiencing the technologies first-hand and being convinced that it works.	A low level of knowledge and awareness of the problem and technological solutions. Negative attitude towards the need for practice change, supported by risk-adverse attitudes. Lacking required skills and future aspirations, with no long-term plans or future outlook. Little likelihood of any practice change.

8 Conclusions and recommendations

There are a number of key issues, recommendations, lessons learned and follow-up actions identified during this project.

8.1 Conclusions

This study identified a range of opportunities for accelerating the adoption of CASI technologies such as HS and ZT seed drills. Whilst a number of these opportunities have been identified in the past, it appears that little action has been initiated by Governments 'on the ground'.

Many may dispute this, and point to financial support schemes such as subsidised machinery purchase programs as evidence of in situ action. However, while such programs may have increased access to CASI technologies there is no evidence to suggest that these schemes have been properly implemented or resulted in wide-scale technology adoption at the farmer level. Interestingly, we found that up to 20% of the adopters of HS/ZT technology had purchased their seed drill without seeking any specific subsidy support, due to a combination of both the difficulty in obtaining a subsidy in the first place and secondly the fact that the benefits alone associated with the technology provided sufficient motivation to purchase the drills.

The provision of subsidies for the purchase of machinery provided by government is in urgent need of review, from the perspective of ensuring that funds directed towards incentivising adoption is maximised in a non-discriminatory manner in an environment of increasing public scrutiny. It is also important to engage with, and involve the finance sector to provide farmers (through custom hire centres or CHC's) with improved access to finance for the purchase of machinery, which in turn should be based on sound commercially-driven custom hiring business models as opposed to a subsidy model for machinery provision.

Critically, as this study shows, a lack of awareness and availability of information relating to CASI technologies (such as the Happy Seeder) amongst farmers across all regions served as a significant barrier to adoption. As such, this study also highlighted the need to firstly create awareness of the HS/ZT seed drills, and secondly the need to change farmer perceptions (and acceptance) of CASI; notably misconceptions relating to the requirement to have a residue free, well tilled soil in order to successfully establish a crop.

However, the development of a CASI system is extremely complex given the transition towards retaining crop stubble residues, an increased reliance upon chemical weed control, and the introduction of cultivars of differing growing season duration as a means to improve overall crop production efficiencies and responses to climate variability. This will require a coordinated effort to address the complexities of these systems through information, training, and technology exposure. As a short- to medium-term policy recommendation, it will be especially important to focus on skill training with respect to zero-till machine calibration and working, effective crop establishment, and business operations. The recommendations provided in this study aim to provide guidance not only in the 'what', but also the 'how' to develop a strategy and implementation that will help to ensure successful adoption and long-term change.

While the collective ownership of a HS between two to three farmers was considered to be an option, many farmers are deterred from such ownership models due to the risk of conflict and arguments arising. In particular, it was considered that farmers in the joint ownership arrangement would all want to use the equipment at the same time, leading to conflict. In response, this report suggests that the development of CHC's at district level is one of the best ways to achieve widespread adoption and out-scaling of technologies that is affordable and accessible by all farmers regardless of farm size. However, as stated above proper functioning CHC’s also need to focus on providing convenient and affordable access to machinery for all farmers on the basis of sound training, information sharing, exposure to the technology, and ongoing assistance in the establishment of these services.

CHC’s provide the opportunity for smallholder farmers to access ZT and HS seeding services that are easily expandable to include other technologies that support the development of CASI farming systems, cost-effective cropping inputs, marketing platforms, training and capacity building services. Importantly, this can include smallholder farming women, and serve as the gateway to introducing sustainable and profitable conservation agriculture based systems to all farmers.

Yet is also critical to recognise that many farmers who wish to establish the CHC generally lack sound financial and business management skills to ensure that such CHC’s can be managed in a professional and profitable manner, and therefore concerted effort needs to be devoted to the training and upskilling of such operators. The study highlighted the importance of providing technically efficient custom hiring services to farmers in order to maximise the area of crop that can be sown using the HS within the short ‘sowing window’ available. Therefore, we advocate a sharing and dissemination of technical research and extension experiences, knowledge and resources as critical to addressing the regional challenges associated with ensuring widespread adoption of CASI, and active engagement and participation by all stakeholders—in particular the private sector, farming women and other marginalised stakeholders. These outcomes, we believe (as others before us have so clearly stated), will serve to accelerate the adoption of HS/ZT technology across the IGP.

These points are reflected in the key recommendations that stem from our evidence-based findings.

8.2 Recommendations

In view of the evidence delivered in this report, the project team offers the following key recommendations:

RECOMMENDATION 1: A communication/awareness strategy incorporating innovative digital media approaches that support the adoption of CASI technologies (focusing on ZT and HS) should be developed and implemented as a long-term opportunity to create positive motivation for on-farm adoption.

RECOMMENDATION 2: Expansion of the InP on-farm program from EGP regions to other targeted regions as an immediate priority to support the introduction and implementation of CASI related technologies (focusing on ZT and HS), facilitated through KVK’s and Farmer Producer Organisations (FPO’s).

RECOMMENDATION 3: Machinery manufacturers should be provided with financial incentives to assist them in providing a larger network of retail agents, service centres and farmer training schools (focusing on the maintenance and operation of equipment) in addition to introducing random market place quality checks for equipment to help support the adoption of ZT and HS seed drills.

RECOMMENDATION 4: Establish a collaborative platform with representatives from the highest level of Government, responsible ministries and the manufacturing sector to help ensure that long-term relationships and the needs of the industry sector are clearly identified and supported to help improve and support the development of effective ZT/HS seed drill supply chains.

RECOMMENDATION 5: A re-orientation of mechanisms that currently provide direct subsidies for machinery purchase be reviewed, and alternative models of support directed towards a range of options. This includes the removal of Government GST on machinery, providing access to affordable finance (consideration towards interest rate subsidies for both manufacturers and purchasers of equipment) in addition to developing business planning skills for custom hire centre operators.

RECOMMENDATION 6: It is strongly recommended that a specific project team and support service comprising state governments, universities and international experts be established to provide a range of support services for the establishment of CHC's, including business and financial planning and governance support, business leadership, technical training (conservation agriculture equipment and CASI systems approaches).

RECOMMENDATION 7: A Regional Collaborative Platform comprising representatives from the highest level of Government (Agricultural Ministry; research, extension and policy related) for the IGP region (comprising country representation from Pakistan, Nepal, India and Bangladesh) be established and maintained. This group provides a central platform for supporting the development of supporting government policy and the out scaling of CASI technologies through sharing and dissemination of information, knowledge and training resources, on-farm validation of best management CASI practices, training and capacity building.

8.3 Project Lessons

The project set and achieved an ambitious number of field studies, workshops and consultations within short time constraints. This was in recognition of the need to commence the project immediately, and undertake a number of field based studies that would in turn provide recommendations that could ideally be acted upon prior to the 2018 stubble burning season. A core value proposition from the study was that key policy recommendations arising from the study would be evidence-based and provide practical solutions in a relatively complex environment.

There were a number of constraints and issues experienced with managing and delivering the project activities, which had an impact on the timely delivery of project outcomes. Each of these are discussed below in some detail and it is hoped that through this level of practical experience and reflection there is the opportunity to improve future field research activities.

8.3.1 Timing

Generally across the project there were short 'lead in' times for each of the specific activities relating to the field survey data collection exercises and the large number of consultative workshops. Since many of the activities were 'back to back' there was often less than 3-4 weeks to organise and prepare for the next round of workshop activities. This at times placed undue pressure on the project team (and in-country partners). However, due to the strong relationships between all partners, all of the research and workshop activities went according to plan.

8.3.2 Credibility in the collection of field data

Prior to undertaking field data collection, some of the local project partners expressed credibility related concerns associated with the utilisation of some local partner resources for field data collection activities. The main concerns related to the importance of collecting unbiased and independent information by skilled enumerators having the required skills and experience.

As a result of these concerns, the project team opted to appoint an independent market research company to conduct the field surveys. Whilst this proved to be a more expensive option for the project, it was considered to be an important priority to ensure that the information collected was undertaken by credible providers. If, for example, more time was available to carry out the field work, then a process of greater vetting and validation of the credentials of partners may have been sought. Part of the benefits of any international project is to help in building the skills and capabilities of local project partners and if time and resources exist then a priority may be to provide intensive training and support so that such skills are left as a lasting legacy to the local partnering organisation.

Whilst in this project example much of the field data was collected by a contracted company, there were some disadvantages. For example, the privately-contracted field staff did not have a strong familiarity with local farming systems (knowing which villages to specifically target for adopters and non-adopters), in addition to lacking a strong technical understanding of CASI principles. This might not have been the case if locally based enumerators sourced from partners were utilised. An additional risk of utilising a market research company is the danger of the company being ‘time focused’ and cutting corners in terms of delving into greater detail a range of underlying issues in focus group discussion sessions. At times there was a degree of repetition in the summary of conversations and observations from the focus group discussions, which was of some concern in terms of maintaining integrity of data collected.

The short time lines associated between each of the activities also placed restrictions on the amount of ‘pre-testing’ and initial analysis and interrogation of the data. If more time was available for this process, then there may have been some additional reframing of survey questionnaires to help ensure that more meaningful and extractable information resulted.

Finally, budget constraints impacted on the number of farm households and stakeholders that could be surveyed/interviewed. This constraint was further compounded by the need to cover a wide geographical spread associated with the project. Sample sizes in each of the states/regions were relatively low, which limited the opportunity to perform analysis that was capable of identifying any statistically significant differences between groupings.

8.3.3 Consultation workshops

The research project included four series of consultation workshops, comprising the Project Inception workshops (3), Policy Briefing workshop (1), Regional ZT Summit workshops (3) and the Regional Collaborative Platform workshop. Every effort was made to ensure that there was a balanced representation of participants attending, and in particular the correct target audience were invited and attended such workshops. Overall these objectives were achieved, particularly with good local support provided by partners including Dr Raj Paroda (TAAS), Dr Randhir Singh (ICAR), RDRS team Rangpur, CIMMYT amongst others. In future though, we would seek to widen the participation to include additional representatives with other knowledge and inputs of value to the process.

8.3.4 Influencing the policy makers

There may have been the opportunity to attract a higher level of policy makers from government to attend the ZT Summit workshops. However, it was a challenge to ‘sell the merits of attending the workshops', since the final policy briefing papers were still in the draft stages. As a recommendation for future projects, where there is the need to obtain strong 'local buy-in' (or engagement) from policy makers, it is recommended that 'one to one' meetings be arranged between the project staff and local project partners (who have a direct relationship with the policy makers). This more personalised approach would help establish a much stronger personal relationship and provide the opportunity to introduce the project and the specific intentions/desired outcomes.

With regard to this project, there remains the opportunity to organise a series of such personal visits and consultations with senior government decision makers, and to formally present to them the Policy Briefing paper and key findings arising from this study.

8.3.5 Importance of networks

Critical to the success of being able to deliver the range of field research and workshop activities within a short time frame was the ability to have trusting relationships with local partners and to gain the confidence of other partners developed thought the course of the project. Regular communication, investing time in one to one meetings to establish credibility were all important elements employed during the course of the project.

8.4 Project Follow-up Actions

8.4.1 Progressing the Regional Collaborative Platform

The commitment to form a Regional Collaborative Platform (described as the Conservation Agriculture Sustainable Intensification Platform or CASI-P) as exhibited by NARS representatives attending the July 2018 workshop in Kathmandu is without doubt a positive outcome. There are, however, a number of steps that need to be undertaken by each of the NARS organisations represented at the workshop as pre-cursers to the CASI-P becoming operationalised.

As indicated in the signed agreement, each NARS has provided an undertaking to seek endorsement and commitment by their respective organisations to proceed with the formation of the CASI-P. Only when this has been completed can the required steps be taken to get the platform up and running.

Further to this, it is important that the terms of agreement and operation of the CASI-P be developed, agreed to, and then formally instigated. It is important that this process is facilitated by a suitably appointed person/organisation to serve in an 'Executive Officer' role. Whilst at the workshop there was a level of commitment expressed in fulfilling this role provided by representatives of CIMMYT South Asia Office (amongst other regionally based organisations), there needs to be an independent driving mechanism to get action happening.

An additional resolution at the workshop was the appointment of a Chair for the CASI-P; this being Dr Baidha Nath Mahato who currently serves as the Executive Director of the Nepal Agricultural Research Council. It was also considered that future follow up meetings would ideally be conducted in Nepal, given its central geographical proximity to member countries and the relative ease for all country representatives to gain entry to Nepal to attend any face to face meetings.

It is important not to lose the momentum that was generated from the workshop. Therefore it is recommended that an interim executive support officer-facilitator be appointed (ideally a person having previous experience in organising the RCP workshop such as a project team member from the University of Adelaide project team) to 'keep things moving along' until more formal support arrangements are put in place. ACIAR may wish to provide resources to assist in facilitating this important role.

Immediate priorities for action would be:

1. Provide follow up communication with all of the workshop attendees as a means of 'opening up the dialogue', to provide a summary of the workshop outcomes and a copy of the Kathmandu Resolution.
2. Communication with each of the NARS representatives (who signed off on the resolution), to specifically:
   - Follow up with the commitment from each of the respective organisation to endorse and 'sign off' on the agreement. Confirm specific timelines for sign-off, and commitment in terms of timing and resources for a follow up workshop
   - Identify each of the respective organisation's level of in-kind contributions (personnel, travel and accommodation and operating costs).
   - Prioritisation of specific steps and tasks to operationalise the CASI-P group.
   - Facilitated by the executive officer, develop the CASI-P Strategic Plan and Operational Framework (comprising the terms of reference, engagement and participation, operational activities, partner engagement strategy, and identification of collaborative project opportunities) over a 3 to 6 month period prior to a review workshop attended by NARS representatives of CASI-P to endorse the plans and officially launch the CASI-P.

8.4.2 Communication with local partners following the 2018 Stubble burning season

Given the proximity of the release of this final report to the 2018 stubble burning season it would be useful to communicate with our local in-country partners to gather their views on wat happened this year, whether the efforts of the project had any impact, and what might be useful going forward.

This information would be a valuable source of assessing the project's worth, but to also establish what action has been determined as necessary after the conclusion of this SRA, and if there is any increased appetite for change. The project team will undertake this communication in November of 2018.

8.4.3 Personal policy briefing meetings

As discussed above, it will be a focus of the project team to engage in personal meetings with as many policy-makers and government decision-makers as possible to promote the findings of this study—in particular the policy briefs. The process has already begun with ACIAR to distil the key messages to a useful format in order to utilise them in discussions at the conclusion to the 2018 stubble burning period. It is anticipated that, should things have not progressed with regard to the stubble burning issue, many policy-makers' appetites for change may have been improved. This will offer an opportunity for the project to capitalise on while members of the team are present in India during 2019.

9 References

9.1 References cited in report

Amemiya, T., 1981. Qualitative Response Models: A Survey. Journal of Economic Literature, 19, 1483–1536.

Bell, R., Haque, M., Johansen, C., Vance, W., Kabir, M., Musa, M., Mia, M., Neogi, M., Islam, M., 2017. Mechanised minimum soil disturbance establishment and yield of diverse crops in paddy fields using a two-wheel tractor-mounted planter suitable for smallholder cropping. Experimental Agriculture, 1-19.

Bhan, S., Behera, U.K., 2014. Conservation agriculture in India - Problems, prospects and policy issues. International Soil and Water Conservation Research 2, 1-12.

Cameron, A.C., Trivedi, P.A., 2009. Microeconomics using Stata. Stata Press Publishing, College Station, TX.

Conover, W.J., 1999. Practical Nonparametric Statistics, 3rd ed. Wiley, New York.

Cornell University, 2014. The System of Rice Intensification (SRI) is climate-smart rice production, in: College of Agriculture and Life Sciences, C.U. (Ed.). Cornell University, Ithaca, NY.

Coventry, D., Poswal, R.S., Yadav, A., Singh, A., Zhou, Y., Kumar, A., Chand, R., Chhokar, R.S., Sharma, R.K., Yadav, V., Gupta, R.K., Mehta, A., Cummins, J., 2015. A comparison of farming practices and wheat production in Haryana, India. Agricultural Systems, 137, 139-153.

Crean, J., Milham, N., Singh, R.P., 2013. Economic assessment of technologies aimed at reducing air pollution in rice-wheat farming systems in NW India, 57th AARES Annual Conference. AARES, Sydney, Australia.

Erenstein, O., 2010. Triangulating technology diffusion indicators: Zero tillage wheat in south Asia's irrigated plains. Experimental Agriculture 46, 293-308.

Ghimire, S., Dhungana, S.M., Krishna, V., Teufel, N., Sherchan, D.P., 2013. Biophysical and socioeconomic characterization of the cereal production systems of Central Nepal, Socioeconomic Working Paper CIMMYT, Mexico.

GRDC, 2012. Persuasion skills to drive technology adoption. C-Qual Agritelligence Pty Ltd., Carbarita, NSW.

Greene, W.H., 2008. Econometric Analysis, 6th ed. Pearson Education Inc, Upper Saddle River, NJ.

Gupta, R., 2012. Happy Seeder: an agricultural solution to air pollution in South Asia, in: Institute, I.S. (Ed.). South Asian Network for Development and Environmental Economics (SANDEE), Delhi, India, p. 4 pp.

Gupta, R., Somanathan, E., 2016. Happy Seeder: a solution to agricultural fires in north India, Ideas for India, New Delhi.

Hoel, P.G., 1984. Introduction to Mathematical Statistics, 5th ed. Wiley, New York.

Jones, D.A., Womack, J., 2002. Seeing the whole - Mapping the extended value stream. LEI, Brookline, MA.

Keil, A., D'souza, A., McDonald, A., 2015. Zero-tillage as a pathway for substitute wheat intensification in the Eastern Indo-Gangetic plains: does it work in farmer's fields? Food Security 7, 983–1001.

Keil, A., D'souza, A., McDonald, A., 2016. Growing the service economy for sustainable wheat intensification in the Eastern Indo-Gangetic plains: lessons from custom hiring services for zero-tillage. Food Security 8, 1011–1028.

Keil, A., D'souza, A., McDonald, A., 2017. Zero-tillage is a proven technology for sustainable wheat intensification in the Eastern Indo-Gangetic Plains: what determines farmer awareness and adoption? Food Security 9, 723-743.

Khan, M.T., Kishore, A., Joshi, P.K., 2016a. Gender dimensions on farmers' preferences for direct-seeded rice with drum seeder in India, IFPRI Discussion Paper 01550. IFPRI South Asia Office, New Delhi.

Khan, M.T., Kishore, A., Pandey, D., Joshi, P.K., 2016b. Using zero tillage to ameliorate yield losses from weather shocks: evidence from panel data in Haryana, India, IFPRI Discussion Paper 01562. IFPRI South Asia Office, New Delhi.

Knapp, S., van der Heijden, M., 2018. A global meta-analysis of yield stability in organic and conservation agriculture. Nature Communications 9, 3632.

Knowler, D., Bradshaw, B., 2007. Farmers' adoption of conservation agriculture: A review and synthesis of recent research. Food Policy 32, 25-48.

Krishna, V., Aravindakshan, S., Chowdhury, A., Rudra, B., 2012. Farmer access and differential impacts of zero tillage technology in the subsistence wheat farming systems of West Bengal, India, Socio-economics Working Paper series 7. CIMMYT, Mexico.

Lindner, R., 1987. Adoption and diffusion of technology: an overview, in: Champ, B., Highley, E., Remenyi, J. (Eds.), Technological change in postharvest handling and transportation of grains in humid tropics. ACAIR: Proceeding No.19, pp. 144-151.

McDonald, A.J., Hobbs, P.R., Riha, S.J., 2006. Does the system of rice intensification outperform conventional best management?: A synopsis of the empirical record. Field Crops Research 96, 31-36.

Milham, N., Kumar, P., Crean, J., Singh, R.P., 2014. Policy instruments to address air pollution in agriculture: Implications for Happy Seeder technology adoption in India. ACIAR, Canberra.

Mudge, B., Cummins, J., 2017. Operational costs of Happy Seeder: Impact of subsidy and area sown on operational costs and service provision profitability. The University of Adelaide, Adelaide, SA.

Mudge, B., Singh, R., Singh, Y., Labana, S., Cummins, J., 2011. Contracting and syndication options for the Happy Seeder in NW India. ACIAR, Canberra.

North, D., 1990. Institutions, institutional change, and economic performance. Cambridge University Press, Cambridge.

Pagan, P., Singh, R.P., 2006. Happy Seeder policy linkage scoping study: Final report. ACIAR, Canberra.

Pal, D.K., Bhattacharya, T., Srivastava, P., Chandran, P., Ray, S.K., 2009. Soils of the Indo Gangetic Plains: Their historical perspective and management. Current Science 96, 1193-1202.

Pandey, T., 2018. Identification of training and capacity building needs of stakeholders involved in the conservation agriculture machinery value chain. Pandey Consulting, New Delhi.

Pingali, P., 2010. Chapter 74 Agriculture Renaissance: Making "Agriculture for Development" Work in the 21st Century, Handbook of Agricultural Economics. Elsevier, pp. 3867-3894.

Porter, M., 1985 Competitive Advantage: Creating and Sustaining Superior Performance. Simon and Schuster, New York.

Rogers, E., 2003. Diffusion of innovations, 5th ed. The Free Press, New York.

Saunders, C., Davis, L., Pearce, D., 2012. Rice-wheat cropping systems in India and Australia, and development of the 'Happy Seeder', ACIAR Impact Assessment Series. ACIAR, Canberra.

Sidhu, H.S., Manpreet-Singh, Humphreys, E., Yadvinder-Singh, Balwinder-Singh, Dhillon, S., Blackwell, J., Bector, V., Malkeet-Singh, Sarbjeet-Singh, 2007. The Happy Seeder enables direct drilling of wheat into rice stubble. Australian Journal of Experimental Agriculture 47, 844-854.

Sidhu, H.S., Singh, M., Singh, Y., Blackwell, J., Lohan, S.K., Humphreys, E., Jat, M.L., Singh, V., Singh, S., 2015. Development and evaluation of the Turbo Happy Seeder for sowing wheat into heavy rice residues in NW India. Field Crops Research 184, 201-212.

Sims, B., Heney, J., 2017. Promoting smallholder adoption of conservation agriculture through mechanization services. Agriculture 7, 7080064.

Singh, A., Kaur, M., Kang, J.S., Geol, A., 2013. Happy Seeder and Rotavator technology for in-situ management of paddy straw. International Journal of Advanced Research 1, 372-379.

Singh, J., Grover, D.K., Dhaliwal, T., 2012. State Agricultural profile - Punjab, AERC Study No. 30. Agro-Economic Research Centre, Department of Economics and Sociology, Punjab Agricultural University, Ludhiana.

TAAS, ACIAR, CIMMYT, 2017. Scaling conservation agriculture for sustainable intensification in South Asia – A regional policy dialogue’. Trust for Advancement of Agricultural Sciences; Australian Centre for International Agricultural Research; and International Maize and Wheat Improvement Centre, Dhaka, Bangladesh.

Tallis, H., Polasky, S., Shyamsundar, P., Springer, N., Ahuja, V., Cummins, J., Datta, I., Dixon, J., Gerard, B., Ginn, W., Gupta, R., Jadhav, A., Jat, M.L., Keil, A., Krishnapriya, P., Ladha, J., Nandrajog, S., Skiba, N., Somanathan, E., 2017. The evergreen revolution: Six ways to empower India's no-burn agriculture future, Wicked EconFest. University of Minnesota; The Nature Conservancy; CIMMYT; and Borlag Institute for South Asia, St. Paul MN.

Taylor, D.H., 2005. Value chain analysis: an approach to supply chain improvement in agri-food chains. International Journal of Physical Distribution & Logistics Management 35, 744-761.

Tisdell, C., 1982. Microeconomics of markets. John Wiley & Sons, Gladesville.

Vermunt, J.K., Magidson, J., 2005. Latent GOLD 4.0 User's Guide. Statistical Innovations Inc., Belmont, MA.

World Bank, 2018. World Development Indicators. World Bank, Washington DC, USA.

Zhang, Z., McHugh, A.D., Li, H., Ma, S., Wang, Q., He, J., K., Z., 2017. Global overview of research and development of crop residue management machinery. Applied Engineering in Agriculture 33, 329-344.

9.2 List of publications produced by project

No publications have as yet been achieved, but at least one paper is currently being written for submission to a special issue of *The Journal of Agricultural Science*. This paper should be completed by early 2019.

Other research papers will follow as opportunities to write and publish them appear.

10 Appendixes

10.1 Appendix 1: Example VCA instrument

V 1 Farmers - VCA Questionnaire

1. Survey Details

1.a Survey Conducted by:	
1.b State:	
1.c Location:	
1.d Date:	
1.e Time:	

2. Farmer Details

2.a Farmer Name:				
2.b Address:				
2.c Phone:				
2.d Contact:				
2.e Gender M/F				
2.f Age Category	< 30 years	30-45 years	45-60 years	>60 years

3. Business Perception

3.1 Overall, how do you feel about the future of the HS/ZT manufacturing business in your state? (Haryana and Punjab)
(for EGP Hoe do you feel about the future of the HS/ZT retail agent) sector in your State)

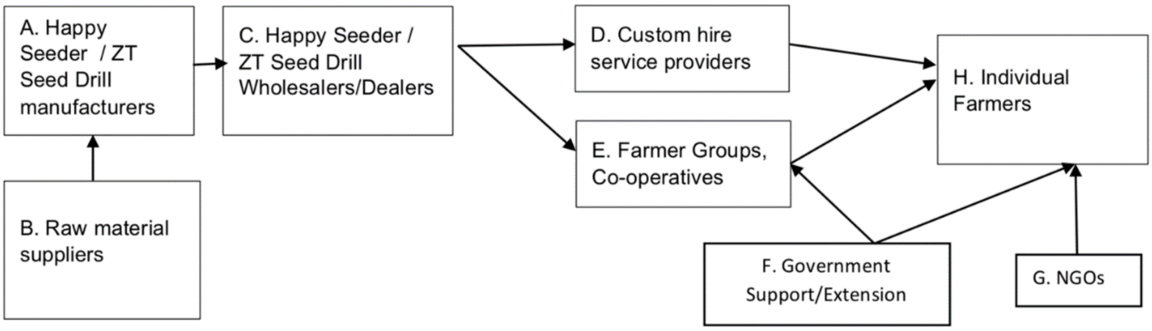
		Tick the box
1	Very positive	
2	Fairly positive	
3	Fairly negative	
4	Very negative	
5	Neutral	

6	Unsure	

3.2 Please explain the reasons you feel this way

4. Challenges and barriers to sector growth

Look at the Industry Value Chain Map provided, and answer the questions listed.



4.a Where is the value chain map incorrect (in terms of linkages and stakeholders)?
4.b How do you think the value chain map can be improved?
4.c Has the value chain map changed over the past 5 years (for example the types of stakeholders, the specific linkages and relationships?)
4.d Are there other stakeholders not listed in the value chain map that should be included in the study?

5. Challenges along the Value Chain

Please answer the following questions (both columns)

Challenges	How to address challenges
At each step of the value chain (listed below), in your opinion, what is the biggest challenge, affecting the manufacturing and availability of HS/ZT seed drills LIST CHALLENGE IN COLUMN BELOW	For each challenge provide ideas to help overcome them and who should be responsible for driving the change (e.g. government, industry, retailers, processors, farmers). HOW TO ADDRESS CHALLENGES – LIST BELOW
5.a Supply of raw materials	
5.b Manufacturing of the equipment	
5.c Distribution of equipment to dealers (if applicable)	
5.d Equipment made available through custom hire centres or contractors	
5.e Farmer groups/cooperatives providing equipment for use by farmers	
5.f Government technical support provided by research, extension	
5.g Technical support provided by NGO's	
5.h Use of the equipment at the farmer field level by farmers themselves	

6. Addressing Challenges

Use the table below to list issues that each of the specific stakeholders face in the value chain, in relation to their role in Happy Seeder and ZT seed drill activities. Record a maximum of three issues per stakeholder. Use the following list to prompt the respondent if needed:

- *Inputs*
- *Production*
- *Market and prices*
- *Transport*
- *Labour*
- *Communications channels*
- *Negotiations*
- *Policies*
- *Competing industries*

Value chain Stakeholder	Challenge / issue	Priorities and recommendations
6.a Machinery manufacturers	1.	
	2.	
	3.	
6.b Machinery dealers	1.	
	2.	
	3.	
6.c Farmer groups/Cooperatives	1.	
	2.	
	3.	
6.d Custom hire service providers	1.	
	2.	
	3.	
6.e Individual Farmers	1.	
	2.	
	3.	
6.f. Research and Extension personnel	1.	
	2.	
	3.	

6.g. Government policy and support	1.	
	2.	
	3.	

7. Communication and Adoption

Please respond to each of the following questions

Question	Response
7.a Do manufacturers ever communicate how the HS/ZT drills can help reduce input costs and increase profitability in growing crops? Yes/NO Do you ever discuss this with manufacturers?	YES/NO
7.b Are there any barriers stopping you from adopting the technology? YES/NO If YES, what are they? (Probe for - access to finance, labour, and logistics?)	YES/NO
7.c Are there any substitute technologies that you are using currently for managing stubble? YES/NO If yes, what are they?	YES/NO
7.d Are you aware of any existing policies (from local / national government) that might act as a barrier to efficient stubble management? YES/NO If YES provide details	YES/NO
7.e What kind/type of policies (from local/national government) do you think would support farmers to adopt conservation agriculture based technologies like the H/ZT seed drills?	

8. **Product Quality and Prices**

Question	Response
8.a Do you intend to purchase a ZT/HS seed drill in the future?	YES/NO
8.b If YES, why do you plan to purchase one?	
8.c If NO, why don't you plan to purchase one?	
8.d Do you receive any information about any dealers that are involved in the sale of the HS machines? YES/NO	YES/NO
8.e If YES describe how you hear about the information and the type of information (detail)	
8.f Are you aware of any Govt. policies that aim to support the adoption of HS machines in your state? YES/NO	YES/NO
8.g If YES, please describe them.	

9. HS/ZT Seed Drill Machinery Supplies and Relationship Dynamics
Please complete the following table with the requested information, starting with the most recent seed drills (Happy Seeder or ZT seed drill) that you have purchased. If you have only purchased one drill, only complete one example

EXAMPLE 1

Characteristics	Seed Drill Example 1	Seed Drill example 2
9.a Type of Drill and model		
9.b Manufacturer		
9.c Date of purchase		
9.d Specifications (capacity)		
9.e Price		
9.f Trading terms (payment)		
9.g Finance Source		

9.h Amount of Subsidy (if applicable)		
9.i The quality of the machine 1 = extremely poor quality 10 = extremely high quality		

EXAMPLE 2

Characteristics	Seed Drill Example 3	Seed Drill example 4
9.a Type of Drill and model		
9.b Manufacturer		
9.c Date of purchase		
9.d Specifications (capacity)		
9.e Price		
9.f Trading terms (payment)		
9.g Finance Source		
9.h Amount of Subsidy (if applicable)		
9.i The quality of the machine 1 = extremely poor quality 10 = extremely high quality		

10. Relationships with suppliers/manufacturers

10.a How many ZT/HS drills did you buy last year (2017)?	
10.b Have your suppliers of HS/ZT seed drills changed in the last 5 years? 10.c If YES what are main reasons for the changes?	YES/NO
10.d On a scale of 1 to 10, where 1 is very informal and 10 is very formal how would you rate your own personal relationship with manufacturers of HS/ZT technology machinery? 10.e Does this vary between suppliers/manufacturers (please explain your answer)	

10.f How is the price you pay your suppliers determined?	
10.g When do you pay the manufacturer /retailer for your HS/ZT seed drill? A. Before delivery (number of days before delivery) B. Payment upon delivery C. After delivery (number of days following delivery)	
10.e Who has the negotiating power in setting the price?	
10.f Are there any specific product specification that you require you suppliers to meet (please describe)?	

11. Relationships between stakeholders

Please rate the relationships that exist between farmers using the HS/ZT and the following stakeholders:

On a scale of 1 to 10, where 1 is very informal and 10 is very formal

Stakeholder	Relationship rating (1 to 10) 1 = very informal and 10 = very formal	Why did you give this rating?
11.a Machinery dealer / retailer of the HS/ZT seed drill		
11.b Government authorities		
11.c Agricultural Extension Services		
11.d Researchers (University and NARS) involved in Conservation Agriculture and/or HS/ZT seed drills		

12. Capital investments

Question	Response
12.a Did you make any on business capital investments in the last 12 months (machinery, facilities, land, etc.)? What were they?	
12.b Are you planning any business capital investments in the next 12 months? What will they be?	

10.2 Appendix 2: Survey instrument

Australian Government

Australian Centre for
International Agricultural Research

অস্ট্রলেয়িার সরকার
আন্তর্জাতকি কৃষি গবয়েণার জন্য অস্ট্রলেীয় কন্দ্র

THE UNIVERSITY of ADELAIDE

THE CENTRE FOR GLOBAL
FOOD AND RESOURCES

এডলিডে বশি্ববদি্যালয়
বশি্ব খাদ্য ও সম্পদ কন্দ্র

Value chain and policy interventions to accelerate adoption of Happy Seeder zero tillage in rice-wheat farming systems across the Gangetic Plains

মূল্য শৃঙ্খল এবং নীতরি হস্তক্ষপেরে মাধ্যমগোঙ্গয়ে সমভূমি জুড়ে ধান-গম চাষ ব্যবস্থায়খুশি বীজবকি্রতোশূন্যকৃষকিার্য ত্বরান্বতি করার জন্যদেত্তক গ্রহণ

Adoption Survey Questionnaire

দত্তক গ্রহণরে জরপিপ্রশ্নাবলী

1. Primary Details প্রাথমকিববিরণ

Name of enumerator গণনাকারীর নাম	
Village IDগ্রামরেপরচিয়	
Household IDপরবিাররে পরচিয়	
Start time of survey (Check Here) সার্ভে শুরু করার সময় (এখানে চকে করুন)	
GPS Coordinates জপিএিস এর সমন্বয়	

2. Household (HH) Member Roster

Enumerator: The following table asks about the persons who live in the same household with the respondent. Explain that a household consists of all people who live under the same roof, eat from the same pot and share resources.

2. পরবিাররে (এইচএইচ) সদস্যদরেপর্যায়

পরসিংখ্যানকরী: নমি্নোক্ত সারণী সহে ব্যক্তদিরে সম্পর্কে জজি্ঞাসা কর যারা উত্তরদাতার সাথে একই পরবিারে বাস কর। ব্যাখ্যা করুন যে, একটি পরবিারসহেসমস্ত মানুষদরেনয়িে গঠতি যারাএকই ছাদরে নচিে বাস কর, একই সাথখোয়এবং একই সম্পদ ভাগ কর ব্যবহার কর।

Enumerator: A person is not considered if he/she spent more than 3 months away in the past 12 months.

গণনাকারী : একজন ব্যক্তি যদি 12 মাসরে মধ্যে 3 মাসরে বশেি সময় বাড়রি বাইরব্যেয় করছেনে তবে তাকে ববিচেনা করা হয় না ।

Enumerator: Ask first about the household head (who should be the respondent). Next add the spouse, the children in order of their age and then the other HH members.

পরসিংখ্যানকারী : প্রথমে পরবিাররে প্রধান (যনিি উত্তর দাতা) সম্পর্কে জজি্ঞাসা করুন। পরে স্বামী বা স্ত্রী , তারপরে বয়স অনুযায়ী তাদরে সন্তানদরে এবং তারপর অন্যান্য এইচএইচ সদস্য যোগ করুন।

HH ID এইচ এইচ পরচিয়	Name নাম	Interviewee সাক্ষাত্কারী	Member Info সদস্যদরে তথ্য			Main occupation of the past 12 months if >6 years old যদি ছয় বছররে বশেি বয়স হয় তবে গত 12 মাসরে প্রধান পশো (সবার জন্যে কোড 3)			Farming experience কৃষকিাজরে অভজ্ঞিতা		HH member's ability to read and write Hindi/Bengali and/or English. হনি্দি / বাংলা এবং / অথবা ইংরজেি পড়তে ও লখিতে এইচএইচ সদস্যরে দক্ষতা হ্যাঁ=1, না=0				Education (Code 4) শকি্ষা (কোড 4)	Children শশিুরা		
		হ্যাঁ=1, না=0	লঙি্গ, 1 = পুরুষ, 2 = মহলিা	আয়ু	ববৈাহকি অবস্থা (কোড 2)	প্রধান পশো	গৌণ পশো	তৃতীয় পশো	কৃষি কাজে কত বছররে অভজি্ঞতা যদি কৃষকিাজ প্রাথমকি বা মাধ্যমকি পশোয় অন্তর্ভুক্ত হয়	অবশষে কপিরবিাররে সদস্যদরে খামাররে দায়দায়ত্বি গ্রহণ করতো শা করা হয়	হনি্দি/বাংলা (ইজর্পি) পড়তে পারে	হনি্দি/বাংলা (ইজর্পি) লখিতে পারে	ইংরজেি পড়তে পারে	ইংরজেি লখিতে পারে	সর্বোচ্চ শ্রণেী পাস (যদি সদস্য 15 বছররে চয়ে বয়স বশেি হয়)	মোটশিশুদরে সংখ্যা	মোট 18 বছর বয়সী প্রাপ্তবয়স্কশশিুদরে সংখ্যা	6 বছররে কম বয়সী শশিুদরে মোট সংখ্যা
1	পরবিাররে প্রধান																	
2	স্বামী বা স্ত্রী																	

Code 2 Marital Statusকোড 2বৈবাহিক অবস্থা	Code 3 Occupation কোড 3	Code 4 Educationকোড 4 শিক্ষা
1 Married, with one spouseবিবাহিত, একটিস্বামী বা স্ত্রীরসঙ্গে	0 = None 0=কিছু না	0 = did not go to school at all 0= কখনই বিদ্যালয়ে যায়নি
2 singleএকক	1 = Self-employed farmer 1= স্ব-নিযুক্ত কৃষক	1 = studied till in between 1st grade and 5th grade 1= প্রথম শ্রেণী থেকে পঞ্চম শ্রেণীর মধ্যে পর্যন্ত শিক্ষা প্রাপ্ত করেছে
3 Divorcedডিভোর্স	2 = House wife2=গৃহবধূ	2 = studied till in between 6th grade and 10th grade 2= ষষ্ঠ শ্রেণী থেকে দশম শ্রেণী মধ্যে পর্যন্ত শিক্ষা প্রাপ্ত করেছে
4 Widowed বিধবা	3 = Domestic worker3= গৃহ কর্মী	3 = studied till 10th grade (Matric pass)3= দশম শ্রেণী পর্যন্ত শিক্ষা প্রাপ্ত করেছে
5 Separated but not divorcedবিচ্ছিন্ন কিন্তু ডিভোর্স প্রাপ্ত নয়	4 = Ag wage labourer4=কৃষি মজুরি শ্রমিক	4 = Studied till 12th grade 4=দ্বাদশ শ্রেণী পর্যন্ত শিক্ষা প্রাপ্ত করেছে
	5 = Non Ag wage labourer (unskilled)5=অকৃষিমজুরি শ্রমিক (অদক্ষ)	5 = Incomplete Bachelor's degree5=অসম্পূর্ণ ব্যাচেলর ডিগ্রি
	6 = Tailor6=দর্জি	6 = Completed Bachelor's degree6=ব্যাচেলর ডিগ্রিসম্পন্ন
	7 = Crafts/potter7 = কারুশিল্প / কুমার	7 = Incomplete Master's degree7 = অসম্পূর্ণ মাস্টার ডিগ্রি
	8 = Weaver 8. তাঁতি	8 = Complete Master's degree8 = মাস্টার ডিগ্রিসম্পন্ন
	9 = Blacksmith 9.কামার	9 = Adult literacy program9 = প্রাপ্তবয়স্কসাক্ষরতাকার্যক্রম
	10 = Food seller/shop owner10 = খাদ্য বিক্রেতা / দোকানের মালিক	10 = Other literacy program 10= অন্য সাক্ষরতাকার্যক্রম
	11 = Driver/mechanic11 = ড্রাইভার / মেকানিক	11 = Church/Mosque schooling11 = চার্চ / মসজিদে পড়াশোনা
	12 = Salaried worker 12.= বেতনভোগী শ্রমিক	12 = Other (please specify) 12=অন্য (উল্লেখ করুন)
	13 = Teacher 13. শিক্ষক	
	14 = Health worker 14. স্বাস্থ্যকর্মী	
	15 = Government employee15 = সরকারী কর্মচারী	
	16 = Soldier 16. সৈনিক	
	17 = Trader 17. ব্যবসায়ী	
	18 = Disabled 18.অক্ষম	
	19 = Student 19. ছাত্র	
	20 = Herding 20.পশুর পাল চালক	
	21 = Dairy21.দুধ ও ঘি বিক্রয়ের স্থান	
	22 = Poultry22. হাঁস মুরগি ইত্যাদি গৃহ পালিত পাখি	
	23= Not working because of old age23.বার্ধক্যের কারণে কাজ না করা	
	24 = Other (please specify24. অন্যান্য (দয়া করে নির্দিষ্ট করুন)	

3. Land Endowment ৩ . ভূমরি বৃত্তদিান

Enumerator: Ask about the respondent's land holdings
পরসিংখ্যানকারী : উত্তরদাতার জমি অধগ্রিহণ সম্পর্কে জজ্ঞিাসা করুন

3.1 Which unit do you use to measure land area? 3.1 আপনি জমরি পরমিাপ করার জন্যে কোন ইউনটিটি ব্যবহার করনে?	

Code 3.1 কোড 3.1
1= Acre 1 = একর
2= Ha 2 = হা
3= Katha 3 = কাঠা
4 = Bigha4 = বঘিা
99 = Other (specify)
99 = অন্যান্য (নর্দিষ্টি করুন)

Enumerator: Make sure the land area is given in (land units given)
গণনাকারী: নশ্চিতি করুন যে জমরি পরমিাপ উক্ত জমরি ইউনটিে দেওয়া হয়ছে।

3.2. How much land do you grow crops on in total (owned + shared in + rented in land)? (in respondent's stated land unit) ৩.২. কত জমতিে আপনি মোট ফসল উত্পন্ন করনে (মালকিানাধীন + ভাগরে জমি + ভাড়া জমি) ? (উত্তরদাতার বর্ণিত জমরি ইউনটিে)	

3.3 How many plots do you grow crops on in total (owned + shared in + rented in land)? 3.3 কতগুলি প্লটে আপনি মোট ফসল উতপাদন করনে (মালকিানাধীন + ভাগরেজমি + ভাড়া জমি) ?	

3.2.Do you have any plans for the farm in future (e.g. expansion, development of soil levels, better irrigation etc.) 3.2.আপনি ভবিষ্যতে খামাররে জন্য কোন পরকিল্পনা আছে (যমেন সম্প্রসারণ, মাটরি স্তর উন্নয়ন, ভাল সচে ইত্যাদি)	

4. Income Sources 4.আয়রে উ□স

4.1 Please indicate all your family's income from the following activities in 20174.1 2017 সালে নিম্নলিখিত কার্যক্রমগুলি থেকে আপনার সমস্ত পরিবারের আয়তানুগ্রহ করে নির্দেশ করুন

Income activities আয়রে ক্রিয়াকলাপ	How much Gross revenue did your household get from this activity? আপনার পরিবার এই কার্যকলাপ থেকে কত মোট আয় পেয়েছিলি?	How much Total cost did your household spend on this activity? আপনার পরিবার এই কার্যকলাপগুলির জন্যে মোট কত খরচ করেছে?	How much profit did your household get from this activity?আপনার পরিবার এই কার্যকলাপগুলির জন্যে মোট কত লাভ পেয়েছে?	How has the importance of this activity changed over last 3 years (2013-2016)? গত 3 বছরে (2013-2016) এই কার্যকলাপরে গুরুত্ব কীভাবে পরিবর্তন হয়েছে?
	1	2	(3) = (1) - (2)	
	INR/year ভারতীয় টাকা/বছর	INR/year ভারতীয় টাকা/বছর	INR/year ভারতীয় টাকা/বছর	1.Increasedবেড়েছে 2.Unchangedঅপরিবর্তিত রয়েছে 3.Decreasedকমেছে
Rice productionচালের উত্পাদন				
Wheat productionগম উ□পাদন				
Mustardসরিষা				
Maizeভুট্টা				
Cottonকার্পাস				
Sugar caneআখ				
Vegetable productionসবজি উ□পাদন				
Animal fodderপশুর খাদ্য				
Jute (for EGP)পাট (ইজিপি জন্য)				
Other crops (specify)অন্যান্য ফসল (উল্লেখ করুন)				
Livestock and animal product salesপ্রাণী এবং পশু পণ্য বিক্রয়				
Off-farm wagesখামারব্যতিত মজুরি				
Pensionপেনশন				
Other :অন্য (অনুগ্রহ করে নিম্নে উল্লেখ করুন)				

4.2 Over the last 12 months what has been the **main** source of capital (finance) for your farming business? Please use the codes below 4.2 গত 12মাসে আপনার কৃষি ব্যবসায়ের মূলধনের (অর্থ) প্রধান উ□স কী? নীচের কোড ব্যবহার করুন	
	Codes for 4.2 4.2 এর জন্যে কোড
	1=private (own/savings) 1 = ব্যক্তিগত (নিজস্ব/সঞ্চয়)
	2=familymember/relative2=পরিবারের সদস্য / আত্মীয়
	3=cash loan (money lender)3 = নগদ ঋণ (ঋণদাতা)
	4=community/village savings group4 = সম্প্রদায় / গ্রাম সঞ্চয়গোষ্ঠী
	5=government aid/subsidy5 = সরকারি সাহায্য / অনুদান
	6=cooperative input credit6 = সমবায় ইনপুট ক্রেডিট
	7 = state owned bank7 = রাষ্ট্রীয় মালিকানাধীন ব্যাংক
	8 = other8. অন্য

5. Willingness to Accept Change

5. পরিবর্তন স্বীকার করতে ইচ্ছুক

Farmers' Willingness to adopt HS/ZT practice based on penalties imposed?
জরিমানা ধার্যের উপর ভিত্তি করে এইচএস / জেডটি অনুশীলনগ্রহণ করার জন্য কৃষকদের সম্মতি?

Detailed description of the HS/ZT practice, including advantages/disadvantages and associated externalities.
সুবিধার / অসুবিধা এবং সংশ্লিষ্ট বাহ্যিকতা সহএইচএস / জেডটির অনুশীলনের বিস্তারিত বিবরণ।

Detailed description of the penalties in place to stop stubble burning, where is it from, how is it paid, whether it is effective etc.

ফসলের অবশিষ্টাংশ জালানো বন্ধ করার জন্যজেরিমানা বিস্তারিত বিবরণ, এটি কোথা থেকে এসেছে, এটি কিভাবে কার্যকর হয়, এটিকার্যকরী কিনা ইত্যাদি।

Thus what is the minimum penalty (rupee/unit of land) applied by the government would make you adopt this practice for your Rabi crop (Kharif crop residual left on field)?এইভাবে সরকার দ্বারা প্রয়োগ করা ন্যূনতম জরিমানা (টাকা/ভূমির ইউনিট) আপনার রাবি ফসলের (জমিতে খরিফ ফসলেরপরে থাকাঅবশিষ্টাংশ) জন্য এই অনুশীলন গ্রহণ করাবে?

*Cheap talk script (Aadland and Caplan 2006, Do and Bennett 2007)*সস্তা আলাপ লিপি (আডল্যান্ড এবং ক্যাপলান 2006, ডো এবং বেনেট 2007)

As you prepare to answer the next few questions, please keep in mind the following three things.পরবর্তী কয়েকটি প্রশ্নের উত্তর দেওয়ার জন্য প্রস্তুত হওয়ার আগে, অনুগ্রহ করে নিম্নলিখিত তিনটি জিনিসগুলি মনে রাখবেন। ***First, keep in mind your household budget.***প্রথমত, আপনার পরিবারের বাজেটের কথা মনে রাখবেন। ***How much would your household be able to afford if you had to incur the penalties for stubble burning?***যদি আপনাকে ফসলেরপরে থাকাঅবশিষ্টাংশজালানোরজন্যে জরিমানাদিতে আপনার পরিবার কতটা সামর্থ্যবান? ***Second, keep in mind that there are other adaptation measures for zero-tillage and conservation agriculture practices which we have not outlined above.***দ্বিতীয়ত, মনে রাখবেন যে শূন্য কৃষিকার্য এবং কৃষি সংরক্ষণ অনুশীলনের জন্য অন্যান্য অভিযোজন ব্যবস্থা রয়েছে যা আমরা উপরে উল্লেখকরিনি। ***Third, keep in mind that previous studies have found that the options people say they prefer are sometimes different from the options that they would actually select when the penalties come into effect and a real payment is required to be made.***তৃতীয়ত, মনে রাখবেন যে পূর্ববর্তী গবেষণায় দেখা গেছে যখন শাস্তি কার্যকর হয় এবং প্রকৃত অর্থ প্রদান করার প্রয়োজন হয় তখনযে বিকল্পগুলি মানুষ পছন্দ করে সেগুলি নির্বাচিত বিকল্পগুলির থেকে আলাদা হয় । ***For these reasons, when choosing your options please imagine that your household will actually have to pay the penalty that you choose.***এই কারণগুলির জন্য, বিকল্পগুলি নির্বাচন করার সময় আপনাককেল্পনাকরতে হবে যে আপনার পরিবারকেই আপনার পছন্দমত শাস্তি/জরিমানা প্রদান করতে হবে।

5.1 What is your family total income per annum in Indian Rupees?
5.1 ভারতীয় টাকায় প্রতি বছর আপনার পরিবারের মোট আয় কত?

5.2 Would you be willing to pay for a legislated fund which requires every farming household to contribute certain INRg/month ? Remember that this contribution reduces the amount of money you could spend on other goods and services.

1 = Yes, skip to 5.4

0 = No, proceed to 5.3

DK = Don't Know, give reasons?

5.2 আপনি কি একটি নির্দিষ্ট তহবিলের জন্য অর্থ প্রদান করতে ইচ্ছুক হবেন যার জন্য প্রতিটি কৃষক পরিবার কে নির্দিষ্ট টাকা / মাসে অবদান দিতে হবে? মনে রাখবেন যে এই অবদান আপনার অন্যান্য পণ্য এবং সেবায় ব্যয়ের অর্থের পরিমাণ হ্রাস করতে পারে।
1 = হ্যাঁ, 5.4 এড়িয়ে যান
0 = না, 5.3 তে এগিয়ে যান
ডিকে = জানেন না, কারণ বলুন?

5.3 Why would not you vote for these penalties? (Code 5.3) 5.3 আপনি এই জরিমানার জন্যে কেন ভোট দেবেন না? (কোড 5.3)		**Code 5.3** কোড 5.3
		1 = I cannot afford that amount1= আমার ঐ পরিমাণ অর্থ বহন করার সমর্থ নেই।
		2= I do not think that stubble burning is wrong/hurts anyone 2= আমি মনে করি না যে ফসলের উপরে থাকা অবশিষ্টাংশ জালানো ভুল / কারো ক্ষতি করছে।
		3 = I do not think that amount I would pay will make any difference in reality3= আমি মনে করি না যে অর্থ আমি প্রদান করব তাতে বাস্তবে কোনো পার্থক্য হবে.
		4 = I think this is the full responsibility of the government4 = আমি মনে করি এটি সম্পূর্ণ দায়িত্ব সরকারের
		5 = I think other adaptation measures are more efficient than this program5 = আমি মনে করি অন্যান্য অভিযোজন ব্যবস্থা এই প্রোগ্রাম তুলনায় অধিক কার্যকরী
		6 = I can live with this problem by adopting other options 6 = অন্যান্য বিকল্পগুলি গ্রহণ করে আমি এই সমস্যার সাথে বাঁচতে পারি
		7 = Others, please specify7 . অন্য (উল্লেখ করুন)

5.4 What is the highest amount you could pay as a penalty, instead of spending on other goods or services?
5.4 অন্য জিনিস বা পরিষেবাগুলিতে ব্যয় করার পরিবর্তে জরিমানা হিসাবে আপনি কত সর্বোচ্চ অর্থদণ্ড দিতে পারেন?

5.5 Do you believe that your votes here will be taken into account by the government?
5.5 আপনি কি বিশ্বাস করেন যে আপনার ভোট সরকার কর্তৃক গ্রহণ করা হবে?
(1 = Yes, 0 = No, DK = Don't Know)
(1 = হ্যাঁ, 0 = না, ডি কে = জানেন না)

5.6 Do you think your neighbor would be willing to pay these penalties?
5.6 আপনি কি মনে করেন আপনার প্রতিবেশী এই জরিমানা দিতে ইচ্ছুক হবে?
1 = Yes, procced to 5.7
0 = No, skip to 5.8
DK = Don't Know, give reasons?
1 = হ্যাঁ, 5.7 এ এগিয়ে যান
0 = না,5.8 এড়িয়ে যান
ডি কে = জানেন না, কারণ দিন?

5.7 How much do you think your neighbor's household would be willing to pay in penalties?5.7 আপনি কি মনে করেন আপনার প্রতিবেশীর পরিবার কত জরিমানা দিতে ইচ্ছুক হবে?

5.8 Would your neighbors think you are willing to vote for these penalties?
5.8 আপনার প্রতিবেশীদের মনে হয় যে আপনি এই জরিমানা জন্য ভোট দিতে ইচ্ছুক?

6. Credit Sources 6 . ক্রেডিটেরউ□স

6.1 What percentage of the total input costs to sow your crops in any one season are financed by a loan (borrowings)? 6.1 কোনো এক ঋতুতে আপনার ফসলের বীজ বপন করার জন্যমোট ইনপুট খরচেরকত শতাংশ ঋণ (ঋণ) দ্বারা অর্থায়ন করা হয়?	
6.2 If you accessed a loan at any time to finance your farm, were you successful (Yes, No) যদি আপনিআপনার জমি জন্যে কখনও ঋণ নিয়ে থাকেন, আপনি কি সফল হয়েছিলেন? (হ্যাঁ, না)	
6.3 If successful, what was the source of that loan? (Use the codes below)6.3 সফল হয়ে থাকলে, সেই ঋণের উ□স কি ছিল? (নীচের কোডগুলি ব্যবহার করুন)	
6.4 If successful, what was the source of that loan? **(Code 6.4)** 6.4 সফল হয়ে থাকলে, সেই ঋণের উ□স কি ছিল? (কোড 6.4)	
1=private commercial bank;1=বেসরকারী বাণিজ্যিক ব্যাংক;	8=NGO8 = এনজিও
2= cooperative 2=সমবায়	9=employer9 = নিয়োগকর্তা
3=farmer's groupকৃষকেরগোষ্ঠী	10=landlordবাড়িওয়ালা
4=government agency/bankসরকারি সংস্থা / ব্যাংক	11=leasingভাড়া দেওয়া
5=input supplierইনপুট সরবরাহকারী	12 = buyerক্রেতা
6=family member পরিবারেরসদস্য	13= other অন্য
7=money lenderমহাজন	
6.5 How much was the loan? (in INR)ঋণের পরিমান কত ছিল (টাকা তে)	
6.6 How long was the payment period? (in months) অর্থ প্রদানের সময়কাল কত ছিল? (মাসে)	
6.7 How much was the monthly payment? (in INR)মাসিক পেমেন্ট কত ছিল? (টাকা তে)	
6.8 What was the interest rate of the loan? (in % per month)ঋণের সুদের হার কি ছিল? (% প্রতি মাসে)	
6.9 What was the main purpose of the loan/credit ?ঋণ/ধারের মুল উদ্দেশ্য কি ছিল?	

ID আইডি	**Potential Lending Institution** সম্ভাব্য ঋণদানের প্রতিষ্ঠান	**6.10 On a scale very difficult to very easy please rank the listed sources with regards to accessibility and ease for you to receive credit for farm production.** 6.10 সকলে খুব কঠিন থেকে খুব সহজ অ্যাক্সেসযোগ্যতা এবং স্বচ্ছন্দতার সম্পর্কে তালিকাভুক্ত সূত্রগুলিকে অনুগ্রহ করে মর্যাদাক্রমে সাজান যাতে আপনার খামার উত্পাদনের জন্য ক্রেডিট পেতে সহজ হবে।
		0 = very difficult

		0= অনেকে কঠিন 1 = somewhat difficult 1=একটু কঠিন 2 = neutral 2=নিরপেক্ষ 3 = easy 3= সহজ 4 = very easy 4= খুব সহজ
1	Public sector banksপাবলিক সেক্টর ব্যাংক	
2	Cooperative banks সমবায় ব্যাংক	
3	Primary Agricultural Cooperative Society (PACS) প্রাথমিক কৃষি সমবায় সমিতি (পিএসিএস)	
4	Private banks বেসরকারী ব্যাংক	
5	Self-help groups স্বনির্ভর গোষ্ঠীগুলি	
6	NGOs/International organisations এনজিও / আন্তর্জাতিক সংস্থা	
7	Informal credit groupইনফরমাল ক্রেডিটগোষ্ঠী	
8	Friends/relatives বন্ধুরা / আত্মীয়	
9	Moneylenders মহাজন	
10	Other sources (please specify)অন্য সূত্র (অনুগ্রহ করে উল্লেখ করুন)	

7. Plot Level Farm Information
প্লট স্তরে কৃষি তথ্য

ENUMERATOR: Collect this information for the largest plot of productionগণনাকারী : উ□পাদনের বৃহত্তম প্লটের জন্যে এই তথ্য সংগ্রহ করুন									
Plot ID প্লট আইডি	7.1 Plot Area Size প্লটের এলাকার আকার	Unit ইউনিট	7.2 Tenure status মেয়াদের স্থিতি	7.3 Distance from Homesteadভিটা থেকে দূরত্ব	7.5 Soil typeমৃত্তিকারধরণ	7.6 Is irrigation available? সেচের সুবিধা আছে ?	7.7 If Yes, what is the irrigation source?যদি হ্যাঁ, সেচ উ□স কি?	7.8 Reliability of irrigation water supply সেচের জল সরবরাহের নির্ভরযোগ্যতা	7.9 Reliability of electricity for irrigation সেচের বিদ্যু□ সরবরাহের নির্ভরযোগ্যতা
			(1 = owned,মালিকানাধীন, 2 = shared,ভাগ, 3 = rented,ভাড়া, 4 = cultivatingচাষ করা)	Unit - (1 = KM, 2 = walking minutes)ইউনিট – (1 = কিমি, 2 = হাঁটা মিনিট)	(1 = sandy, 2 = sandy loam, 3 = loam, 4 = clay)(1 = বালু মাটি, 2 = বালু দোআঁশ মাটি, 3 = দোআঁশ মাটি, 4 = কাদামাটি)	(1 = yes, 0 = No)(1 = হ্যাঁ, 0 = না)	(Code1) (কোড1)	(code 2) (কোড 2)	(code 3) (কোড3)

7.10 Do you lease any of your land out to other farmers? (Yes =1, No =0)আপনি কি আপনার জমি অন্য কৃষকদের কাছে ভাড়া দেন? (হ্যাঁ = 1, না = 0)	
7.11 If yes, how much of your land do you lease out to other farmer(s)? Make sure land units are given in the farmer's specified area unitsযদি হ্যাঁ, তাহলে আপনি আপনার জমির কতখানি অন্য কৃষকদেরভাড়া দেন? নিশ্চিত করুনযে কৃষকের নির্দিষ্ট এলাকার ইউনিটে জমি ইউনিট দেওয়া হয়।	
7.12 Do you share out any land from other farmers? (Yes =1, No =0)আপনি কি অন্য কৃষকদের সাথে কোন জমি ভাগ করেন? (হ্যাঁ = 1, না = 0)	
7.13 If yes, how much of your land do you share out to other farmers?যদি হ্যাঁ, তবেআপনার কতটা জমি অন্য কৃষকদের কাছে ভাগ করেন? Make sure land units are given in the farmer's specified area units. কৃষকের নির্দিষ্ট এলাকার ইউনিটে জমি ইউনিট দেওয়া হয় তা নিশ্চিত করুন।	

Code 1 কে‌াডা	Code 2কে‌াড 2	code 3কে‌াড 3
1 = canalখাল	1 = very erratic water supplyখুব অনশ্চিতি জল সরবরাহ	1 = very erratic electricity supplyখুব অনয়িমতি বদ্যিু□ সরবরাহ
2 = riverনদী	2 = somewhat reliable water supply2 = কছিুটা নর্িভরযে‌াগ্য জল সরবরাহ 4 = নর্িভরযে‌াগ্য, কনি্তু শুষ্ক যখন পূর্বাভাস 5 = জল সবসময় উপলব্ধ	2 = somewhat reliable electricity supply2 = কছিুটা নর্িভরযে‌াগ্য বদি্যুত সরবরাহ
3 = pondপুকুর	3 = mostly reliable but not always 3 = বশেরিভাগ নর্িভরযে‌াগ্য কনি্তু সর্বদা নয়	3 = mostly reliable but not always3 = বশেরিভাগ নর্িভরযে‌াগ্য কনি্তু সর্বদা নয়
4 = tube well (electric)টউিব ওয়লে (বদ্যৈুতকি) 6 = অন্যান্য (অনুগ্রহ করে উল্লখে করুন)	4 = reliable, but dry when predicted4 = নর্িভরযে‌াগ্য, কনি্তু শুষ্ক যখন পূর্বাভাস দয়ে	4 = reliable, but no electricity at predictable periods4 = নর্িভরযে‌াগ্য, কনি্তু পূর্বঘে‌াষতিসময়ে বদ্যিু□ থাকে না
5 = tube well (diesel) 5 = টউিব ওয়লে (ডজিলে)	5 = water always available5 = জল সবসময় উপলব্ধ	5 = water always available5 = জল সবসময় উপলব্ধ
6 = other (please specify) 6 = অন্যান্য (অনুগ্রহ করে উল্লখে করুন)		

8 Plot Level Wheat and Rice Production

প্লট স্তরে গম এবং ধানরে উত্পাদন

Plot 1 (Largest Plot)প্লট 1 (সব থকেে বড় প্লট	Sown Area % of the plot প্লটে বপন এলাকার %	8.1 Who in your household is making decisions on cultivation? 8.1 আপনার পরবিারে কে চাষরে সদি্ধান্ত গ্রহণ করনে?	8.2 What type of crop was sown in the corresponding Kharif and Rabi season? 8.2 খরফি ও রবি মেৌসুমে কোন ফসল চাষ করা হয়ছেলি?	8.3 Please give details about the sowing practice? 8.3 বপন প্রথা সম্পর্কে বস্তািরতি বলুন?	8.4 Please give yield quantities of harvest of corresponding cropsঅনুগ্রহ করেসংশ্লষ্টি ফসলরে উতপাদনরে অনুপাত পরমিাণ প্রদান করুন	8.5 Did you sow crop without tilling the soil first, a practice we call Zero Till (ZT)8.5 আপনি কি মাটি প্রথমে কর্ষণনা করে ফসলরে বীজ বপন করছেলিনে, আমরা প্রচলতি ভাষায় জরিো টলি (জডেটি) বলি	8.6 If Yes to 8.5, did you hire a ZT service provider to do the sowing for you?8.6 যদি8.5 হ্যাঁ হয়, তাহলেআপনি কি বীজ বুননরে জন্য একটি জডেটপিরষিবো প্রদানকারী নয়িোগ করছেলিনে?	8.7 If Yes to 8.6, rate the accessibility to ZT services on a scale from 0 to 4যদি 8.6হ্যাঁ হয়, স্কলেে 0 থকেে 4 পর্যন্ত জডেটি পরষিবোগুলরি অভগিম্যতার অনুপাতবলুন	8.8 If Yes to 8.5, but No to 8.6, did you rent a ZT drill that you operated yourself or do you use your own ZT drill? 8.8 যদি8.5 হ্যাঁ হয়, এবং8.6 তে না হয়, আপনি কি জডে টড্রিলি ভাড়া নয়িছেলিনে যা আপনি নজিে পরচিালনা করছেলিনেনা কি আপনি নজিরে জডেটড্রিলি ব্যবহার করছেলিনে?	8.9 What was the yield per harvest area?8.9 প্রতি চাষরে এলাকায় ফলন কত ছলি?	8.10 What is the stubble height after harvesting (inches)8.10 ফসল তোলার পরে মাটি থকেে অবশষ্টিাংশরে উচ্চতা (ইঞ্চতিে) কত ছলি?	8.11 What did you do with the crop residues?8.11 ফসলরে অবশষ্টিাংশ দয়িে আপনি কি করছেনে?	8.12 If NO to 8.5, যদি 8.5 তে না হয়, তবে ফসল বপনেরে পূর্বে কত বার জমি চাষ হয়?
		(Code 8.1) (কোড 8.1)	(Code 8.2) (কোড 8.2)	(code 8.3) (কোড 8.3)	(code 8.4) (কোড 8.4)	(1 = Yes, 0 = No) (1 = হ্যাঁ, 0 = না)	(1 = Yes, 0 = No) (1 = হ্যাঁ, 0 = না)	(Code 8.7) (কোড 8.7)	(code 8.8) (কোড 8.8)				
Kharif Crop (Spring 2017)খরফি ফসল (বসন্ত 2017)													
Rabi Crop (Winter 2016)রবি শস্য (শীতকালীন 2013)													

Code 8.1 কোড 8.1	Code 8.2কোড 8.2	Code 8.3 (for wheat)কোড 8.3 (গমের জন্যে)	Code 8.4কোড 8.4	Code 8.7কোড 8.7	code 8.8কোড 8.8
0 = Household head solely0 = পরিবার প্রধান শুধুমাত্র	0 = Wheat গম	0 = Conventional tillage broad cast wheat0 = প্রচলিত মৃত্তিকা কর্ষণ দ্বারা বিস্তৃত ভাবে গম রোপন	0 = Kg কে.জী.	0 = very poor/difficult খুবইখারাপ/কঠিন	0 = rent zt drillজেডটি ড্রিল ভাড়া
1 = Household head and spouse jointly1 = পরিবারের প্রধান এবং পত্নী যৌথভাবে	1 = Rice ধান	1 = conventional tillage line sown wheat (seed drill) 1 = প্রচলিত কর্ষণ দ্বারা লাইনে গম বপন (বীজ ড্রিল)	1 = Quintal কুইন্টাল	1 = difficultকঠিন	1 = use own zt drill নিজেরজেডটি ড্রিল ব্যবহার করা
2 = Household head and parent jointly 2 = পরিবারের প্রধান এবং অভিভাবক যৌথভাব	2 = Other অন্য (উল্লেখ করুন)	2 = Oxen pulled ploughed tilled wheat ষাঁড়টানা লাঙল দিয়ে কর্ষণ করা গম	2 = Mann (40 Kg)মন (40কে.জী.)	2 = neutral নিরপেক্ষ	
3 = Spouse solely3 = স্বামী বা স্ত্রী		3 = Hand tilled and sown wheat3 = হাত দ্বারা ভূমিতে চাষ ও বীজ বপন গম	3 = Other অন্য (উল্লেখ করুন)	3 = easy সহজ	
99 = Other (please specify) 99 = অন্যান্য (দয়া করে উল্লেখ করুন)		4 = Zero tillage wheat শূন্য কর্ষণ গম		4 = very easy খুব ই সহজ	

Code 8.3 (for rice) কোড 8.3 (ধানের জন্যে)
5 = Conventionally transplanted rice5 = প্রচলিত রোপণ করাধান
6 = Mechanically transplanted rice without soil puddling6 = মৃত্তিকারআলোড়ন ছাড়া যান্ত্রিকভাবে ধানরোপণ
7 = direct seeded rice with tillageকর্ষণ করেসরাসরি পুর্ণবর্ধিত ধান রোপণ
8 = Oxen pulled ploughed tilled rice ষাঁড়টানা লাঙল দিয়ে কর্ষণ করে ধান রোপণ
9 = Zero tillage rice 9 = শূন্য কর্ষণধান

Code 9.2 কোড 9.2	Code 9.4 কোড 9.4	Code 9.6 কোড 9.6	Code 9.9 কোড 9.9
0 = Krishi Vigyan Kendras (KVKs= কৃষিবিজ্ঞান কেন্দ্র (কেভিকেএস)	1 To reduce costs of production1 . উত্পাদন খরচ কমাতে	1 = Lack of information about the new technology 1 = নতুন প্রযুক্তি সম্পর্কে তথ্যের অভাব	0 = Rs.50000 to Rs.100,000, 50000 টাকা থেকে100,000 টাকা
1 = state Ag universities 1 = রাষ্ট্রের এগ্রি বিশ্ববিদ্যালয়	2 To reduce risks 2 ঝুঁকি কমানোর জন্য	2 = Costs of adoption or implementation are too high2 = গ্রহণ বা বাস্তবায়নের খরচ খুব বেশী	1 = Rs.100,000 to Rs.150,000.100,000 টাকা থেকে150,000 টাকার
2 = Krishi Mela 2= কৃষি মেলা	3 To increase cropping yields3 ফসলের ফলন বাড়ানোর জন্য	3 = Too complicated to adopt 3 = দত্তক গ্রহণ করার জন্য খুব জটিল	2 = Above Rs.150,000, 150,000টাকার উর্ধে
3 = Ag officers/ectension officers3 = এআইএফ অফিসার / ইস্টান্স অফিসার	4 To earn higher profits4 উচ্চ লাভ অর্জন করতে	4 = Labour requirements are too cheap4 = শ্রম প্রয়োজনীয়তা খুব সস্তা	
4 = input dealers4 = ইনপুট বিক্রেতা	5 Increase quality of production 5 উ□পাদন গুণমান বৃদ্ধি	5 = am satisfied with the current practice5 = বর্তমান অনুশীলনে সন্তুষ্ট	
5 = TV programs (Kisan TV)5 = টিভি প্রোগ্রাম (কিষাণ টিভি)	6 To reduce labour use6 শ্রম ব্যবহারের কমাতে	6 = Lower yields than expected 6 = প্রত্যাশিত তুলনায় নিম্ন উ□পাদন	
6 = Facebook/Internet ফেসবুক / ইন্টারনেটে	7 Saw neighbours adopting with good results7 ভাল ফলাফল গ্রহণ করতে প্রতিবেশীদের দেখেছি	7 = Benefits too far in the future7 = ভবিষ্যতে উপকারিতা অনেক দূরে	
7 = Newspapers খবরের কাগজ	8 To improve health and wellbeing of the farm8 খামারের স্বাস্থ্য ও কল্যাণের উন্নতির জন্য	8 = Limited availability of inputs8 = ইনপুটের সীমিত প্রাপ্যতা	
8 = Other farmers অন্য কৃষক	9 A new technology that becomes available9 একটি নতুন প্রযুক্তি যা পাওয়া যায়	9 = Other farmers recommend stopping9 = অন্যান্য কৃষককে থামানোর সুপারিশ করেছিল	
	10 To have access to new buyers10 নতুন ক্রেতাদের অনুপ্রবেশ আছে	10 = Extension agent recommends stopping10 = এক্সটেনশন এজেন্ট বন্ধ করার সুপারিশ করেছিল	
	11 To take advantage of promotions by vendors11 বিক্রেতার দ্বারা প্রচারিত সুবিধা গ্রহণ করা	11 = Other government officials recommend stopping11 = অন্যান্য সরকারী কর্মকর্তা সুপারিশ বন্ধ করার সুপারিশ করেছিল	
	12 To benefit from assistance programs12 সহায়তা প্রোগ্রাম থেকে উপকৃত হওয়া	12 = Lack of financial support or credit12 = আর্থিক সহায়তা বা ঋণের অভাব	
	13 Learned and implemented after training13 প্রশিক্ষণ করে শিখেছি এবং বাস্তবায়িতকরেছি	13 = Lack of government support13 = সরকারি সমর্থনের অভাব	
	14 Recommended by other farmers14 অন্যান্য কৃষকদের দ্বারা প্রস্তাবিত	14 = Complaints from neighbours 14 = প্রতিবেশীদের কাছ থেকে অভিযোগ এসেছিল	
	15 Recommended by extension agent15 এক্সটেনশন এজেন্ট দ্বারা প্রস্তাবিত	15 = Price paid for the stubble is too low15 = অবশিষ্টাংশ ফলোরদয়ে মূল্য খুবই কম	
	16 Recommended by a trader16 একটি ব্যবসায়ী দ্বারা প্রস্তাবিত	16 = Too much risk involved16 = অনেক ঝুঁকি জড়িত	

	17 Recommended by other government officials17 অন্যান্য সরকারি কর্মকর্তাদের দ্বারা প্রস্তাবিত	17 = The existing practice is better17 = বিদ্যমান অনুশীলন অপেক্ষাকৃত ভাল	
	18 More practical18 আরও ব্যবহারিক	18 = Unsuitable for local area conditions18 = স্থানীয় এলাকার অবস্থার জন্য অযোগ্য	
	19 To be environmentally friendly19 পরিবেশগতভাবে বন্ধুত্বপূর্ণ হতে হবে	19 = Other 19 = অন্যান্য	
	20 other20 অন্যান্য		

10. Input Costs
10. ইনপুট খরচ

10.1 The following questions deal with the type of inputs and input costs for crop production on your largest plotনম্নিোক্ত প্রশ্নগুলি আপনার বৃহত্তম প্লটে ফসলরে উ□পাদনে ইনপুটরে ধরণ এবং ইনপুটরে খরচরে সাথে সম্পর্কতি

	Total Cost (in INR) মোট খরচ (টাকা তে)			Quantity (Kg)পরমািণ (কজেি)	
	Kharif 2017 খারফি2017		Rabi 2016রবি 2016	Kharif 2017 খারফি2017	Rabi 2016রবি 2016
Fertilizers সার					
Herbicides (weed control) উদ্ভদিনাশক (আগাছা নয়িন্ত্রণ)					
Insecticides (insect control) কীটনাশক (পোকা নয়িন্ত্রণ)					
Fungicides (plant disease control)ছত্রাক (উদ্ভদিরে রোগ নয়িন্ত্রণ)					
Fuelজ্বালানি					
Water জল					
Electricityবদ্যিু□					
Machinery capital যন্ত্রপাতি মূলধন					
Seed বীজ					
Harvest costsফসলরে খরচ					
Transport/storageপরবিহন / স্টোরজে					

11. Labour Sources শ্রমরে উ□স			
			Code 11.1 কোড 11.1
11.1 What is the main source of labour on your farm? আপনার ক্ষতে শ্রমরে মুখ্য উ□স কি?			1 = just myself 1=শুধু নজি
			2 = my family and I2 = আমার পরবিার এবং আমি
			3 = hired labour3 = ভাড়া করা শ্রমকি
			4 = hired labour and I ভাড়া করা শ্রমকি এবং আমি
			5 = collective action5 = সমষ্টগিত/একত্রতি কর্ম
			6= other (please specify) 6 = অন্যান্য (অনুগ্রহ করে উল্লখে করুন)
12.2 Have you hired anyone to work in your business in the last 12 months? 11.2 আপনি কি গত 12 মাসরে মধ্যে আপনার ব্যবসাতে কাজ করার জন্য কাউকে নিয়োগ করছেনে?			(1 = Yes, 0 = No) (1=হ্যাঁ, 0=না)
If 11.2 = 0, skip to 11.5যদি 11.2=0, তবে 11.5 তে এগিয়ে যান			
11.3 If 11.2 = 1, How many people are you currently hiring? (no. of people) 11.3 যদি 11.2 = 1, আপনি কতজন মানুষকে বর্তমানে নিয়োগ করছনে? (জনগণরে সংখ্যা)			
11.4 If you were to hire someone to work at the farm, what would be the daily rate including meals? (in INR) (dK = don't know) 11.4যদি আপনি খামারে কাজ করার জন্য কাউকে ভাড়া নেনে, তাহলে খাবার সহ দনৈকি হার কত হবে? (টাকা তে) (ডকি = জানি না)			
			Code 11.5কোড 11.5
11.5 From the following selection, please choose the most common methods of payment for farm labour11.5 নিম্নলিখিত নির্বাচন থকে, কৃষি শ্রমকিরে জন্য পমেন্টেরে সর্বাধকি সাধারণ পদ্ধতি বছে নিন			1 = only cashশুধুমাত্র নগদ
			2 = cash and mealsনগদ এবং খাবার
			3 = cash and cropনগদ এবং ফসল
			4 = cash, meals and cropনগদ, খাবার এবং ফসল
			5 = Other (please specify) অন্যা (দয়া করে উল্লখে করুন)
			Code 11.6কোড 11.6

11.6 In your local area how easy is it to find people for hire to work at your farm?11.6 আপনার স্থানীয় এলাকায় আপনার ক্ষেতে কাজ করার জন্য লোক খুঁজে পাওয়া কত সহজ?			1 = easy সহজ
			2 = somewhat difficult একটু কঠিন
			3 = difficult কঠিন
			4 = very difficult খুবই কঠিন
			Code 11.7 কোড 11.7
11.7 How much of a concern are labout shortages during peak periods of farming operations (crop sowing, harvesting periods)11.7 চাষের কাজের (ফসল বপন, ফসল কাটার সময়ের) চূড়ান্ত পর্বের সময়শ্রম সংকট কতটা উদ্বেগের বিষয়।			1 = no concern1 = কোনো উদ্বেগ নেই
			2 = little concern2 = একটু উদ্বেগ
			3 = moderate concern3 = মাঝারি উদ্বেগ
			4= extreme concern 4 = চরম উদ্বেগ

11.8 The following questions deal specifically with labour use and input costs in crop production on your largest plot নিম্নোক্ত প্রশ্নগুলি আপনার সবচেয়ে বড় প্লটে ফসল উ□পাদনে শ্রমের ব্যবহার এবং ইনপুট খরচের সাথে বিশেষভাবে জড়িত

Daily Activities দৈনন্দিন কার্যকলাপ		Family labour (total working hours/day)পারিবারিক শ্রম (মোট কর্ম ঘন্টা / দিন)			Hire Labour ভাড়ার শ্রমিক Daily hours and # hired workersদৈনিক ঘন্টা এবং # ভাড়া লাগানো শ্রমিক	
		Male পুরুষ	Femaleমহিলা	*Children *বাচ্চা	Hours/day ঘন্টা/দিন	# hired workers # ভাড়ার শ্রমিক
1	Field preparationক্ষেত্রের প্রস্তুতি					
2	Sowing seedবীজ বপন					
3	Irrigating fields ক্ষেতেজল-সরবরাহ করা					
4	Fertilising সার দেওয়					
5	Weedingআগাছা পরিষ্কার					
6	Pest controlকীটপতঙ্গ নিয়ন্ত্রণ					
7	Maintaining machinery/infrastructureযন্ত্রপাতি / অবকাঠামো বজায় রাখা					
8	Harvesting ফসল কাটা					

11.9 Who usually is responsible for makes the following decisions on your farm? (Tick all that apply)আপনার ফার্মে নিম্নোক্ত সিদ্ধান্তগুলিসাধারণত কে নেয়? (সমস্ত প্রযোজ্য টিক্ করুন)				
	You আপনি	Your wife/husbandআপনার স্ত্রী/স্বামী	Another HH memberঅন্য এইচএইচ সদস্য	Non-HH member (specifiy) এইচএইচ সদস্য নয় (উল্লেখ করুন)
1 Farm production decisions 1 খামারে উত্পাদনের সিদ্ধান্ত				
2. selling/marketing farm produce2. বিক্রয় / বিপণন খামার উত্পাদন				
2. The purchase, sale or transfer of land and other major assets2. ভূমি এবং অন্যান্য প্রধান সম্পদ ক্রয়, বিক্রয় বা স্থানান্তর করা				
3. Access to and decisions about credit/loansক্রেডিট / ঋণ সম্পর্কে অ্যাক্সেস এবং সিদ্ধান্ত নেওয়া				
4. Control over the use of farm income4. খামার আয় ব্যবহারের উপর নিয়ন্ত্রণ				
5. How the workload on the farm is divided across family members5. খামারের কাজের চাপ পরিবারের সদস্যদের মধ্যে কিভাবে বিভক্ত করা হবে				
6. Group membership6. গোষ্ঠির সদস্যপদ				

12. Group Membership.গোষ্ঠির সদস্যপদ

Now I am going to ask you about groups in the community. These can be either formal or informal and customary groups. এখন আমি আপনাকে সম্প্রদায়ের গোষ্ঠী সম্পর্কে জিজ্ঞাসা করব। এইগুলি আনুষ্ঠানিক বা অনানুষ্ঠানিক এবং প্রথাগত গোষ্ঠীগুলি হতে পারে.	12.1 Is there a [GROUP] in your community (village/commune)? আপনার সম্প্রদায়ের কোনো গোষ্ঠী আছে? (গ্রাম/যৌথভাবে বসবাসকারী জনগোষ্ঠী) ?	12.2 Are you an active member of this [GROUP]? আপনি কি এই গোষ্ঠির একজন সক্রিয় সদস্য?	12.3 Is any of other male household members an active member of this [GROUP]?অন্য কোন পুরুষ পরিবারের সদস্যরা এই গোষ্ঠির একটি সক্রিয় সদস্য?	12.4 Is any of other female household members an active member of this [GROUP]?অন্য কোন মহিলা পরিবারের সদস্যরা এই একটি সক্রিয় সদস্য?
Groupগোষ্ঠী	0. no ***(go to next group)***না(পরের গোষ্ঠীতে এগিয়ে যান)	0. no না	0. no না	0. no না
	1. yesহ্যাঁ	1. yesহ্যাঁ	1. yes হ্যাঁ	1. yes হ্যাঁ
	999 don't know জানি না			
A Agricultural/Livestock/Fisheries Cooperative or farmer's clubকৃষি / পশুসম্পদ / ম☐স্য সমবায় বা কৃষক ক্লাব				
B. Agricultural marketing commodity group কৃষি বিপণন পণ্য গোষ্ঠী				
C. Farming technology improvement groupকৃষিকাজ প্রযুক্তির উন্নতির গোষ্ঠী				
D Youth Union যুব ইউনিয়ন				
E Forest user's group বন ব্যবহারকারীর গোষ্ঠী				
F Credit or microfinance group, insurance group ক্রেডিট বা মাইক্রোফিনান্স গোষ্ঠী, বীমা গোষ্ঠী				

G Trade and business association groupবাণিজ্য ও ব্যবসায় সংস্থার গোষ্ঠী				
H Civic groups (improving community) or charitable group সিভিকি গোষ্ঠী (সম্প্রদায় উন্নতি) বা দাতব্য গোষ্ঠী				
I Religious groupধর্মীয় গোষ্ঠী				
J Women's Union মহিলা ইউনিয়ন				
K Other (specify)অন্য(উল্লেখ করুন)				

13. Information Sources তথ্যের উ□স

The next few questions concern other important sources of information who you consult or get information most frequently about agricultural practices পরবর্তী কয়েকটি প্রশ্ন অন্যান্য গুরুত্বপূর্ণ সূত্রগুলি সম্পর্কে যেখান থেকে আপনি কৃষি প্রথাগুলি সম্পর্কে প্রায়শই তথ্য সংগ্রহ করেন বা তথ্য পান

	13.1 Do you use any of the sources below to obtain useful information?আপনি দরকারী তথ্য প্রাপ্ত করতে নিচের উ□সগুলির কোনটি ব্যবহার করেন?	13.2 Is this information source available in your village?এই তথ্যের উ□স আপনার গ্রামে পাওয়া যায়?	13.3 Have received any information about the HAPPY SEEDER/Zero Till and its uses from any of the following sources?নিম্নলিখিত উত্সগুলির কোনোটি থেকে হ্যাপি সিডার / জিরো টিল সম্পর্কে কোনো তথ্য এবং তার ব্যবহারসম্পর্ককে জানতে পেরেছেন?	13.4 How credible/trustworthy is this information source? (On a scale of 1 to 5)এই তথ্যের উ□স কতটা বিশ্বাসযোগ্য / নির্ভরযোগ্য? (1 থেকে 5 স্কেলে)

	(1 = Yes, 0 = No) (1= হ্যাঁ, 0=না)	(1 = Yes, 0 = No) (1= হ্যাঁ, 0=না)	(1 = Yes, 0 = No) (1= হ্যাঁ, 0=না)	(Code 13.4) (কোড13.4)
1. Krishi Vigyan Kendra (KVKS) 1. কৃষি বিজ্ঞান কেন্দ্র (কেভি কেএস)				
2. State Ag, Universities2. রাজ্য এজ, বিশ্ববিদ্যালয়				
3.Krishi 3.কৃষি মেলা				
4.Ag officer/Extension officers4. অফিসার / এক্সটেনশন অফিসারগণ				
5. Input dealers5. ইনপুট বিক্রেতা				
6. Commission Agents6. কমিশন এজেন্ট				
7. Farmer cooperatives7. কৃষক সমবায়				
8. Facebook/What's App8. ফেসবুক / অ্যাপটি কি				
9. TV Programs (Kisan TV) 9. টিভি প্রোগ্রাম (কিষাণ টিভি)				
10. Radio programs10. রেডিও প্রোগ্রাম				
11. Community radio11. কমিউনিটি রেডিও				
12. Newspapers12. সংবাদপত্র				
13. Kisan call centres13. কিষান কল সেন্টার				
14. Mobile phone based services/Whatsapp14. মোবাইল ফোন ভিত্তিক সেবা / হোয়াটসঅ্যাপ				
15. Internet Kiosk/E-choupal15. ইন্টারনেট কিওস্ক / ই-চৌপাল				
16. Digital Green16. ডিজিটাল গ্রিন				
17. NGOs17. এনজিও				
Code 13.4কোড **13.4**				
1 = very poor credibility1 = খুব খারাপ বিশ্বাসযোগ্যতা				
2 = small amount of credibility2 = কমপরিমাণ বিশ্বাসযোগ্যতা				

3 = moderate credibility3 = মধ্যপন্থী বিশ্বাসযোগ্যতা				
4 = highly credible4 = অত্যন্ত বিশ্বাসযোগ্য				
5 = extremely credible5 = অত্যন্ত বিশ্বাসযোগ্য				

14. Important factors for decision making সিদ্ধান্ত গ্রহণের জন্য গুরুত্বপূর্ণ কারণ

When you decide on crop sowing and crop management practices, please rate each of the following factors from not important (1) at all to very important (5).যখন আপনি ফসলের বীজ এবং ফসল ব্যবস্থাপনা পদ্ধতি সম্পর্কে সিদ্ধান্ত নেবেন, তখন অনুগ্রহ করে সমস্ত কার্যাবলীকে গুরুত্ব নয় (1) থেকে খুবইগুরুত্বপূর্ণ (5) হিসাবে প্রত্যেকটিকে রেট দিন।

14.1 Cost of HS machinery or service 14.1এইচএস যন্ত্রপাতি বা সেবার খরচ	❐Not important at all ❐Not important ❐Unsure ❐Somewhat important ❐Very important ❐ একদমই গুরুত্বপূর্ণ নয়❐গুরুত্বপূর্ণ নয়❐নিশ্চিত না❐কিছুটা গুরুত্বপূর্ণ❐খুবই গুরুত্বপূর্ণ
14.2 Availability of on time HS service 14.2 সময় এইচএস সেবার উপলভ্যতা	
14.3 Government subsidy on HS machinery 14.3 এইচএস যন্ত্রপাতি সংক্রান্ত সরকারি ভর্তুকি	
14.4 Availability of on time ZT service 14.4 সময় জেডটিসেবার উপলব্ধতা	
14.5 Government subsidy on ZT machinery 14.5 জি. টি. যন্ত্রপাতিতে সরকারি ভর্তুকি	
14.6 Government subsidy on other machinery 14.6 অন্যান্য যন্ত্রপাতিতে সরকারি ভর্তুকি	
14.7 Labour input 14.7 শ্রম ইনপুট	
14.8 Soil moisture14.8 মৃত্তিকার আর্দ্রতা	

14.9 Soil fertility 14.9 মাটি উর্বরতা	
14.10 Late harvest of crops 14.10দেরিতে ফসল কাটা হয়েছিল	
14.11 Being able to sow early14.11শীঘ্রচাষ করা সম্ভব হয়েছিল	
14.12 Lodging risk for rice/wheat crops14.12ধান/গম ফসলের জন্য ঝুঁকি	
14.13 Precise placement of seed and fertilizer14.13 বীজ এবং সারের যথাযথ স্থান নির্ধারণ	
14.14 Seed rate 14.14 বীজের হার	
14.15 Yield 4.15 ফলন	
14.16 Weed infestation 14.16 আগাছা উপসর্গ	
14.17 Rodent or pest infestations 14.17ইঁদুর বা কীটপতঙ্গেরউপসর্গ	
14.18 Herbicides expenses 14.18উদ্ভিদনাশকের খরচ	
14.19 Volume of crop straw residue 14.19 ফসলেরখড় এর অবশিষ্টাংশ পরিমান	
14.20 Tractor capacityট্র্যাক্টরের ক্ষমতা	
14.21 Poor spreading of residue during harvest14.21 ফসল কাটার সময় অবশিষ্টাংশ ছড়িয়ে পরা	
14.22 Prior experience with machinery/practices14.22 যন্ত্রপাতি / অনুশীলনগুলির সাথে পূর্ব অভিজ্ঞতা	
14.23 Threat of fines for burning crop residues y government officials14.23 ফসলের অবশিষ্টাংশ জালানোর জন্য সরকারি কর্মকর্তাদের দ্বারা জরিমানার হুমকি	
14.24 Differentiate between HS and ZT seed drills 14.24এইচএস এবং জেডটি বীজ ড্রিলের মধ্যে পার্থক্য	

14.25 Who makes the major decisions in the household over the following areas in the past 12 months? (for primary male household member) (Code 14.25) 14.25 গত 12 মাসে নিম্নোক্ত অঞ্চলে পরিবারের প্রধান সিদ্ধান্ত কে নিয়েছে? (প্রাথমিক পুরুষ পরিবারের সদস্যদের জন্য) (কোড 14.25)		Code 14.25 কোড14.25
1. Crop/variety choice decision1. ফসল / বিভিন্ন পছন্দের সিদ্ধান্ত		1 = myself নিজে
2. Tillage practice decision কৃষিকার্যে অনুশীলনের সিদ্ধান্ত		2 = wife স্ত্রী
3. Sowing decision3. বপন সিদ্ধান্ত		3= myself and wife jointly আমি এবং আমার স্ত্রী
4. Irrigation decision4. সেচের সিদ্ধান্ত		4 = son/son in law পুত্র/ জামাই

5. Fertiliser/weeding/pest control decision5. সার / আগাছা / কীটপতঙ্গ নয়িন্ত্রণরে সদ্িধান্ত		5 = daughter/daughrer in law কন্যা/ পুত্রবধূর
6. Harvesting decision 6. ফসল কাটার সদ্িধান্ত		6 = mother/mother in law মাতা/ শাশুড়ি মাতা
7. selling/marketing farm produce7. বক্িরয় / বপিণন খামার উত্পাদন		7 = father/father in law পতিা/শ্বশুর মহাশয়
8. The purchase, sale or transfer of land and other major assets8. জমি এবং অন্যান্য প্রধান সম্পদ ক্রয়, বক্িরয় বা স্থানান্তর		8 = grandsonনাতি
9. Access to and decisions about credit/loans9. ক্রডেটি / ঋণ সম্পর্কে অ্যাক্সসে এবং সদ্িধান্ত		9 = granddaughterনাতনী
10. Control over the use of farm income10. খামার আয় ব্যবহাররে উপর নয়িন্ত্রণ		10 = other (please speciy)অন্য (অনুগ্রহ করে উল্লখে করুন)
11. How the workload on the farm is divided across family membersখামাররে কাজরে চাপ পরবিাররে সদস্যদরে মধ্যে কভিাবে বভিক্ত করা হবে		
12. Join group membership গ্রুপের সদস্যতায় যোগ দনি		

14.26 Who makes the major decisions in the household over the following areas in the past 12 months? (for primary female household member) (Code 14.26) 14.26 গত 12 মাসে নম্নিলখিত অঞ্চলে পরবিাররে প্রধান সদ্িধান্ত কে নয়িছেে? (প্রাথমকি মহলিা পরবিাররে সদস্যদরে জন্য) (কোড 14.26)		**Code 14.26**
1. Crop/variety choice decision1. ফসল / বভিন্নি পছন্দর সদ্িধান্ত		1 = myself নজিে
2. Tillage practice decision কৃষিকার্যে অনুশীলনরে সদ্িধান্ত		2 = wife স্ত্রী
3. Sowing decision3. বপন সদ্িধান্ত		3= myself and wife jointly আমি এবং আমার স্ত্রী
4. Irrigation decision4. সচেরে সদ্িধান্ত		4 = son/son in law পুত্র/ জামাই
5. Fertiliser/weeding/pest control decision5. সার / আগাছা / কীটপতঙ্গ নয়িন্ত্রণরে সদ্িধান্ত		5 = daughter/daughrer in law কন্যা/ পুত্রবধূর
6. Harvesting decision 6. ফসল কাটার সদ্িধান্ত		6 = mother/mother in law মাতা/ শাশুড়ি মাতা
7. selling/marketing farm produce7. বক্িরয় / বপিণন খামার উত্পাদন		7 = father/father in law পতিা/ শ্বশুর মহাশয়
8. The purchase, sale or transfer of land and other major assets8. জমি এবং অন্যান্য প্রধান সম্পদ ক্রয়, বক্িরয় বা স্থানান্তর		8 = grandson নাতি
9. Access to and decisions about credit/loans9. ক্রডেটি / ঋণ সম্পর্কে অ্যাক্সসে এবং সদ্িধান্ত		9 = granddaughterনাতনী

10. Control over the use of farm income10. খামার আয় ব্যবহারের উপর নিয়ন্ত্রণ		10 = other (please speciy)অন্য (অনুগ্রহ করে উল্লেখ করুন)
11. How the workload on the farm is divided across family members খামারের কাজের চাপ পরিবারের সদস্যদের মধ্যে কিভাবে বিভক্ত করা হবে		
12. Join group membership গোষ্ঠীর সদস্যতায় যোগ দিন		

15. Household wealth indicators

15.1 How many rooms does the dwelling have?	
(Include detached rooms in the same compound if it is the same household, exclude bathrooms, toilets, kitchen and basement)	
What are the main materials that your home constructed of?	
1. Straw/ plant material	
2. Straw/plant material and iron or timber	
3. Timber and iron'	
4. Iron and brick/stone	
5. Brick/stone	
6. Other (specify)	

15.2 What is the primary cooking fuel source used?	
1. Leaves/grass/rice husks/stubble/straw	
2. Wood	
3. Dung	
4. Coal or charcoal	
5. Kerosene	
6. Biogas	
7. LPG	
8. Electricity	
99. Other (specify)	

15.6 How many of the following agricultural machines do you own?

ID	Machine	Number of machines owned by the HH
1	Machine Tractor (specify HP Capacity)	
2	Wheel Tractor (specify HP capacity)	
3	Zero-till drill (ZT machine)	
4	Turbo Happy Seeder	
5	Laser land leveller	
6	Power tiller	
7	Rotavator	
8	Rice transplanter	
9	Bed planter	
10	Potato planter	
11	Sprayer	
12	Mobile diesel irrigation pump	
13	Combine harvester	
14	Reaper-cum-binder	
15	Drum thresher	
16	Power thresher	

15. 3 What is the secondary cooking fuel source used?	
0. No other	
Rest Codes as above	

15.4 Do you have electricity available to your home? (1 = Yes, 0 = No)	

15.5 How many of each of the following items does the respondent's household possesses?	
Mobile Phone (basic)	
Mobile phone (smart phone) that can access facebook	
Radio	
TV	
Electric Fan	
Air cooler/AC	
Gas or diesel electric generator	
Bicycle	
Motorbike	
Car/Jeep	

16.
Risk
ঝুঁকি

Please select the statement below that best describes your attitude towards new technologies, new management practices and new production methods.অনুগ্রহ করে নীচরে ববিৃতটিি নরি্বাচন করুন যটো নতুন প্রযুক্তা, নতুন ব্যবস্থাপনা পদ্ধতা এবং নতুন উ□পাদন পদ্ধতগিুলরি প্রতা আপনার মনোভাবকে সর্বোত্তমভাবে বর্ণনা করে ।

Answer
উত্তর

Select only one of the following: [1, 2, 3, 4, or 5]
নম্নিলখিতিগুলরি মধ্যে শুধুমাত্র একটা নরি্বাচন করুন : **[1, 2, 3, 4,** বা **5]**

1. I am **always the first** to try new technologies new management practices and new production methods.1 . আমসির্বদাসর্বপ্রথম নতুন প্রযুক্তা নতুন ব্যবস্থাপনা চর্চা এবং নতুন উ□পাদন পদ্ধতা চষ্টো করা।

2. I am **one of the first** to try new technologies new management practices and new production methods.2 . আমা প্রথম কয়কে জনরে মধ্যে এক জন যনেতুন প্রযুক্তা নতুন ব্যবস্থাপনা চর্চা এবং নতুন উ□পাদন পদ্ধতা চষ্টো করে।

3. I normally **wait to see other's success** with new technologies new management practices and new production methods before I try them.3 . আমা সাধারনত আমা চষ্টো করার আগে সাধারণত নতুন প্রযুক্তা নতুন ব্যবস্থাপনা চর্চা এবং নতুন উ□পাদন পদ্ধতাতে অন্যদরে সাফল্য দখেতে অপক্ষো করুন।

4. I am **one of the last** to try new technologies new management practices and new production methods.4 . আমা নতুন প্রযুক্তরি নতুন ব্যবস্থাপনা চর্চা এবং নতুন উ□পাদন পদ্ধতরি চষ্টো করাতে সর্বশষেরে একজন।

5. I **never** try new technologies new management practices and new production methods.5 . আমা নতুন প্রযুক্তা নতুন ব্যবস্থাপনা চর্চা এবং নতুন উ□পাদন পদ্ধতা কখনইচষ্টোইকরনিা।

17. Business Models ব্যবসায়িক মডেলে

If the government were to examine opportunities for providing HS technology access to your village, how would you see it being best managed for the benefit of local farmers?যদি আপনার গ্রামে এইচএস প্রযুক্তির প্রবেশাধিকার প্রদানের জন্য সরকারকে সুযোগের সন্ধান করতে হতো, তাহলে কীভাবে স্থানীয় চাষীদের সুবিধার জন্য এটি সবচেয়ে ভালভাবে পরিচালিত হবে?

17.1 What is your preferred business model for adoption of the Happy Seeder technology? (Code 17.1) 17.1 হ্যাপি সিডার প্রযুক্তি গ্রহণের জন্য আপনার পছন্দের ব্যবসায়িক মডেল কী? (কোড 17.1)

Code 17.1 কোড17.1
1 = self owned1 = স্ব মালিকানাধীন
2 = hire of custom services2 = কাস্টম সেবার ভাড়া
3 = community owned/shared3 = সম্প্রদায়ের মালিকানাধীন / শেয়ার করা
4 = farmer cooperative4 = কৃষক সমবায়
5 = government supplied services5 = সরকার সরবরাহ সেবা
6= other 6 = অন্যান্য

17.2 What is the main reason for your preference above?
17.2 উপরোক্ত বিষয়ে আপনার পছন্দের প্রধান কারণ কি?

Code 17.3

17.3 Thinking about the options that you didn’t preference, why do you think that these other business models do not work? (Code 17.3) 17.3 আপনার পছন্দসই নয় এমন বিকল্পগুলি সম্পর্কে চিন্তা করে, কেন আপনি মনে করেন যে এই অন্যান্য ব্যবসায়িক মডেলগুলি কাজ করে না? (কোড 17.3)	1 = Economies of scale – costly to use HS on a per-hectare basis1 = স্কেলের অর্থনীতি – প্রতি হেক্টরের ভিত্তিতে এইচএস ব্যবহারের ব্যয়বহুল 3 = যে কোন বছরে এইচএসএল এর সীমিত ব্যবহার 4 = কৃষকদের মধ্যে প্রতিযোগিতা খুব বেশী হবে 5 = মেশিনগুলো সম্পূর্ণরূপে নিজের জন্য ব্যয়বহুল 6 = আমরা যেখানে বসবাস করি সেখানে কোনও চুক্তিতে আসতে পারি না 7 = এটি অর্থনৈতিকভাবে কাজ করতে আগ্রহী যথেষ্ট মানুষ নেই 8 = এইচএস প্রযুক্তির সুবিধার বিষয়ে সচেতনতা / বিশ্বাসের সাধারণ অভাব 9 = সরকার / সম্প্রসারণ পরিষেবা প্রদানকারীদের জন্য ট্রাস্টের অভাব 10 = অন্যান্য
	2 = Timing - difficult to get a HS when you need it2 = টাইমিং – প্রয়োজনেরসময়এইচএসপাওয়া কঠিন হয়.
	3 = Limited use of the HS during any year3 = যে কোন বছরে এইচএস এর সীমিত ব্যবহার
	4 = Competition between farmers would be too high4 = কৃষকদের মধ্যে প্রতিযোগিতা খুব বেশী হবে
	5 = The machines are too expensive to own outright5 = মেশিনগুলোর পুরাদস্তুররূপে মালিকাধীন হওয়ারজন্য ব্যয়বহুল
	6 = We cannot come to agreement where I live6 = আমরা যেখানে বসবাস করি সেখানে থেকে আমরাকোনও চুক্তিতে আসতে পারি না
	7 = There are not enough people interested to make it work economically7 = এটিকে অর্থনৈতিকভাবে কাজকরা করতে পারে এরকম আগ্রহী মানুষ যথেষ্ট নেই
	8 = General lack of awareness/belief in the benefits of the HS technology8 = এইচএস প্রযুক্তির সুবিধার বিষয়ে সাধারণ সচেতনতা / বিশ্বাসের অভাব
	9 = Lack of trust for government / extension service providers9 = সরকার / সম্প্রসারণ পরিষেবা প্রদানকারীদের জন্য ট্রাস্টের অভাব
	10 = Other 10 = অন্য

18. Farmer Behavioural Characteristicsকৃষকের আচরণগত বৈশিষ্ট্য

No সং.	ATTITUDINAL STATEMENT ব্যক্তিগত দৃষ্টিভঙ্গির বিবৃতি	Strongly Disagree দৃঢ়ভাবে অসম্মত	Disagree অসম্মতি	Neither disagree nor agreeঅসম্মতিও নহে সম্মতিও নহে	Agreeসম্মতি	Strongly Agreeদৃঢ়ভাবে সম্মত
1	I consider myself a traditional farmer.আমি নিজেকে একটি ঐতিহ্যগত কৃষক বিবেচনা করি।					
2	As long as I can grow enough farm produce to feed my family that is all that matters to me as a farmer.যতদিন পর্যন্ত আমি আমার পরিবারকে খাওয়ানোর জন্য পর্যাপ্ত ফসল উত্পাদন করতে পারি, কৃষক হিসাবে আমার কাছে সেইটিই গুরুত্বপূর্ণ					
3	There is a positive future for farming in my village.আমার গ্রামে চাষের জন্য একটি ইতিবাচক ভবিষ্যত আছে।					
4	Not having enough spare money prevents me from adopting new technologies on my farm.পর্যাপ্ত অতিরিক্ত অর্থ না থাকার ফলে আমি আমার খামারে নতুন প্রযুক্তিগুলি গ্রহণ করতে পারি না।					
5	Labour shortages during crop sowing and harvest limits farm productivity in my village area. ফসলের বীজ বপন এবং কাটার সময়শ্রমের ঘাটতিআমার গ্রামেফসলের উত্পাদনশীলতা সীমিত করে।					
6	There is a good opportunity for me to increase crop yields on my farm through adopting new and improved farming practices.নতুন এবং উন্নত চাষ পদ্ধতি গ্রহণের মাধ্যমে আমার খামারে ফসলের ফলন বাড়ানোর জন্য আমার কাছে একটি ভাল সুযোগ রয়েছে।					
7	Custom hiring services for machinery such as ZT seed drills are readily available in my district. জেডটিবীজ ড্রিলের যন্ত্রপাতির জন্য কাস্টম নিয়োগের সেবা আমার জেলায় সহজেই পাওয়া যায়।					
8	It is not possible to sow wheat without first cultivating the soil.প্রথম মাটি চাষ করাছাড়া গম বপন করা সম্ভব নয়।					
9	I would like my children to one day be farmers just like me.আমি চাই যে আমার সন্তানরা একদিন আমার মতইকৃষক হবে ।					
10	I am concerned about depleting groundwater reserves in my district.আমি আমার জেলায় ভূগর্ভস্থ জল সংরক্ষণের বিষয়ে উদ্বিগ্ন।					
11	Learning from other farmers is one of the best ways to learn and adopt a new farming practice.অন্য কৃষকদের কাছ থেকে একটি নতুন চাষের অনুশীলন পদ্ধতি শেখা এবং গ্রহণ করার একটি ভালো উপায়।					
12	There is little incentive to improve crop yields because of the lack of markets for my crops.আমার ফসলের জন্য বাজারের অভাবেরকারণে ফসলের উ□পাদনের উন্নতির জন্য সামান্য উদ্দীপনা রয়েছে					
13	I am happy with my life as a farmer.আমি একজন কৃষক হিসাবে আমার জীবনে খুশি					
14	It is important to have a rice-straw (stubble) free fields prior to sowing a wheat crop.একটি গমের ফসল বপনের পূর্বে ক্ষেত্রেটি ধান–খড় বিহীন (খামরিবিহীন) ক্ষেত্র হওয়া গুরুত্বপূর্ণ।					
15	A large proportion of my income from crops is used to pay off debt/loans to money lenders.ফসল থেকে আসা আমার আয়ের একটি বড় অংশ ঋণদাতার ঋণ শোধ করতে ব্যবহার হয়ে হয়।					

16	I like to be one of the first in my village to try growing a new crop variety.আমি একটি নতুন ফসলের জাত উদ্দীপ্ত করার চেষ্টা করাতে আমার গ্রামের মধ্যে প্রথম এক হতে চাই।				
17	Farmers have no choice but to burn their rice straw stubbles prior to sowing their wheat crops. গমের ফসল বপন করার পূর্বে ধানের খড়ের অবশিষ্টাংশ জালানো ছাড়াকৃষকদের কোন উপায় থাকে না				
18	The Government should pay farmers to adopt conservation agriculture related farming practices.সংরক্ষণ কৃষি সম্পর্কিত চাষ পদ্ধতি গ্রহণ করার জন্যসেরকারের উচিত কৃষকদের অর্থ প্রদান করা।				
19	The Rotavator helps to improve soil health by mixing the soil together.মাটি একসাথে মিশিয়ে মাটি স্বাস্থ্যের উন্নতির জন্য রোটাভেটর সাহায্য করে।				
20	I will not adopt a new farming practice until I see it working successfully on other farms in my district.আমি ততক্ষণ একটি নতুন চাষ পদ্ধতি গ্রহণ করব না যতক্ষণ না আমি আমার জেলায় অন্যান্য খামারগুলিতে সেই পদ্ধতিটিকিসেফলভাবে কাজ করতে দেখেছি।				
21	Increasingly, I am finding out more valuable information about farming through Facebook and/or What's app.ক্রমবর্ধমানভাবে, আমি ফেসবুক এবং / অথবা হোয়াটস অ্যাপের মাধ্যমে চাষ সম্পর্কে আরও মূল্যবান তথ্য খুঁজে পাচ্ছি।				
22	I am concerned about the impact of climate change and the ability to maintain crop yields into the future.জলবায়ু পরিবর্তনের প্রভাব এবং ভবিষ্যতে ফসল উ□পাদনের বিকাশের বিষয়ে আমি উদ্বিগ্ন।				
23	It is important to leave the condition of my farm's soil health in better condition for the future generations of farmers.ভবিষ্যত প্রজন্মের কৃষকদের জন্য ভাল অবস্থায় আমার খামারের মাটির স্বাস্থ্যের ভালো অবস্থা ছেড়ে যাওয়া গুরুত্বপূর্ণ।				
24	Rice stubble residues are an important source of feed for livestock. ধানের খড়েরঅবশেষেগুলি পশুসম্পত্তিদের খাদ্যের একটি গুরুত্বপূর্ণ উ□স।				
25	I will not adopt a new farming practice until I am convinced that it is risk free.আমি একটি নতুন চাষ পদ্ধতি গ্রহণ করব না যতক্ষণ না আমি নিশ্চিত হই যে এটি ঝুঁকি মুক্ত।				
26	There is a lack the skills to properly maintain agricultural machinery such as tractors and implements in my district.কৃষিকার্যেরযন্ত্রপাতি যেমন ট্রাক্টর এবং সরঞ্জাম যথাযথ ভাবে বজায় রাখার দক্ষতা আমার জেলায় অভাব রয়েছে।				
27	I like to seek out as much information as possible relating to a new farming practice . আমি একটি নতুন চাষ পদ্ধতি সম্পর্কিত যতটা সম্ভব তথ্য খুঁজে বের করতে চাই				
28	The yield penalty from late sown wheat can be very highদেরী বপন গম থেকে ফলন জরিপ খুব বেশী হতে পারে				
29	I am concerned about personal health impacts from stubble burningআমি খড়ের অবশিষ্টাংশ জালানো থেকে হওয়া ব্যক্তিগত স্বাস্থ্যে প্রভাব সম্পর্কে উদ্বিগ্ন				
30	I think that stubble burning causes severe health problems for other areas (e.g. Delhi)আমি মনে করি যে খড়ের অবশিষ্টাংশ জালানোর ফলে অন্যান্য এলাকাতে (যেমন দিল্লিতে) গুরুতর স্বাস্থ্য সমস্যার কারণ হয়ে দাড়াচ্ছে।				
31	The impacts of stubble burning on people are overstatedমানুষের উপর খড়ের অবশিষ্টাংশ জালানোরপ্রভাবগুলি অত্যধিক				

10.3 Appendix 3: Kathmandu Resolution

Value chain and policy interventions to accelerate adoption of zero tillage in the rice-wheat farming systems across the Indo-Gangetic Plains

Regional Collaborative Platform Workshop on

Conservation Agriculture for Sustainable Intensification (CASI)

July 22-23, 2018, Kathmandu, Nepal

The Kathmandu Resolution:

We, the participants of the *Regional Collaborative Platform on Conservation Agriculture for Sustainable Intensification* Workshop, held in Kathmandu on the 22-23 July 2018, reviewed the evidence and information, progress and achievements made to date on conservation agriculture and sustainable intensification (CASI) across the Indo Gangetic Plain region. This information highlighted the value of facilitatedand accelerated adoption of CASI sustainable agricultural practices to boost farmers' income, enhance farmers' and custom hire service providers' livelihoods, improve soil health, and increase the efficient use of inputs (e.g. water). It was recognised that achieving the benefits of CASI adoption requires urgent regional action in the form of a *CASI Platform* (CASI-P) for knowledge-sharing, capacity development, research and development partnerships, policy advocacy, and public awareness.

We recognise that a sustainable CASI-P initiative will primarily be propelled by regional partnerships of NARS, in collaboration with other International Centres of Excellence in Agricultural Research, extension, and development organisations - including private sector involvement. We further recognise that fostering such partnerships will be critical for the success of this initiative, and also for delivering regional public goods with cross-country benefits for South Asia. To achieve this partnership, those participants representing the NARS in the region agree to have an effective and functional regional partnership framework established with immediate effect, for which broad objectives and guidelines have been discussed, and endorsed in principle. We the undersigned therefore jointly undertake to submit this resolution for further approval with our respective NARS organisations in order to nurture effectively this crucial initiative for the sustainable future of the region.

Signed on this day by the NARS representatives in the Kathmandu workshop:

Dr Wais Kabir (Bangladesh)	Dr AK Singh (India)	Dr Yubak Dhoj G.C. (Nepal)	Dr Yusuf Zafar (Pakistan)

23rd July, 2018

10.4 Appendix 4: Policy Brief document

ADVANCING ZERO-TILL

Policy Brief Recommendations in Support of Accelerating the Adoption of HS/ZT Seed Drills Across the Indo-Gangetic Plains

PURPOSE AND OUTCOMES OF THE STUDY

The Australian Centre for International Agricultural Research (ACIAR) through the Sustainable Development Innovation Portfolio (SDIP) commissioned the University of Adelaide's Centre for Global Food and Resources (GFAR) to undertake a study to investigate and provide recommendations as to how the adoption of zero-till (ZT) technology (particularly the Happy Seeder (HS)) could be accelerated in an effort to provide a viable option for farmers to cease the practice of burning crop stubble residues and in turn reduce human health impacts through reduced air pollution.

Key outcomes from this study is the development of this policy brief that provides recommendations for creating enabling environments that support the accelerated adoption of conservation agriculture sustainable intensification (CASI) technologies such as ZT through identifying innovative implementation pathways and enhanced value chains. A series of specific actionable recommendations are provided.

IMPENDING CHALLENGES

This Indo-Gangetic Plains (IGP) region is characterised by an intensive rice-wheat cropping system that represents a successful outcome of the green revolution. Farmers have readily adopted high yielding, short season varieties that when combined with high inputs, ready access to irrigation and tillage has resulted in regional food security. This success has come at a cost.

Increased intensification of cropping systems is leading to serious environmental concerns in relation to the long term impact on sustainability. The fragility of the farming environment is reflected in the impact of significant air pollution from the burning of crop residues, decreasing soil health (declining soil fertility and soil structure), increased weed and pest resistance (such as herbicide resistance in *Phalaris minor*) and declining water resources and water quality (through contamination from nitrate fertiliser, pesticide residues from excessive use). At the same time farmers are under immense pressure to maintain their livelihoods as increasing costs of production and a lack of market opportunities place them under financial hardship. Maintaining regional food and water security remains a significant challenge under the current environmental conditions that place long-term sustainability on a knife-edge.

RESEARCH APPROACH

Extensive field research studies involving on-farm adoption studies and a value chain analysis (linked to the supply and availability of ZT seed drills including the Happy Seeder) followed by a series of workshops engaging with stakeholder and senior policy makers provided the avenue for developing evidence based policy recommendations. In particular the study identified reasons why policy change is required, what policy changes would be effective, and how best relevant policy could be best implemented.

REGIONALLY SPECIFIC CHARACTERISTICS AND ISSUES

Cropping Systems in NW India (Haryana and Punjab)

Long-term sustainability of the intensive rice-wheat cropping systems are being questioned by farmers and agricultural experts. The impact of farmers burning rice straw residues prior to cultivating and sowing wheat is now recognised as a significant environmental problem, affecting all in the wider Indian community notwithstanding the serious air pollution problems in the nation's capital New Delhi. Despite the Happy Seeder being available commercially for more than 10 years as the only viable option to direct seeding cereal crops into standing crop stubble there is little farmer awareness of the technology. A lack of awareness and difficulty in accessing information combined with traditional farmer beliefs that crops can only be sown into well-tilled residue free seed beds serve as some of the major constraints to adoption of the HS and ZT seed drills.

Cropping Systems in the Eastern Gangetic Plains (Bihar and West Bengal)

Increased intensification of cropping systems across the Eastern Gangetic Plains (EGP) region is largely being achieved through the introduction of mechanisation in place of manual labour (that increasingly is becoming in short supply and more expensive). Whilst the manual harvesting of rice crops removes much of the straw (that is regarded as a highly valued animal feed source), an increasing trend towards the machine harvesting of crops is seeing a greater amount of stubble residue remaining in the field that is being burnt prior to the sowing of the next crop. Wheat straw residue levels (less valued as an animal feed source) are also increasingly being burnt in a trend triggered by the introduction of mechanical harvesting. The burning of rice straw residues is becoming an issue in western Bihar (in close proximity to the UP border region), as well as in the Malda district of West Bengal. As mechanical harvesting of rice crops becomes popularised it is anticipated that burning will become a much deeper concern. Availability of HS seeding equipment remains a challenge with poor sales and distribution networks, and very limited capacity in terms of machinery servicing, maintenance and operation.

Cropping Systems in Northern Bangladesh

Increased intensification of the cropping systems in northern Bangladesh is increasing as farmers aim to advance the intensity of their cropping systems even further. Whilst rice straw is a valued commodity for animal feed, like other surrounding regions it is expected that the burning of stubble residues will increase where the mechanical harvesting of crops increases. Agricultural mechanisation in the region is largely undertaken using two-wheeled tractors, and there has been a localised industry that provides the sales, servicing and maintenance support for the two wheel tractors. Implements designed and manufactured locally for the two wheel tractor include ZT seed drills. The smaller tractors are more affordable for the smallholder farmer and are well suited to fragmented land holdings comprising small plot sizes. The two-wheel tractors however require significant physical strength for the operator, placing the four wheel tractor at a more significant advantage and particularly suited for larger land holdings and/or for use in CHC operations.

Cropping Systems in Terai Region of Nepal

Increased intensification of cropping systems across the Terai region of southern Nepal has only in recent years become more of an accepted opportunity, however the benefits of such intensification is becoming apparent and has been clearly demonstrated through the SRFSI project and others. Increased mechanisation offers many advantages to village communities, however the opportunity to access tractors and ZT seed drills remains a significant challenge for most smallholder farmers. The establishment of CHC's at the farmer level presents a real opportunity to be capitalised upon as part of the out scaling initiatives associated with CASI systems development. Issues relating to the need to retain crop residues as part of a CASI system will require continued farmer awareness and education due to the conflicting practices between harvesting of straw for livestock production and the risk of stubble residues being burnt as stubble loadings post-harvest begin to build up as mechanised crop harvesting becomes more popularised throughout this region of Nepal. Availability of HS seeding equipment remains a challenge with poor sales and distribution networks, and very limited capacity in terms of machinery servicing, maintenance and operation.

THE OPPORTUNITY

Initiatives introduced to date across the Indo-Gangetic Plains (IGP) have successfully demonstrated the opportunity and potential for conservation agriculture sustainable intensification (CASI) technologies to significantly address cropping systems constraints. The development of Zero-Till (ZT) Seeding systems (using ZT seed drills including the 'Happy Seeder' (HS)) to sow crops without the need to burn or remove crop residues or cultivate the soil provides an opportunity to reverse traditional farming practices of burning crop residues and cultivation whilst at the same time significantly reducing crop establishment costs, improving irrigation efficiency and achieving similar if not higher crop yields.

Opportunities for the establishment of local service providers (Custom Hire Centres CHC's) that capture entrepreneurial spirit to assist in providing smallholder farmers with convenient access to the technology and locally adapted information are now available. Accelerating rapid adoption by farmers will not be realised unless the constraints to adoption, machinery technology and supply value chain inefficiencies (and impacts from the systems intensification associated with the green revolution) are addressed. Recommendations provided in this Policy Brief aim to support the development of an 'enabling environment' to assist in the accelerated adoption of ZT seeding systems in an innovation led farmer participatory driven environment.

POLICY INTERVENTION RECOMMENDATIONS

Consistent and long-term policies are required to achieve change and support the adoption of CASI technologies. The objective is to achieve scaled outcomes across the IGP, with all Governments needing to adopt a long-term planned approach towards providing an enabling environment for the adoption of ZT and HS seed drills. Demonstrated impact and benefits arising from policy implementation needs to be integrated into all initiatives, through introducing simple monitoring tools to measure practice change and improvements in environmental sustainability, including the use of GIS and satellite monitoring tools. A 'scorecard approach' applied consistently across the IGP to measure impact and benefits is required to help demonstrate the success and returns to government, industry and farmer investment in CASI related technologies.

KEY RECOMMENDATIONS ARE PRESENTED

1 ZERO-BURN FROM ZERO-TILL Awareness Raising Campaign be Introduced

A lack of awareness and availability of information relating to CASI technologies (such as the Happy Seeder) amongst farmers across all regions served as a significant barrier to adoption. An awareness campaign, through introducing a marketing campaign 'ZERO-BURN FROM ZERO-TILL' is strongly recommended, featuring ZT and HS seeding systems. The environmental, agronomic and economic benefits of the system need to be highlighted, in addition to addressing common farmer misconceptions that a well-cultivated soil (often using a rotavator) that is also stubble and plant residue free is required to successfully achieve high yielding crops. Awareness raising through social media, traditional media avenues, billboard advertising and the appointment of local 'champion farmers' as local advocates of the technology should be considered.

RECOMMENDATION 1: A communication / awareness strategy incorporating innovative digital media approaches that support the adoption of CASI technologies (focusing on ZT and HS) be developed and implemented as a long-term opportunity to create positive motivation for on-farm adoption.

2 Innovation Platforms as an Inclusive Extension Vehicle for CASI be Expanded

The introduction of InP groups offers such a collaborative framework to reach common goals. InP groups have successfully motivated farmer participants to work more closely with the private sector, and to develop entrepreneurial skills as a means of gaining access to CASI technologies such as ZT in the EGP. Through utilising the skills and experience of local research and extension specialists supported by farmer advocates and stakeholders associated with the provision of CASI related services, technologies and inputs ZT technologies have been successfully introduced.

RECOMMENDATION 2: Expansion of the InP on-farm program from EGP be extended to other targeted regions as an immediate priority to support the introduction and implementation of CASI related technologies (focusing on ZT and HS), facilitated through KVK's and Farmer Producer Organisations (FPO's).

3 Building a More Effective ZT/HS Seed Drill Supply and Service Sector

Field studies concluded that there is an urgent need to improve the quality, supply and availability of ZT and HS seed drills to farmers (particularly in EGP), the need to provide additional instructions on machinery operation and use, and maintenance of such equipment (including the supply of spare parts). A series of initiatives supported by Government and manufacturers be developed as an immediate priority in order to ensure the successful introduction of such equipment and minimise dis-adoption.

RECOMMENDATION 3: Machinery manufacturers should be provided with support incentives to assist them in providing a larger network of retail agents, service centres and farmer training schools (focusing on the maintenance and operation of equipment) in addition to introducing random market place quality checks for equipment to help support the adoption of ZT and HS seed drills.

RECOMMENDATION 4: A collaborative platform be established with representatives from the highest level of Government, responsible ministries and the manufacturing sector to help ensure that long term relationships and the needs of the industry sector are clearly identified and supported to help improve and support the development of effective ZT/HS seed drill supply chains.

4 Re-orientation of Government Subsidies and Support Mechanisms are Required

The provision of subsidies for the purchase of machinery provided by government is in urgent need of review, from the perspective of ensuring that funds directed towards incentivising adoption is maximised in a non-discriminatory manner in an environment of increasing public scrutiny. Subsidies provided to rotavators that reinforces poor farming practices needs cease immediately.

RECOMMENDATION 5: A re-orientation of mechanisms that currently provide direct subsidies for machinery purchase be reviewed and alternative models of support directed towards a range of options such as the removal of Government GST on machinery, providing access to affordable finance (consideration towards interest rate subsidies for both manufacturers and purchasers of equipment) in addition to developing business planning skills for custom hire centre operators be explored.

5 Concerted Effort to Support the Establishment of Sustainable Business Models for Custom Hire Centres (CHC's)

CHC's provide the opportunity for smallholder farmers to access ZT and HS seeding services that are easily expandable to include other technologies that support the development of CASI farming systems, cost-effective cropping inputs, marketing platforms, training and capacity building services. Once established and when linked to local Innovation Platform Groups, CHC's are driven by the entrepreneurial spirits of local community based operators who provide locally adaptable services and advice to farmers that in turn builds local capacity in relation to CASI systems. The development of Custom Hiring Centres (CHC) at district level is considered to be one of the best ways to achieve widespread adoption and out-scaling of technologies that is affordable and accessible by all farmers regardless of farm size. Proper functioning CHC's need to focus on providing convenient and affordable access to machinery for all farmers including smallholder farming women, and serve as the gateway to introducing sustainable and profitable conservation agriculture based systems to all farmers.

RECOMMENDATION 6: It is strongly recommended that a specific project team and support service be established that would provide a range of support services for the establishment of CHC's, including business and financial planning and governance support, business leadership, technical training (conservation agriculture equipment and CASI systems approaches).

6 Formation of a Regional Collaborative Platform (RCP) for the IGP Region

Establishing a RCP for the IGP region (comprising country representation from Pakistan, Nepal, India and Bangladesh) as a central platform for supporting the out scaling of CASI technologies, the sharing and dissemination of technical research and extension experiences, knowledge and resources is critical to addressing the regional challenges associated with ensuring widespread adoption of CASI, and active engagement and participation by all stakeholders in particular the private sector, farming women and other marginalised stakeholders. RCP membership should include: Principal Agricultural Secretaries at national/state levels; private sector representatives (manufacturers, input suppliers, finance sector), research (national and international), farmer/CHC representatives, and women's groups.

RECOMMENDATION 7: A Regional Collaborative Platform comprising representatives from the highest level of Government (Agricultural Ministry; research, extension and policy related) be established for the IGP region (comprising country representation from Pakistan, Nepal, India and Bangladesh) as a central platform for supporting the development of supporting government policy and the out scaling of CASI technologies through sharing and dissemination of information, knowledge and training resources, on-farm validation of best management CASI practices, training and capacity building.

KEY RECOMMENDATIONS REVIEW

1. ZERO-BURN FROM ZERO-TILL Awareness Raising Campaign be Introduced
2. Innovation Platforms as an Inclusive Extension Vehicle for CASI be Expanded
3. Building a More Effective ZT/HS Seed Drill Supply and Service Sector
4. Re-orientation of Government Subsidies and Support Mechanisms are Required
5. Concerted Effort to Support the Establishment of Sustainable Business Models for Custom Hire Centres (CHC's)
6. Formation of a Regional Collaborative Platform (RCP) for the IGP Region