CABI Ref: U3013

India's (BHU) Final Report to DFID

Reaping the Benefits: Assessing the Impact and Facilitating the Uptake of Resource Conserving Technologies in the Rice-Wheat Systems of the Indo-Gangetic Plain

Impact Studies On Zero Tillage Technology and Replacement of Varieties in Eastern Uttar Pradesh

Study by A K Joshi, R Chand and V. K. Chandola
Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India
Analysis and compilation by Dr Tahseen Jafry, CABI Associate

www.cabi.org
KNOWLEDGE FOR LIFE

Contents

Boxes, Figures, Maps and Tables

Boxes

Figures

Maps

Tables

Executive Summary

The goal of this DFID-funded project was to improve rural livelihoods through accelerated adoption of resource conserving technologies (RCTs).

Farmers in two villages, Bhurkura and Karhat, were assigned to one of the four socio-economic groups, i.e. Landless, Marginal, Subsistence or Food surplus/Cash cropping, depending on their landholding and perceived ability to take the risks involved in adopting new technologies. It must be noted that prior to the CABI project, the Banares Hindu University (BHU) team had been working with the Directorate of Wheat (DWR) and CIMMYT on the zero tillage (ZT) technology and replacement of wheat varieties, later receiving support from another DFID funded project on 'farmer participatory varietal selection' implemented through CIMMYT South Asia. Thus the data collected on impacts are not purely related to the CABI research project.

Data collected under Output 1 indicated that all socio-economic groups have benefited from using the ZT machine. It is the cash croppers and subsistence farmers who are the main users. However, during this research the project team did develop strategies to encourage more marginal farmers to use the machine. The main benefits are: increased wheat productivity, reduced cost of cultivation and sowing, and saving time in land preparation. Women benefit because there is said to be more food available. Also, using the time saved, the farmers are able to grow vegetables for home consumption which contributes to improved family diets.

Labour displacement was raised as a concern but the real extent of the problem remains unknown and it would be worthwhile for the project team to keep track of this.

Timely availability was cited as one of the major reasons for non-adoption of the machine. Also, there was strong demand for hiring rather than buying the machine. Although the project team did facilitate networking between farmers, private sector and government agencies, the fact remains that the number of private dealers wanting to provide ZT machines remains too small to satisfy the demand for them.

Investigations of the uptake of new varieties, shows that both the availability and affordability of quality seeds is given high importance by farmers in the adoption process.

Investigations into the ways in which farmers access information, under Output 2, indicated that marginal farmers are dependent on farmer–farmer contact for information whereas subsistence and food surplus farmers have many more sources such as newspapers, radio, and direct contact with scientists. Women farmers are dependent on their families for new knowledge and information.

The researchers concluded that marginal farmers preferred a much more 'seeing is believing approach' to the adoption of new technology. Subsistence farmers required more detailed skills orientation for confidence building and cash croppers were more interested in networking with private sector and government for knowledge.

This study has shown that the ZT technology and replacement of varieties are spreading to villages outside the core project sites. The speed of the spread of the ZT machines is not as fast as it could be, as illustrated by the maps in this report, this is attributed to the fact that the BHU team are the only serious promoters of this technology. Replacement wheat varieties are spreading more quickly across villages outside the core project villages. This is attributed to the success of farmer entrepreneurs starting to sell replaced varieties via their own seed multiplication businesses. The BHU team have demonstrated that participatory approaches and continual exchange of knowledge and information are key in successful development activities, as seen in the women's *Trichoderma* co-operative.

This research has shown that different socio-economic groups of farmers have different needs in terms of knowledge and that one package does not fit all. The BHU team developed a 'roving in the field' approach, which addressed this problem through confidence building.

A number of institutional blockages have been identified which prevents the adoption of technologies. These include lack of back-up support services from the government extension department, absence of seed of the newest varieties from the market and the limited number of machines available. But despite these blockages change is taking place.

This research has illustrated that the technologies are spreading to other villages. However, it has also shown that for technologies to scale up and scale out at a much faster pace, the involvement of a number of stakeholders from both the pubic and private sector is required. Achieving involvement of these groups of stakeholders proved to be difficult, despite project activities such as workshops for networking. The BHU team have worked hard to provide back-up support in the dissemination of new technologies in the project area, but without increased support from other stakeholders this process is likely to stall.

Acronyms and Abbreviations

BHU	Banaras Hindu University
CIMMYT	International Maize and Wheat Improvement Centre, Mexico
DAC	Department of Agriculture and Cooperation
DAP	Di-ammonium phosphate
DFID	Department for International Development
DWR	Directorate of Wheat Research
FLD	Front Line Demonstration
GoI	Government of India
IAS	Institute of Agricultural Research
ICAR	Indian Council of Agricultural Research
IFFCO	Indian Farmers Fertilizers Cooperative Ltd
IIVR	Indian Institute of Vegetable Research
IIVR	Indian Institute of Vegetable Research
KRIBHCO	Krishak Bharti Cooperative Limited
N.A.	Not applicable
NGO	Non-Governmental Organization
NPK	Nitrogen-phosphorus-potassium fertilizer
NSC	National Seeds Corporation
PVS	Participatory Varietal Selection
q	Quintals
RCTs	Resource-Conserving Technologies
Rs	Rupees
RWC	Rice-Wheat Consortium
UP	Uttar Pradesh
UPSSCA	UP State Seed Certification Agency
ZT	Zero Tillage

Introduction

Project Goal:

Improved rural livelihoods through accelerated adoption of productive, appropriate and sustainable agricultural practises:

- ***Increased incomes and social benefits***
- ***Increased productivity and food needs met***
- ***Sustainable agro-ecosystems***

Project Purpose:

To maximize opportunities and options for livelihood improvement by ensuring the relevance, impact and sustainability of new production mechanisms to optimise uptake of beneficial practises to all social strata involved in agriculture.

This project was implemented by scientists from CABI-Europe and CIMMYT South Asia, in collaboration with NARS scientists and local NGOs at five sites with rice-wheat farmers inhabiting villages across the Indo-Gangetic Plain:

- Dinajpur, Bangladesh (Wheat Research Centre + DIPSHIKA)
- Basti, Faizabad, India (Narendra Deva University of Agriculture and Technology)
- Varanasi, India (Institute of Agricultural Services, Banaras Hindu University)
- Belwa, Tarai region, Nepal (Nepal Agricultural Research Council + CIMMYT Nepal)
- Sheikapura and Sailkot, Pakistan (CABI Pakistan)

The Banaras Hindu University Team

The principal investigator for the BHU team was Dr Tahseen Jafry (CABI Associate) and the regional co-ordinator was Dr Etienne Duveiller of CIMMYT South Asia. The site manager was Dr. Arum Kumar Joshi, who was assisted by Ramesh Chand and Veerendra Kumar Chandola of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India.

Fig. 1. The BHU team at the planning workshop in Dhaka, December, 2004

Using a livelihoods approach to target the poorest farmers

The adoption of new technologies which impact on crop yields and/or household budgets pose a threat to the livelihoods of resource-poor farming families in terms of their food security and income, thus it is that only those farmers who have sufficient land to guarantee household food security throughout the year that can take the necessary risk. In an effort to target the poorest groups with our research, the following socio-economic categories were drawn up according to their ability to take risk:

- **Landless/ Food deplete farmer**: Must rent land or do paid labour to get food and pay for other necessities. *Cannot take any risks.*

- **Marginal/ Food deficit farmer**: Has insufficient land to achieve household food security. Regular shortage of food and cash. Must do labour in order to buy additional food, inputs and other basic necessities. Can enter a downward spiral very easily. *Cannot take any risks.*

- **Subsistence/Self-sufficient farmer**: Has sufficient land to meet basic food needs under normal conditions. May need to do labour to pay for inputs and other necessities (including school fees). Remains vulnerable to economic and environmental shocks. *Risk averse.*

- **Food surplus /Cash cropping farmer**: Has sufficient land to guarantee household food security. Able to produce surplus grain and cash crops for sale to buy inputs, send children to school and accumulate "middle class" assets, e.g. bicycle, TV, electric fan. *Able to take risk.*

According to this classification, only subsistence and food surplus farmers are able to take risk and therefore it is these farmers who are most likely to adopt new technologies.

Output 1: "Implications and benefits of new technologies on social well-being and system productivity and sustainability determined and key beneficial practises identified for each agro-ecosystem and social group within each community at selected benchmark sites."

1.1 Assessing the impact of improved technologies on farmers' livelihoods

The BHU team decided to investigate the impact of zero tillage on the livelihoods of four groups of farmers – cash cropper/large, subsistence, marginal and landless – on the use of resource conserving technologies (RCTs).

Tables 1–14 contain the results of this study. Presented below is an analysis and overview of the findings. The villages where this study was conducted are the initial core villages where the zero tillage (ZT) technology and new varieties were initially introduced. The study captures the impact that these technologies have made on these villages. Future research work will focus on where and how the technology has spread from these villages to the wider area.

1.1.1 Introduction of zero tillage machine

(a) Why was zero till technology introduced?

This technology was introduced as an RCT having several advantages. The technology was intended to reduce the cost of cultivation and advance the sowing date for wheat, thereby enhancing the profitability of wheat growing for farmers in the rice–wheat cropping areas of the North East Plains Zone of India comprising eastern Uttar Pradesh, Bihar, West Bengal, Assam and other North East States.

(b) Who introduced zero till technology to farmers?

It was introduced by Banares Hindu University (BHU) in 1997 through support from the Directorate of Wheat Research (DWR) (Indian Council of Agricultural Research; ICAR), Karnal. This was part of a strategic plan chalked out by ICAR, New Delhi, to solve the problems of the vast rice–wheat cropping region of the Indo-Gangetic plains of India. Later on CIMMYT (South Asia Office, Kathmandu) joined in promoting this technology. Currently, we have also been working with RWC, CIMMYT, New Delhi to promote ZT technology.

(c) How was zero till technology introduced to farmers?

This technology was introduced following the Farmer Participatory Approach in which ZT trials were arranged with conventional methods as the control. The participatory approach was initiated on the suggestion of Dr O. Ferrara, CIMMYT South Asia, Kathmandu, Nepal. It was first introduced in Karhat village (District Mirzapur) after a detailed survey was conducted to identify farmers showing interest in such technologies. Information concerning the success of this innovative technology being practiced in Karhat village spread and was soon adopted by other villages including Bhurkura village in the same district.

(d) Who were the first beneficiaries?

The first beneficiaries were Subsistence farmers who were desperate to improve the profitability of the rice–wheat cropping system. Subsequently, it spread to all categories of farmers.

1.1.2 Introduction of new varieties

(a) Why were new varieties introduced?

One of the reasons for low productivity of wheat in eastern India is the widespread use of older and inappropriate varieties by most of the farmers. In this part of India, around 80% of the wheat area is late (December) sown and the cultivar HUW 234 is most popular due to its tremendous flexibility; it is able to adapt to a range of sowing dates and management conditions. However, a number of other varieties are available that have the potential to be better yielding than HUW 234 especially under normal sown irrigated conditions. Therefore, these varieties were introduced to enable farmers to obtain higher yields for the same cost of cultivation. In addition, this component was added to obtain synergism with RCTs being introduced in this area. Since ZT technology gave the potential for advancing sowing dates of wheat, newer varieties were seen as another means of increasing yield and thereby enhancing farmers' profitability under diverse conditions of the North East Plains Zone of India.

(b) Who introduced wheat varieties to farmers?

Introduction of new varieties to farmers is not a novel activity in eastern India. It is an important activity of the government associated with extension of agricultural technologies to farmers. However, due to the existence of huge diversity in farmers' fields and weak linkages with sources of technology, many of the varieties are not able to reach farmers. The front line demonstrations (FLDs) of new varieties and associated technologies are conducted by the Ministry of Agriculture and ICAR all over India. However, there are various limitations to the use of FLD for convincing farmers to adopt new technology. The major limitation is that it is a mostly non-interactive type of activity in which the farmers' opinion is not given due consideration. Therefore, it was decided to involve farmers in Participatory Varietal Selection (PVS) which is an interactive type of activity. This approach was first suggested to BHU scientists by Dr Ortiz Ferrara, Regional Coordinator, CIMMYT South Asia, Nepal in 1997 and the work started immediately thereafter. The main idea behind this activity was to enable farmers to grow varieties which were best suited to their conditions and thereby enhance their profitability.

(c) How were new varieties introduced to farmers?

This technology was introduced through the Farmer Participatory Approach in which mother–baby trials were conducted. The mother trial consisted of around a dozen varieties including the local variety HUW 234 as a control. It was first tried in the villages of Karhat and Banouli (District Mirzapur) following the same approach adopted for the promotion of ZT technology in which a survey was made for innovative and intelligent farmers. Information concerning the success of the appropriate combination of better varieties and ZT spread and was soon adopted by a large number of other villages including Bhurkura village in the same district.

(d) Who were the first beneficiaries?

The first beneficiaries were largely Subsistence farmers who believed in innovative thinking and were able to take the risk of trying a new variety. But soon it spread to all categories of farmers.

1.1.3 Introduction of participatory seed production

(a) Why was seed production introduced?

Good quality seed is an important input desired by almost all the farmers. The seed replacement rate for crops like wheat is very low (less than 10%) in India. It is even less than this in eastern India. The poor availability of good quality seed is considered to be an important reason in the low productivity of wheat as well as other crops in eastern India. Generally, seed production in eastern India is undertaken by Government agencies. The private sector is less active in self-pollinated crops like wheat. However, some government agencies such as the National Seed Corporation (NSC) and the UP Beej Nigam (earlier called the Tarai Development Corporation before Uttaranchal was formed) involve farmers (mostly Large farmers with good resources) in seed production activity. But overall, very few farmers

used to be involved in seed production with almost zero participation of Subsistence and Marginal farmers.

As ZT and new varieties started becoming popular, farmers started demanding more and more seed of successful varieties. Since farmers were able to see the advantages of new technologies (ZT and appropriate variety), from the year following their introduction, i.e. 1998, they were given training in the production of good quality seed. This initiative was called participatory seed production. The initiative proved very useful since not only was availability of quality seed poor, but there was a mismatch between the varieties of seed available within the public or private sectors and those demanded by the farmers.

Through participatory research activities, one of the varieties selected by farmers, , HUW 516, reached the Advanced Varietal Trial of the All Indian Coordinated Wheat Improvement Project but was finally found not suitable for release. This variety is now being made available to farmers in a substantial area around Varanasi through participatory seed production. Similarly, HUW 510, a wheat variety released for late sown conditions in Peninsular India, is also becoming popular in eastern India. For timely sowing, which remains the main objective of all to secure good yields, HUW 468 became very popular and rapidly replaced HUW 234. Farmer to farmer interaction was also encouraged.

(b) Who introduced seed production to farmers?

Participatory seed production was introduced by the BHU wheat team that was promoting use of ZT and appropriate wheat varieties among farmers.

(c) How was seed production introduced to farmers?

Participatory seed production was introduced through the Farmer Participatory Approach, in which farmers were given practical training in the field. They were trained in all the steps of seed production, i.e. obtaining a small amount of good seed from a reliable agency such as BHU, cultivating pure seed in the field, and processing and seed production (through special training days). Now seed days are an important part of the National Seed Project (ICAR) in all universities and institutions.

(d) Who were the first beneficiaries?

The first beneficiaries of participatory seed production were mostly subsistence farmers who accepted new varieties and ZT. Soon this spread to Marginal farmers as well. Many cash cropper/large farmers who were initially not interested in seed production have also taken up this activity. For example in Karhat village (Mirzapur) a few farmers (subsistence and marginal) under the leadership of Mr Anil Singh have opened up a new seed agency with the name 'SOORAAJ SEEDS'. In Bhurkura village (Mirzapur), within two years of the introduction of participatory seed production activities, around 30% of the village's growing area was being used for seed production (i.e. in the year 2003-04).

1.2 Results of Impact Studies

1.2.1 'User map' for machinery and livelihood impact assessment studies

(a) Bhurkura village

Users of machines

In this village, it is clear that the ZT machine has made a positive impact on the socio-economic situation of the farming community as a whole. The main impact has been food security, largely because, through the use of the ZT machine, wheat production has increased. In 2004, between 70% and 80% of the village's growing area was cultivated using ZT. It is recognized by the farming community that the machine does mean that fewer labourers are required to manage the land, but this is not having a negative impact. On average, broadcasting and ploughing required four labourers for 2.5 ha of land. Using ZT technology, this same area requires only two labourers. However, since the village is in close proximity to Varanasi, there also seems to be no shortage of employment opportunities in the

construction industry where landless labourers can get work. Generally, work in the construction industry is better paid than agriculture. Overall, the cost of sowing and cultivation has reduced.

Although, wheat production has increased, this has not had the effect of generating more paid work but has led to an increase the amount of physical work in harvesting because there is more wheat to harvest. Overall, harvesting is easier because the crops are sown in lines. It is mainly women who are involved in harvesting (Fig. 1) and they get paid a fixed amount per hectare that they harvest. On average the harvest amounts to 6.4 quintals (one quintal = 100 kg) per hectare.

Fig.2. Women find harvesting easier because crops are sown in rows

For users of the machine, whether they are marginal, subsistence or cash cropper/large farmers, there are cost savings, and there are both monetary and time aspects to this. Monetary savings come from the lower cost of cultivation and having more to sell in the market, while the time that is saved allow farmers to tend growing vegetables and spend more time in caring for the family.

For all socio-economic groups of farmer, there were some initial fears about using the ZT machine when it was initially introduced in 1997. This was mainly attributed to lack of farmer confidence and absence of clarity about the benefits given the cost of necessary inputs. However, since the introduction of the machine, there have been increases in crop production and this has improved farmer confidence. The landless, although they do not possess land, want training in how to operate the machine so that they can benefit as machine drivers.

There are also quite clear natural resource/biological impacts from the use of the machine, including:

- Fewer insects.

- Fewer pests.
- Less disease.
- Reduced incidence of grasshoppers.
- Reduced requirement for fertilizer, e.g. sulphur, zinc.
- Fewer weed problems.
- No water related problems.
- Less infestation by *Phalaris minor.*
- Better germination of seed.

There were also some other natural resource/biological issues. These were:

- It clogs up in heavy soil.
- More weeds than before

The results of this study also indicate that there are not enough machines available to reach all farmers. The reality is that the owners of a machine use it first before passing it on to other farmers on a first come first served basis (see Table 5). Consequently, the institutional issue that has arisen is the request for more machines to be made available, both to purchase and to hire. Overall, there is more demand for hiring than purchasing. There is significant interest in getting more private dealers in the area to further popularize the machine and enable access and availability to all socio-economic group of farmers.

Non –users of the machine
In this village, it seems that reasons for non-use of the machine by landless farmers are not an issue because most of them get paid employment in the nearby cities and towns. Some of the landless use the machine on other farmers' land. In turn they get wages as labourers. They are not taking any risk themselves because it is not their crop they are farming with the machine. So, if the crop fails it is not a catastrophe for them.

Reasons for not using the machine seems to be a more of an issue with marginal farmers. This group do not have risk bearing capacity because they cannot afford to take risk. Most marginal farmers are busy in other employment to earn income and so do not have time available to take part in BHU training programmes on the use of the machine. The farmers do not want to give up paid employment to take part in training programmes for a machine they may not use or have use for.

For subsistence farmers, the issue of availability is important. They can take the risk but they cannot hire a machine at the right time. The owners use the machines first, work gets delayed and so ploughing is the only option. There is great demand for hiring a machine (see Table 6).

For non-users among large farmers, the main issue is investment. This is the cost of purchasing and running a machine, including fuel, maintenance, spares, etc., compared with the cost of hiring. The machine is only required for 15 days a year and so some do not want to invest in this capital item. Again there is significant demand for hire schemes.

(b) Karhat village

Users of machines
The use of ZT technology has spread to cover approximately 80% of the land in the village since its introduction 4 years ago. All socio-economic groups of farmers are benefiting from this machine directly and indirectly.

The landless farmers in this village take land on lease and hire a machine to use on it. They are convinced of the benefits in terms of cost saving, and the pay off in increased crop production. The main concern of landless farmers is the rental charge: it is expensive to hire a machine. Equitable access to this technology is an issue, and creating mechanisms which would allow for this need to be developed. The Landless in this village have not yet had the

opportunity to participate in any ZT training programme. This is mainly because they are in the cities and town in employment as daily wage labourers. Perhaps this is something that could be looked at in the future, which would also address equity issues.

On the whole, for marginal farmers, yield, income and food security are positive impacts of the machine. Women are happier because the food security situation has improved. This group is also able to sell surplus. The only negative impact is the cost of hiring. Marginal farmers do not have the appropriate level of monetary flexibility to allow spending on machinery for agricultural production. They also have a very low risk bearing capacity.

For subsistence farmers the cost–benefits of using the technology are apparent. They have reduced their cost of cultivation and are getting good yields. Part of this cost saving is in using fewer labourers than for conventional tillage. However, this is not a negative impact at the village level because labourers who are no longer employed by the subsistence farmers get employment opportunities in nearby Varanasi. This work is usually in the construction industry which also pays better than working in agriculture. Subsistence farmers also sell surplus yield in the local markets.

The owners of the machines (who are the cash croppers/large farmers) have by far the greatest benefits, in terms of reduced cost of cultivation, increased production, sale of surplus and food security, mainly because they have the largest plots of land. Some do provide demonstrations to other farmers and encourage them to use the machine. There are only three machines in this village and the biggest draw back is one owner not wanting to hire his machine to others for personal reasons. This places huge demand on the remaining two machines and again points to the need for more machines, and for more hire schemes to be implemented.

Natural resource and biological issues are the same as those described above from Bhurkura village (refer to section 1.2.1 (a)).

Non-users of machine

There are some landless farmers who do not have much knowledge about the machine because they do not use it. However, they are benefiting from its use. Increased production means that there is more to harvest and there is sufficient employment in harvesting.

In this village, marginal farmers indicated that they cannot afford to take the risk of using it because they have only smaller plots of land, and also the rental cost of the machine is too high for them. It is a question of affordability rather than usability/adoptability.

For subsistence farmers it is a question of availability and affordable hire charges. As with Bhurkura village, the owners use the machines first, and by the time a machine is available it is too late in the season for some to use. Equitable access is an issue that needs to be addressed.

As found in Bhurkura village, investment is an issue and many are not willing to pay for a machine that is only required for 15 days a year. Not all farmers see this as an investment opportunity – i.e. the potential for gaining income from running a hire scheme. The development of private sector hire schemes are a must if the technology is to reach all groups of farmers.

1.2.2 Calendar of machine use

The calendar of machine use, given in Table 5, for the year 2004 for Bhurkura village supports the socio-economic impact study in that, on the whole, it is the cash cropper/large farmers and subsistence farmers that have priority for machine use. The total number of days these groups use the machines in the sowing season does not leave enough time for the other groups to get their sowing done in a timely fashion.

Although approximately 70% of the farmers in Bhurkua village cultivated using a ZT machine, it would be interesting to know which socio-economic groups the remaining 30% of farmers, who do not use the machine, belong to. This needs further study and clarification.

From the data, it is also quite clear that two machines are not sufficient to give the whole of the village access to and benefit from them. This does raise the wider issues of equitable access and the development of research strategies to ensure that an enabling environment is created to allow access for all.

The calendar of machine use, given in Table 6, for Karhat village for the year 2004 indicates that there is no pattern to the order of machine use, for either Marginal or Subsistence farmers. Approximately 80% of the villagers are using ZT. It would be interesting to know the socio-economic makeup of the remaining 20% and to understand what prevents them from adopting the technology.

1.2.3 Resource maps

(a) Karhat village map

The resource map in Fig. 2 indicates that there are two machine owners. In the red colour: Anil Singh. In the black colour: Ramjee. The green colour indicates non-users.

It is quite clear that, irrespective of machine owner, it is the cash cropper/large farmers and subsistence farmers who have best access to a machine. The Marginal farmers have a lower priority in the order of machine use. However, on a positive note, marginal farmers are utilizing the machine. It is also interesting to note that non-users of the machine (Subsistence and marginal farmers) have plots adjacent to users yet they are not convinced about its use. Perhaps it is just a question of access. It is also notable that the spread of machine use is concentrated around the owners. This map does not indicate much if any spread of the technology around the rest of the village.

In order to get a better idea about the spread of the technology in the village, it would be of interest to complete the village map indicating the order of use and to identify areas where the machine is not being used if at all. It would also be useful to compile some maps of machine use in villages around Karhat in order to get an idea of the spread of machine use area-wise and also by socio-economic farmer category.

(b) Bhurkura village map

The map of this village is Fig. 3. There are three owners of three machines in this village. In the red colour: Bhagwat Singh. In the green colour: Sanjay Singh. In the black colour: Bhola & Indra Sen Singh.

In this village the machine is used initially by Large farmers but then the spread of machine use does not follow any pattern, varying between large, subsistence and marginal farmers.

As with Karhat village, the spread seems to be concentrated around the owner's plot, with one exception, user number 11 Chadra Masi Singh, who has taken a machine right to the other side of the village. It would be interesting to document how farmers on the other side of the village perceive this technology. And also to document how machine use has spread outside of the village.

1.2.4 Livelihood impact studies of users and non-users of new varieties

The adoption of new crop varieties by farmers has a number of advantages; it increases crop diversity, there may be fewer pests and diseases, and also the new varieties may be better adapted to local conditions. There are also some disadvantages; such as seed of new varieties not being available, (or conversely) lack of market demand for some new varieties, and no local knowledge about the new varieties. CIMMYT and DFID have been working on promoting the adoption of new seeds since 1998 via their participatory varietal selection and participatory plant breeding research programme. Much of this work was initiated in Bhurkura

and Karhat villages. A livelihoods impact assessment study has been conducted with farmers who have and have not adopted the new varieties being introduced in order to understand issues that determine adoption of technology by different socio-economic groups of farmer.

Users of a new wheat variety who attended BHU demonstrations - Bhurkura and Karhat villages

BHU have been promoting new varieties and it is clear that information is available to all socio-economic groups of farmer that attend demonstrations. However, the quality and quantity of information that is retained by farmers varies. For instance, landless farmers in Karhat, who take land on lease, depend on a head farmer for guidance and faith because they feel that they do not know enough about the technology. Cash cropper/large farmers tend to play a pivotal role in the extension of technology. They are able to take more risk and thus able to experiment with new seeds, grow many different varieties and grow enough for home consumption and to sell. The impact study indicates that farmers from within the village come to see the plots of cash cropper/large farmers who are experimenting with new seeds. Subsistence and Marginal farmers, on the other hand, cannot take risks and can only grow enough for home consumption. It is apparent that replaced varieties have provided these Marginal farmers with better yields and they are now more food secure.

A spin off from the introduction of new varieties is seed production and many farmers, from all socio-economic categories, are interested in developing seed production businesses, which makes financial sense.

Marginal farmers in Bhurkura village have been using new seeds for 2 years, compared with cash cropper/large farmers in Karhat village who have been using them for 5–6 years. This indicates that although the technology is spreading it takes time, but it also indicates that perhaps more emphasis needs to be given to helping Subsistence and Marginal farmers adopt technology more quickly.

Non-users of a new wheat variety who attended BHU demonstrations - Bhurkura and Karhat villages

Despite having attended demonstrations, there are still farmers from all socio-economic groups who have not adopted new varieties. The main reason for this is that they are not totally convinced about the benefits of adopting new varieties. Farmers know that scientists from BHU do visit the villages but farmers want more interaction with them. This study shows that BHU scientists have played a vital role in the introduction of new varieties. However, a limited number of scientists from BHU cannot reach individual farmers and cannot cover the whole eastern Indo-Gangetic region. Extending dissemination of knowledge about new varieties across the region and to all socio-economic groups is required in order to have greater impact in terms of adoption. Developing mechanisms to scale up and scale out this technology is essential.

Other reasons for non-adoption of the technology are the limited availability of good quality new seed and the affordability of it. Affordability is more of a concern for marginal farmers who are not in the position to take risks.

Users of a new wheat variety who did not attend BHU demonstrations - Bhurkura and Karhat villages

There are a number of factors that determine whether farmers attend demonstrations. Reasons for not attending demonstrations in these particular villages include: perception of farmers' meetings as political; there may be jealousy/poor relationships between farmers; and employment in other jobs means they do not have time to take part in demonstrations. But despite this, farmers' feedback from the villages indicates that information is spreading amongst farmers about new varieties. Overall, the landless farmers (those who take land on lease) are dependent on the head farmer for their information. Other than this, they rely on asking farmers from within the village, and the quality of information they get back depends on whether farmers are interested in talking to them

The main source of information for marginal farmers is via relatives. Subsistence farmers have more sources of information including newspapers, radio and contact with BHU scientists. Cash cropper/large farmers have direct contact with BHU scientists, and access to TV and newspapers. This project needs to capitalize on these sources of information and pathways of information transfer so that information can be disseminated more widely, reaching many more villages. It also needs to look more closely at how to strengthen pathways to reach the Subsistence and Marginal farmers so that they receive the same quality and quantity of information as the cash cropper farmers, as this can affect the adoption of technology.

Non-users of a new wheat variety who did not attend BHU demonstrations - Bhurkura and Karhat villages

Little information was available on this group of farmers. The only reason for not using new varieties was lack of availability of quality seed. No information has been provided on why these farmers do not attend demonstrations.

1.3 Discussion

1.3.1 Zero tillage

At the time of introduction, all farmers had an initial fear about using the ZT machine. There was lack of confidence and very little interest or enthusiasm about it. However, since its introduction in 1997 the impact on farmers' well-being has been positive. This study has shown that the main benefits of using the ZT machine across the two villages by each of the socio-economic groups are:

- Food security.
- Reduced cost of cultivation and sowing.
- Time saving.

Maintaining food security is a high priority and it is mainly the role of women to ensure there is enough food to eat. The fact that wheat and rice production has increased has changed the lives of these farmers, whether cash cropper/large, subsistence or marginal. The cash cropper farmers do have surplus to sell. This is mainly due to the fact that they have the larger plots but some Marginal farmers now do not need to buy paddy or wheat in these two villages because they have a greater yield owing to the use of the ZT machine.

The saving in the cost of cultivation varies. The large farmers save the most because they do not need to employ labourers. However, it seems that these 'displaced' labourers do get employment opportunities in Varanasi in the construction industry, which actually gives better incomes than working in agriculture.

For the other farmers, there are other savings in monetary terms too. For instance, using the time that is saved by ZT cultivation, farmers grow vegetables to feed the family so that they do not need to buy them in the market.

Approximately 70% of Bhurkura village farmers and 80% of Karhat village farmers use the ZT technology. It would be interesting to know the socio-economic make-up of the remaining farmers who do not use the technology and to understand what prevents them from adopting this technology.

The main reason for non-use of the machine, by all categories of farmers, is lack of access. More specifically:

- Marginal farmers: They do not have the risk bearing capacity, only have small plots of land, and cost of hiring is too high. It is a question of affordability rather than use-ability.

- Subsistence farmers: They can take the risk but there is an availability problem: they cannot get a machine at the right time.
- Cash cropper/large farmers: For them it is a question of investment. The machine is only required for 15 days per year and most do not want to invest in this capital item.

Equitable access to this technology is a major issue, and creating a mechanism which would allow better access needs to be developed and given priority. The calendar of machine use indicates that in Bhurkura village, it is the cash cropper/large farmers who have priority access to the machine. To change this, the private sector or other dealers need to be encouraged and to establish themselves in the area so that there is no demarcation over access. Creating an enabling environment could mean developing a strategy which would allow marginal farmers to have access to a machine at the same time as Cash cropper/Large farmers.

The resource maps given in Figs 2 and 3 indicate that both users and non-users of the machine (subsistence and marginal) have plots adjacent to each other. This poses a question: is it really a question of access or are the non-users still not convinced about its use? It is also notable that the spread of machine use is concentrated around the owners of machines. This is probably because the immediate neighbouring farmers see the machine and want to use it. But getting the technology further disseminated was a key aspect of this project and was addressed under output 2.

1.3.2 Replacement of varieties

This study has indicated that information on new varieties of seed is getting through to farmers in the villages. However, the four main factors that determine the adoption of technology are:

- Quality of information reaching farmers.
- Quantity of information reaching farmers.
- Availability of good seed.
- Affordability of good seed.

The landless farmer, who takes land on lease, is reliant on the head farmer for guidance and information. They place their 'faith' in these farmers because they themselves do not have enough information to make a decision about whether to adopt a new variety or not.

Cash cropper/large farmers do have a vital role to play in the extension of technology because they are able to experiment with many more seeds since they can take the risk of crop failure. Marginal farmers are beginning to adopt new varieties, although not as quickly, and are reporting to be more food secure than before for doing so. Future direction needs to focus on getting better quality of information to marginal farmers to help them adopt new varieties more quickly.

There seem to be several reasons why farmers do not attend demonstrations (farmers' meetings are seen as political, employment in other jobs with concomitant lack of time to attend, poor farmer–farmer relationships). Even those farmers who have attended demonstrations, there are many who have not adopted new seed varieties. The main reason for this is that they are not totally convinced about the benefits. There seems to be a lot of emphasis placed by farmers on the need for BHU scientists to visit individual farmers and convince them to adopt new varieties. This may be possible in one or two villages but it is impractical on a large scale. The only way to reach a really large number of farmers is to develop an effective knowledge dissemination strategy that focuses on each socio-economic group of farmer.

The study shows that different socio-economic groups of farmer have access to different sources of information:

- Marginal farmers depend mainly on relatives and other farmers.
- Subsistence farmers have more access to newspapers and radio and some contact with scientists.
- Large farmers have TV, newspapers, radio and direct contact with scientists.

Future work needs to concentrate on capitalizing on these information pathways and to develop mechanisms to get quality information to all farmers.

Table 1: Bhurkura village – impact studies with users of the machine

	Socio-economic	Human	Biological/natural resources	Institutional issues
Landless/ labourers	• No shortage of work. • No change in wages noticed. • No migration of labour. • "Have leased land and have planted seed using ZT machine." • Harvesting in ZT field requires 3 labourers instead of 4. • Sowing requires less labour but higher production gives more work during harvesting.	• Training not required as only delivery pipe needs to be checked • Knowledge of machine is available. • Women who visit field during sowing are well aware of this machine.	• Wheat production has increased. • Harvesting is easier due to well levelled field and line sowing. • Requires one irrigation less than conventional method.	• Want training on machine use so that can obtain work as tractor driver. • Machine rent is 800 Rs/ha.
Marginal farmers	• Used less seed. • Used less fertilizer. • Saved time in sowing – 30%; 50% now take land on lease for sowing vegetables, spending time with family. • Advancement of sowing by 8 days. • Increase in yield: sold 10 quintals in the market, previous sold only 3 quintals (1 quintal earns 700 Rs). • Used less labour – e.g. reduced from 6 persons/acre for sowing to only 2 persons. • Cost of sowing is reduced by 750 Rs/ha, 1000 Rs, 70%. • Improved wealth.	• Obtained information from BHU. • Confident about using machine; no need for training. • Saw machine in use and understood its use and advantages. • Initial fears but now confident in its use. • First time user – still waiting to see its benefits. • Making comparison by machine on half the plot and preparing half by conventional method. • Taken informal training from other farmers. • Low percolation of knowledge about machine to women.	• Clogs in heavy soil. • Good in black soil. • No crop diseases • Reduction in disease – blight • Fewer pests. • Good in all soil types. • More weeds than before. • More pests. • Fewer weeds – uses less herbicide. • Use DAP, urea, farm yard manure, SSP, NPK. • Requires less fertilizer. • Does not need training, easy to use machine. • Knowledge transferred from other farmers, radio, TV, newspapers.	• Not enough machines available. • Can maintain machine independently.
Subsistence farmers	• Timely sowing, more time for better growth. • 15 days advancement of sowing. • Time saved used for growing other crops, e.g. radish, off farm activities, socializing. • Labour saved – 2/3 labourers less for planting. • Increase in yield by 20%; 4 tonnes/ha, 2 quintals/acre. • Helped to start seed production because of better quality of grain.	• Disseminating the knowledge as an informed individual (teacher). • Obtained training from BHU (informal), knowledge sharing with others. • Less percolation of knowledge about technology to women. • No formal training required. • Gained knowledge to avoid slippage of tractor wheel in case of increase in moisture. • Efficiency of work is enhanced.	• No difference in insect pest attack. • Fewer insects. • Fewer pests. • Less disease. • Incidence of grasshopper reduced. • Uses compost, urea, DAP, NPK. • Reduced requirement for fertilizer, e.g. sulphur, zinc. • Reduced weed problems. • Increased incidence of fertilizer use. • No water related problems. • Can be used on any soil type. • Difficult to use in heavy soil. • Reduced infestation of *Phalaris minor.* • Better germination of seed. • Water logging problem is solved.	• Subsidy of ZT machine from government. • Demonstration in the village. • Women are aware. • Institutional support for better seed quality needed.

continued

Table 1 continued

	Socio-economic	Human	Biological / natural resources	Institutional issues
Cash cropper / Large farmers	• Time saved in planting. • Less seed required, 30–40 kg for ZT compared with 200 kg conventional method. • Less fertilizer used. • Labour saving. • Increases yield, from 35 quintals to 45 quintals/ha. • Increase in market price – from 6 to 7 Rs/kg. • Increased profit.	• More employment for 2 Landless labourers	• Bold grains. • More tillering. • Less water required. • Weed infestation is less. • No yellowing after irrigation. • Less fertilizer is required. • Use green manure, urea, DAP.	• Obtained informal training from BHU. • Frequent visits (2–3/month) by BHU staff. • Demonstrations in the village.
Owners [Cash cropper/ Large farmers who own a machine]	• Cost of sowing/cultivation reduced by 50%; saved 2500 Rs, 5000Rs, 2200 Rs. • Increase in yield – by 2 quintals, by 20%; before had 2.5 tonnes/ha. • Timely sowing, advanced by 15 days; more time for crop growth and development. • Labour saving, previously required 20 days for planting; now only 7 days. • Purchased a machine to make money from hiring scheme.	• Initially not confident, now feels comfortable. • Good for women because line sowing makes harvesting easier than in broadcasted fields.	• Fewer insects – grasshoppers. • Useful in all soil types. • No water problems. • Urea, DAP, compost. • Good germination. • Early planting. • Crops look good.	• All purchased from UP Agro for 13000 Rs (after 5000 Rs subsidy). • Good training from BHU. • women know less than men. • UP Agro for maintenance and BHU. • Chisel behind the wheel needs to be longer. • Good machine, all kinds of farmers can use it.

Table 2: Karhat village – impact studies with users of machine

	Socio-economic	Human	Biological/natural resources	Institutional issues
Landless/ labourers	• Rental charges is too high – 1200 Rs/ha. • Take land on lease and want to use machine to save time – half a day for 0.25 ha instead of 3 days. Can get work in construction/road building.	• Machine looks good to use but not seen it in the market.	• No problems and it has increased production.	• No training on use of machine but have listened to BHU scientists talk about the machine.
Marginal farmers	• Advance of sowing date, 10–20 days • Increase in yield, from 6 to 8 quintals; sold the extra quintals, over 5 years 18–48 quintals. • Saved on cost of sowing, 2400 Rs, 2000 Rs, 400 Rs/ha, 1200 Rs/ha – used to be 2400 Rs now 1000 Rs. • No need to purchase grain from outside. • Hiring charges too high – 300 Rs for ¼ ha, 800 Rs/ha • Saved seed and fertilizer from 200 kg/ha to 120 kg/ha. • Small farmers cannot purchase machine. • Does not hire labour, family does the farm work, previously 12 days/ha for sowing, now 3 days/ha. • Sowing is done in half the time. • Using machine and new variety, yield gone from 18 quintals/ha to 50 quintals, 17 to 40, 18 to 40. • Able to sell extra for cash.	• Training is not required. • Women in know about the machine. • Women are happier about food security; from 24 quintals/ha to 32 quintals/ha. Family requires 7 quintals; can sell the rest. • Trained in farmer's field by BHU. • Understood the machine, no need for more training. • Obtained information from village head.	• Chemicals are costly. • Does not know about herbicides. • Crop does not become yellow after irrigation. • Requires less water. • Black soil no problem. • DAP, Urea, Potash. • Planting early but not sure when he will get canal water. • Less fertilizer used. • Less seed is used. • grass hopper attack – this year Grasshopper came more because winter was late and had planted early, control by phoridon – 400 Rs/ha. • No disease. • Good germination. • Weed problems remain.	• None identified
Subsistence farmers	• Saved cost in cultivation, 2000 Rs, 400 Rs. • Earlier sowing by 15 days. • Time saved; used in poultry farming, labouring in construction. • Triggered use of new variety, more seed replacement. • Early sowing, early harvesting – led to better yield • Less seed used • Less fertilizer used • Good crop establishment • More food secure • Required less labour, from 3 to 1, for sowing. • Sell a bit if left after own consumption.	• Known about ZT for 5 years, using it for 3 years. • Information from BHU, and village head. • No need for training. • Women know about the technology. • No knowledge reached women about technical issues.	• Reduced weeds • Reduced water required for 1st irrigation. • Less seed required. • Reduced waterlogging. • Less use of urea and DAP. • Insect attack during seed germination. • Increased weeds. • No difference in insects/pests. • Can be used in all soil types.	• Information from BHU and village head, who disseminated knowledge. • Urea and DAP from co-operative society. • Need extension support. • Demonstrations are good.

continued

Table 2 continued

	Socio-economic	Human	Biological / natural resources	Institutional issues
Cash cropper / Large farmers	• Increase in yield, 30 to 50 quintals/ha. • Using [machine] for 6 years and no risk. • Sowing cost is halved. • Helps in line sowing. • Sowing date advanced by 15–20 days. • Labour saved. • 400 Rs saved toward cost of seed.	• Information came from BHU. • No training needed. • Women do know about [machine] but not technical matters.	• No difference in insects and pests. • Reduced water use. • Crops look better in the field stand better. • No difference in soil compaction. • Urea, NPK, Farmyard manure.	• Credit required
Owners [Cash cropper/ Large farmers who own machines]	• 15 day advancement of sowing date. • Saved 1600 Rs in cost of sowing, reduced cost by 50%. • Used to employ 3 labourers for 10 days, now needs only 2 labourers for 3 days; labour used in sowing is less than half. • Increase in yield of more than 2 tonnes/ha.	• More food secure. • Money saved is used for other cash crops. • Trained at BHU. • Mother and wife know about the machine. • Conducts demonstrations to other farmers to prove [machine's] worth.	• no problem with water. • Urea, DAP, NPK, cow dung manure. • Crops require less water. • Field looks good.	• 3rd owner only uses machine himself, does not want to hire.

Table 3: Bhurkura village – Impact studies with non-users of the machine

	Socio-economic	Human	Biological / natural resources	Institutional issues
Landless / labourers	• "We do not use the machine but are only involved in filling seeds and fertilizer into tanks and check delivery pipes." • "We use the machine on other people's land to get wages."	• "We do not need knowledge about the machine as we do not use it, we have no land."	• "Have heard from others that crop yield is good."	• "I accept that the machine is good."
Marginal farmers	• Three machines in the village."I know about it but do not use it." • "I have fear as I have only 0.125 ha land and am unable to afford the risk."	• "We do have some knowledge and have interacted with scientists from BHU."	• "Machine seems to be good for production."	• "Not received any training. Would like training but am busy in betel nut shop from morning to evening."
Subsistence farmers	• Lack of sufficient machines. • Owners use machines in their fields first and hence machines are not available at appropriate times. Work gets delayed, field dries so ploughing is the only alternative. • Impressed by ZT machine. Want to use it but can't get access due to heavy demand.	• "Not fully informed of the machine and its uses." • "Do want training on use."	• "Have not used the machine so we can't talk about the issues."	• "Do want to use the machine if available for rent at the appropriate time."
Cash cropper / large farmers	• "Do not use. Field dries by the time we have to do sowing." • "Have a tractors and will buy [machine] if available at low cost." • "Machine is only needed for 15 days so hiring is a good option."	• "Do have knowledge about the machine but not been trained. Do want training."	• "This year grasshoppers attacked the fields. Do not have any information on chemicals for this problem."	• "Machine hiring schemes are required."
Owners [Cash cropper/Large farmers who own machines]	• n/a	• n/a	• n/a	• n/a

Table 4: Karhat village – impact studies with non-users of machine

	Socio-economic	Human	Biological / natural resources	Institutional issues
Landless / labourers	• Farmers sow wheat by machine which gives greater production and more for us to harvest. Harvesting Is easier. • Earn enough to get food for the year. Get 100 days work/year from farming. • Construction and building jobs pay more wages.	• Don't know much about the machines, only that it is good for sowing and production.	• Don't know because don't use. But production has increased in the village.	• No training taken.
Marginal farmers	• Machine in the village. Not used it. • Have enough rice but not wheat. • Buy wheat from wages from job in irrigation department.	• Scientists have come to the village • I have only 0.125 ha, can't afford to take risk. • May use next year.	• Machine is good for production but rent is too high. Should not be more than 800 Rs/ha	• No training taken but do want.
Subsistence farmers	• Not enough machines in the village. Owners use them first so not available at appropriate time. Work gets delayed, field dries so ploughing is the only alternative. • Impressed by ZT machine. Want to use it, but can't get access due to heavy demand.	• Not fully informed of the machine and its uses. • Do want training on use.	• Have not used the machine so can't talk about the issues.	• Do want to use the machine if available for rent at the appropriate time.
Cash cropper / Large farmers	• Do not use. Field dries by the time machine available. • Have a tractors and will [machine] buy if available at low cost. • Machine is only needed for 15 days so hiring is a good option.	• Do have knowledge about the machine but not been trained. Do want training.	• This year grasshoppers attacked the fields. Do not have any information on chemicals for this problem.	• Machine hiring schemes are required.
Owners [Cash croppers/ Large farmers who own machines]	• n/a	• n/a	• n/a	• n/a

Table 5: Calendar of machine use in Bhurkura village in 2004[1]

(a)

ZT machine owner: Bhagwat Singh			
Priority	**Name and social group[2]**	**Period used (days)**	**Area tilled (acres)**
1	Bhagwat Singh CC	2	10
2	Dilip S CC	1	7
3	Chandswami CC	2	11
4	Bhagwat Singh CC	2	6
5	Gulab M	0.5	2
6	RamBachan M	2	10
7	Ram Ratan M	0.5	2
8	Ramesh Vishu M	0.5	2
9	Balkishan Dixil S	0.5	2
10	Rakesh Panday S	0.5	2
11	Ram Lal S	1	4

(b)

ZT machine owner: Bhola Singh and Indra Sen Singh			
Priority	**Name and social group[2]**	**Period used (days)**	**Area tilled (acres)**
1	Bhola Singh CC	15 days in total between them	45
2	Indra Sen Singh CC		
3	Bhafalu M	1	5
4	Gaun Shankar S	2	6
5	Tej Bali S	1	3
6	Amresh Singh S	1	5
7	Unknown	0.5	2
8	Ram Surat S	1	8
9	Shiv Pajan S	1	5
10	Shiv Moorat S	0.5	7

[1]This village has two machine owners.

[2]Farmer group: CC = Cash cropper. M = Marginal. S = Subsistence. L = Landless.

Table 6: Calendar of machine use in Karhat village[1]

ZT machine owner: Anil Singh			
Priority	**Name and social group[2]**	**Period used (days)**	**Area Tilled (Acres)**
1	Anil Singh (CC)	7	12.5
2	Ram Swamp (S)	0.5	2
3	Saddhu (M)	0.25	3
4	Mana Cal (M)	0.25	1
5	Dukhanlu (M)	0.25	2
6	Shanti (M)	0.25	2
7	Raj Kumar (M)	0.25	1
8	Bihan (L)	0.25	1
9	Ramjanam (S)	0.25	3
10	Ram Chandar (M)	0.25	1
11	Shivdhani (S)	0.25	1
12	Babulal (S)	0.25	1.5
13	Babulal (S)	1	6
14	Ramneruh (M)	0.5	1.5
15	Ramdhan (M)	0.5	1.5
16	Ramdhan (M)	0.5	3
17	Loknath (M)	0.5	2
18	Jairaw (M)	0.5	1.5
19	Lallu (M)	0.5	1.5
20	Soran (S)	0.5	1
21	Rajlal (S)	0.5	1
22	Dallu (S)	0.5	2
23	Banwan (S)	0.5	3
24	Jawahar (M)	0.5	1.5
25	Ramakant (S)	0.5	1.5
26	Vinod (M)	0.5	1.5

[1]This village has one machine owner.

[2]Farmer group: CC = Cash cropper. M = Marginal. S = Subsistence. L = Landless.

Table 7: Bhurkura village – impact studies with users of the new variety (attended demonstrations)

	Socio-economic	Human	Biological / natural resources	Institutional issues
Landless / labourers	• Take 0.25 ha land on lease (brother gives money for this) and take new seed varieties from lead farmer (who gets from BHU). • Lead farmer grow many varieties. • Grow sufficient wheat for consumption but not for sale. Have paddy in surplus for sale.	• Do not know much about new seed varieties. Get some info from BHU but and lead farmer.	• First time grasshoppers in wheat field. Obtained Folidol from lead farmer to control.	• Get information from BHU and lead farmer who is employer. • Prefer not to work in dairying or other indoor job.
Marginal farmers	• Have been using new varieties for 2 years. • Do know about many new varieties from BHU. • Introduction of new varieties have changed economic situation. • Have food security now.	• Seems to be 2 groups in the village: the progressive group and those who only criticise. The progressive ones are doing well.	• Saw grasshopper for the first time in fields. This was less in late sown wheat.	• Want to know about seed production. Some farmers are doing this and earn good money. • Need training for this.
Subsistence farmers	• Get information from BHU scientists. • Purchase seed from UP Agro. • HUW 234 liked best because it gives good production. • Sells surplus paddy for income but not wheat. Wheat is for own consumption and for cattle.	No data collected	• No disease on wheat.	• Get information from BHU and lead farmers
Cash cropper / Large farmers	• Get lots of new varieties from BHU. Able to experiment with them. • Prefer new varieties because gives good yield.	• Produce enough rice and wheat for whole family. • Earn 100 000 Rs in selling grains. • Purchase only pulses.	• Grasshopper attacked early sown wheat due to high temperature in December. When temperature went down grasshoppers died away.	• Regular contact with BHU, and with BHU via friends.

Table 8: Bhurkura village – impact studies with non-users of the new variety (attended demonstrations)

	Socio-economic	Human	Biological / natural resources	Institutional issues
Landless / labourers	• "Do know of new varieties but will only use new variety when convinced." • Not in a position to take risk.	• Produces enough food for consumption but not enough to sell. • Wants to diversify into dairying. Gives better return on investment. • Off-season work in construction.	• "Saw grasshoppers from paddy damaging wheat crop."	• Gets information from BHU and lead farmer. • "Want more of such interactions, it gives us confidence and makes us feel more secure."
Marginal farmers	• "Do not know much about new varieties. The ones I know about, there is not good seed available. • Seed is costly. • Needs to purchase seed for home consumption.	• Not met any scientists so far but know they come to the village.	• "Not much disease on wheat but this year grasshopper was a problem."	• Wants to interact with BHU scientists who come to the village and to do training programmes.
Subsistence farmers	• "Do not know much about new varieties." • "Know that BHU come to the village but I have conflict with lead farmer so I do not get knowledge." • Most wheat is sold in the market.	No data collected	• "There were grasshoppers this year."	• Would like information from BHU.
Cash cropper / Large farmers	• Has not seen any variety other than HUW234. • Need good grain quality. • "Food is not a problem. Sell both wheat and paddy."	• "Know that BHU scientists come to the village. Not met them but if they have an alternative to HUW234 than I will only use if convinced."	• Grasshoppers attacked wheat especially adjacent to canal bunds.	• "Information I get from newspaper, friends, relatives. Not met scientists from BHU because of my shy nature."

Table 9: Bhurkura village – impact studies with users of the new variety (did not attended demonstrations)

	Socio-economic	Human	Biological / natural resources	Institutional issues
Landless/ labourers	• Take 0.25-0.5 ha land on lease. • Was convinced by lead farmer. • "Was guaranteed success if I used new variety." • Last year harvested 20 quintals/ha, with new variety got 27 quintals/ha. • "New grains make better flour." • "Have enough rice and wheat for the year."	• "Do not eat much fruit and vegetables." • "Try to work on vegetable cultivation but marketing is difficult."	• New variety was free of disease. • Did not face grasshopper problem. • Tillering was good and colour was dark green.	• Get information from contact persons in the village. • "Listen to good farmers but they do not talk much." • "Have to keep on asking farmers who are in a good mood."
Marginal farmers	• Gets new varieties from relatives. • "Do not get the correct information from within the village." • "Many factors control relationships in the village including jealousy." • Yield has improved. • Has sufficient paddy but wants more wheat yield.	• "Diversifying into vegetable production is difficult because of marketing issues."	• Paddy MTU7029 has lots of pests. • Wheat is free from pest problems. • Does not use any chemicals.	• "Training is good if it is tailor made for our benefit." • "Training for new employment generation would also be good."
Subsistence farmers	• "Got new seed varieties from farmer in nearby village where I have good relations." • Are getting good yields. • Have enough to consume and also do sell rice and wheat to get income. • "Am in regular contact with people doing new things but never attend demonstrations." • "Farmers meetings are generally political." • "Seen scientists from BHU in the villages but want to meet them in my house."	No data collected	• "New varieties are good." • "Disease is less but weeds are the same." • "This year grasshopper attacked wheat."	• "Get information from other farmers and newspapers." • "Heard BHU scientists talking on the radio."
Cash cropper/ Large farmers	• "Am a school teacher so do not have time to contact scientists from BHU." • "Got new varieties from farmer who has contact with BHU." • Produces enough rice and wheat for home consumption and for selling. • Purchases pulses and spices.	No data collected	• Grasshopper attacked wheat. • "Grasshoppers died from cold weather in December."	• Gets information from friends and relatives. • Wants to develop strong relationships with scientists and universities.

Table 10: Bhurkura village – impact studies with non-users of the new variety (did not attended demonstrations)

	Socio-economic	Human	Biological / natural resources	Institutional issues
Landless / labourers	Not data collected	No data collected	No data collected	No data collected
Marginal farmers	• "Know about other varieties but good seed is not available at low cost." • "Relatives said they would give me some seed of new varieties." • "Not met any scientists from BHU." • "Wheat production is not good." • "Need 4 quintals of wheat for home consumption but only getting 2 quintals."	No data collected	• "Not seen any disease on wheat but lots on paddy." • Uses a lot of chemicals to control pest and diseases. • Uses nothing for wheat.	• "Ready to participate in any training. on how to improve our production. and income."
Subsistence farmers	No data collected	No data collected	No data collected	No data collected
Cash cropper / Large farmers	No data collected	No data collected	No data collected	No data collected

Table 11: Karhat village – impact studies with users of the new variety (attended demonstrations)

	Socio-economic	Human	Biological / natural resources	Institutional issues
Landless / labourers	• Takes land on lease. • Takes new seed varieties from lead farmer who gets them from BHU. • "Do not know much about new seed but have faith in the lead farmer." • Seen 12 variety trials. • Has sufficient paddy for sale but not wheat. • Gets money for leasing land from brother.	No data collected	• Grasshoppers in wheat. Used folidol from lead farmers to control spread. • Use DAP and urea.	• "Get information from BHU and lead farmer who is my employer." • Also works in construction during the off season.
Marginal farmers	• Does grow new varieties. • Takes land on lease and does seed production with lead farmer. • "Got right information from BHU scientists on saving seeds and fertilizer use." • "Seed businesses are also coming to us for purchasing of seed."	• "Thankful to BHU for uplifting us. I never thought I could do seed production." • "Get a lot of encouragement from BHU scientists." • Wheat production has increased considerably. Can sell and making good profit. • "I am financially better and my social prestige is like a good farmer."	• "New varieties, HUW 468, HUW 510, HUW 516 and PBW 343 do not show disease but weeds are still the same." • Did re-sow one field due to grasshopper damage.	• Seen demonstrations in the village and visited BHU several times.
Subsistence farmers	• Source of information is BHU. • "Growing new varieties for last 5–6 years and now doing demonstrations ourselves."	• "I am now called an important farmer." • Was an ordinary farmer before but is now a seed grower. • Has involved 5–6 marginal farmers in the seed business. •	• Some problem of waterlogging. • Use pesticides • Grasshopper problem only this year.	• Gets information from BHU and lead farmers. • Interested to take further training.
Cash cropper / Large farmers	• "Get new varieties from BHU. Scientists have been visiting us for many years. Get information from them." • "Farmers from other villages come to see our crops. • "New varieties give more production and hence more income." • "Have enough food. Also have job for extra income."	No data collected	• "Grasshopper attacked early sown wheat so had to replant." • "Grasshopper due to high temperature in December."	• Get information and ideas from BHU.

Table 12: Karhat village – impact studies with non-users of the new variety (attended demonstrations)

	Socio-economic	Human	Biological / natural resources	Institutional issues
Landless/ labourers	• Will use new variety when fully convinced. • Cannot take any risks. • Enough wheat for home consumption but not for sale. • "Have enough food grains but do not have money for other things."	No data collected	• "Saw grasshopper damaging wheat crops. Given pesticide by lead farmer."	• "Get some information from BHU and lead farmer. " • "Want more interaction of this type because it boosts our confidence."
Marginal farmers	• "Know about other varieties but good seed is not available at low cost." • Needs better wheat production. • "Do not produce enough wheat from home consumption so need to purchase."	No data collected	• Grasshoppers attacked early sown varieties.	• "BHU scientists came to our field. Want more interaction with them because relationship with lead farmer is not good."
Subsistence farmers	No data collected	No data collected	No data collected	No data collected
–Cash cropper/ Large farmers	No data collected	No data collected	No data collected	No data collected

Table 13: Karhat village – impact studies with users of the new variety (did not attend demonstrations)

	Socio-economic	Human	Biological / NR	Institutional issues
Landless / labourers	• Knows of some varieties, e.g. HUW 468. "New variety means more production." • Has enough rice and wheat for consumption but not for sale. "Lack of money for other things." • Work in construction to get extra money.	No data collected	• "Disease is less in new variety."	• Information received from farmers and employer. • No training taken. • Wants interest free loan to start dairying.
Marginal farmers	• "Did not attend demonstrations but just came to know that new varieties are good." • "Wheat production has gone up. I am financially better of and taking more land on lease." • "Wheat production has increased and made us more food secure."	No data collected	• "New varieties do not show any problem of disease but weeds are the same." • Waterlogging is a problem.	• Receives information from other farmers.
Subsistence farmers	• Did not attend demonstrations but got to know of new variety from social contacts and fellow farmers. • "Wheat yield has increased and raised our confidence of using new variety." • Wants also to try seed production.	• Increased confidence to try new things.	• Disease is less. Weeds can be managed by herbicide.	• No training taken, but eager to meet scientists from BHU. • Get printed matter from BHU.
Cash cropper / Large farmers	• Source of information is BHU but does not say why did not attend demonstration. • Uses new variety because it gives higher production. • Are food secure. Only purchase pulses and oils.	No data collected	• Grasshopper attacked early sown wheat.	• Gets information from friends and relatives. • Information also from newspapers and TV. • Interaction with scientists from BHU.

Table 14: Karhat village – impact studies with non-users of the new variety (did not attend demonstrations)

No information on this.

	Socio-economic	Human	Biological / natural resources	Institutional issues
Landless / labourers	• –	• –	• –	• –
Marginal farmers	• –	• –	• –	• –
Subsistence farmers	• –	• –	• –	• –
Cash cropper / Large farmers	• –	• –	• –	• –

Fig. 3. Village resource map: Karhat

Fig. 4. Village resource map: Bhurkura

Output 2: "Agricultural knowledge systems identified in regions concerned, uptake and adoption blockages ascertained and strategies developed to overcome these and optimise pro-poor development"

2.1 Introduction

New hope has emerged among the farmers of eastern Uttar Pradesh following the positive impact of the ZT technology and some of the new high yielding varieties of wheat in Varanasi and adjoining districts, especially Mirzapur and Chandaul. A team from the Institute of Agricultural Sciences, Banaras Hindu University has been promoting these new technologies since 1997–98 in a proactive manner with the collaboration of the DWR (ICAR), Karnal, and CIMMYT, Mexico. From the year 2001–02, the Department of Agriculture and Cooperation (DAC), Government of India also extended support to BHU for this activity. Recently, some other organizations such as DFID (UK) have also given support through the University of Bangor, UK and CIMMYT, Mexico. This section of the report looks at addressing Project Output 2: knowledge pathways and identifying blockages to knowledge flow to farmers.

2.2 Location of Villages

A study was conducted in two core villages to look at knowledge pathways in the context of ZT technology. Specifically, activities were undertaken to address blockages to knowledge and information about ZT technology so that they can be overcome and thus the technology popularized among all socio-economic categories of farmer. The first village, Karhat (Post office: Narainpur) is situated in Mirzapur district and located around 25 km east of Banaras Hindu University. The second village, Bhurkura, is also in Mirzapur district and is around 20 km from Karhat village.

2.3 Approaches Taken to Popularize the Zero Tillage Technology

2.3.1 The overarching approaches to popularize the technology

- A participatory approach was used having an interactive component between scientists and farmers.
- A multidisciplinary team of scientists worked in a participatory manner with different categories of farmers for greater impact. The team consisted mainly of a plant breeder, a plant pathologist and an agricultural engineer with active support of entomologists, agronomists, soil scientists, agricultural economists and social scientists.
- ZT was used alone and in combination with new high yielding wheat varieties, then compared with controls.
- Farmers of all categories namely, subsistence, marginal and cash cropper/large, were involved, and these were selected based on their interest in and capacity to try a new technology. Landless farmers were also encouraged to join in.
- Gradually, other activities such as quality seed production, *Trichoderma* production and its usage, diversification of crops, etc., were introduced.
- All categories of farmers were encouraged to initiate activities such as custom hiring of machines, creation of seed and other societies/groups, development of better marketing skills, etc., to increase their incomes and profits.
- Visiting scientists from different parts of the country and abroad were also involved in field visits to develop further confidence among farmers.

- Farmers' work was honoured in farmer–scientist workshops to encourage and develop local leadership in promoting such activities.
- A great deal of promotional material was produced using print as well as electronic media.
- Gradually, other stakeholders became involved in the promotion of the new technology and also in giving an integrated shape to the programme in order to enhance farmers' profitability.

2.3.2 Specific CABI activities

(a) Farmer–scientist workshops and their impact – looking at geographical spread, locations, farmer groups and other stakeholders

In order to achieve a greater area planted with wheat using ZT technology and to encourage farmers to use the technology, farmer–scientist workshops were initiated in 2002. The workshops were to be held before the start of the *Rabi* crop season. In the first two years (2002 and 2003) they were organized for 10 November, but with an increasing area being sown early because of the uptake of ZT and a change in the mindset of farmers, the third workshop was organized around ten days earlier i.e., 30 October, 2004.

Objectives of the workshops

The main objective was to encourage the direct participation of more and more farmers in adopting RCTs such as ZT and surface seeding along with use of appropriate seed varieties, quality seed production, *Trichoderma,* etc. In addition, the meeting aimed to expose farmers to other useful practices such as seed priming, integrated weed management, efficient marketing of wheat and use of information technology, etc. for increasing their profit and speeding up the process of poverty alleviation in rural areas.

Stakeholders/participants in the workshops

The major stakeholders were farmers from Varanasi and adjoining districts of eastern Uttar Pradesh as well as Bihar. In the first workshop, around 150 farmers from 42 villages belonging to eleven districts of Uttar Pradesh and one district of Bihar participated. In the subsequent workshops, the number of farmers grew substantially (Table 15). As shown in Table 15, the participation of all categories of farmers increased over the three years including that of the landless.

Subsistence and cash cropping/large farmers both increased their participation by 22%, while that of marginal farmers increased by 13% and landless by 9%.

Other than farmers and scientists of Banaras Hindu University, stakeholders that have been participating in such workshops are from CIMMYT, National Seeds Corporation (NSC), Indian Farmers Fertilizers Cooperative Limited (IFFCO), Indian Institute of Vegetable Research (ICAR), UP State Agriculture Department, UP State Agriculture Extension Department, UP State Seed Certification Agency (UPSSAC) NGOs, private companies such as the Indian Tobacco Company (ITC), farmers societies, etc.

Table 15: Participation of farmers in the three farmer-scientist workshops organized by Banaras Hindu University

Socio-economic catagory	Numbers participating		
	Ist year (2002)	2nd year (2003)	3rd year (2004)
Farmers			
1. Landless	4	15	44
2. Subsistence	48	129	366
3. Marginal	85	188	383
4.Cash cropper/large	13	27	57
Total farmers	**150**	**400**	**850**
Villages	42	78	132
Districts	10	12	15
States	2	2	2

Table 16: Participation of various stakeholders in the three farmer-scientist workshops (2002-04) organized by Banaras Hindu University, Varanasi, India

Workshops	Stakeholders	
	No.	Names
Ist year (2002)	4	Farmers (all categories landless, subsistence, marginal and large) BHU NGO (Surabhi Sodh Sansthan) Private sector (ITC)
2nd year (2003)	9	Farmers (all categories: landless, subsistence, marginal and large) BHU IIVR (Indian Institute of Vegetable Research) NSC (National Seeds Corporation) UP State Agric Department. UPSSCA (UP State Seed Certification Agency) NGO (Surabhi Sodh Sansthan) Private sector (ITC; seed companies) Press and media
3rd year (2004)	14	Farmers (all categories: landless, subsistence, marginal and large) Farmers cooperatives BHU IIVR (Indian Institute of Vegetable Research) NSC (National Seeds Corporation) KRIBHCO (Krishak Bharti Cooperative Limited) UP State Agric Department. UP Agric Extension Department. UPSSCA (UP State Seed Certification Agency) IFFCO (Indian Farmers Fertilizers Cooperative Ltd) NGO (Surabhi Sodh Sansthan) Private sector (ITC, Dhanuka pesticides, Kafico, Plant care, Northern Engineering, local seed companies etc.) Niryatak Kheti Bari (an agricultural magazine group) Other press and media

In the first year, the stakeholders were few (four) but increased in number in the subsequent two years (see Table 16). This was again indicative of the growing popularity of the ZT technology and impact of these workshops in creating new linkages and extending the area in which the technology was being used.

General programme of the workshops

In the first year, the workshop programme was divided into four major sessions, viz., inauguration, addresses by scientists and farmers, followed by field demonstrations. The same pattern was kept for the next year but the venue was changed from Institute Seminar

Hall (Institute of Agricultural Sciences, BHU) to the biggest auditorium of the university (Swatantrata Bhawan). The idea behind this change was not only to accommodate the growing number of participants but also to extend full honour and facilities to our farmers.

In the third year, an exhibition cum demonstration element was added to the programme which was organized for the whole day i.e. 8 am–5 pm, to run simultaneously with the rest of the programme. In this exhibition, sale of seeds of different crops and vegetables was also arranged by the National Seed Corporation and the Indian Institute of Vegetable Research, Varanasi. All other stakeholders such as IFFCO, UP Government, NGOs, private companies, farmers' seed societies and the women's *Trichoderma* group also displayed their products on different stalls.

Except for the inauguration session, a two-way interaction was encouraged in the sessions, and around two-thirds of the total time was devoted to questions and answers. In these workshops, an important discussion was devoted to reviewing the work done under ZT in farmer's fields during previous years and to looking for the possibility of extending the programme into newer areas.

A very interesting aspect of the third workshop was that farmers were given the opportunity to run a session by themselves to share their experiences in a free environment. This was useful in making interactions more real and acceptable for participating farmers. The number of farmers sharing the microphone with the audience increased substantially with the years (see Table 17), which was indicative of both the growing confidence of farmers and greater interactions. It was interesting to note that even farmers belonging to landless categories were able to share their experiences with other farmers.

Table 17: Number of farmers and other stakeholders sharing the microphone in the three farmer-scientist workshops organized by Banaras Hindu University (2002-2004)

Number	Ist year (2002)	2nd year (2003)	3rd year (2004)
Scientists	10	12	18
Farmers			
1. Landless	0	1	3
2. Subsistence	1	3	10
3. Marginal	1	7	22
4. Cash cropper/Large	6	10	17
Total Farmers	**8**	**21**	**52**
Other stakeholders	2	6	12

Honouring farmers

In each of the workshops, a very important activity was honouring the farmers whose performance in the previous crop seasons had been commendable. Farmers were given honours irrespective of their economic status. The major criterion in the selection of such farmers was the impact they had made in influencing other farmers, from the same or different villages, to use the technology. The limitations for the less well-resourced farmers were taken into account. Thus, all categories of farmers were honoured. So far, out of 30 farmers honoured, one was from the landless category, six were subsistence farmers, eight were marginal farmers and 15 were large farmers. In addition, honours were also given to different institutions viz. IFFCO, National Seeds Corporation, Kafico (Bhabhua, Bihar) and Women Bio-agent Group (Rehiya, Mirzapur) who played active roles in the promotion of new technologies and farmers' profitability.

The honouring of farmers proved very helpful in following ways:

1. All categories of farmers felt encouraged and thus healthy competition was initiated for promoting technology adoption and creating an impact in different villages and localities.

2. It strengthened linkages between farmers, scientists and other stakeholders.
3. It created 'Ambassadors of Technology' in the form of innovative farmers to meet the objectives of the whole programme.
4. Spread of technology was made easier owing to increased numbers of hands popularizing the technology.

Impact of farmer–scientist workshops on dissemination

Although, the impact of the workshops is visible in the growing number of farmers and other stakeholders attending (Tables 15 and 16), they helped in making positive impacts in different categories of farmers in the following ways:

Impact on landless Farmers

- Presence of a large number of farmers of all categories convinced Landless farmers more effectively about the positive role of ZT technology.
- Since landless farmers work with marginal and large farmers, their enhanced understanding of the ZT machine and technology also helped with greater promotion of the technology.
- The interaction of landless farmers with scientists and other stakeholders increased substantially.
- A gradual increase in participation of landless farmers over three workshops led to a build-up in their confidence in taking advantage of the new technology.
- Participation of landless farmers in the adoption of ZT technology nullified the fear of losing work and thus helped in further popularization of the technology.

Impact on marginal farmers

- Participation by marginal farmers was largest, hence the adoption of ZT was also noted to be highest among them.
- Group meetings provided an opportunity for marginal farmers owning machines to acquire new customers eager to use the new technology.
- The interaction of marginal farmers with scientists and other stakeholders increased substantially.
- The workshops helped in building their confidence about RCTs and associated technologies like new varieties, quality seed production, etc.

Impact on subsistence Farmers

- The presence of large numbers of farmers also convinced Subsistence farmers more effectively about the positive role of ZT technology and they started adopting ZT technology through custom hiring. Hence, they also contributed significantly to the dissemination of ZT technology.
- The interaction of subsistence farmers with scientists and other stakeholders increased substantially.
- Participation by subsistence farmers increased significantly leading to a build-up in their confidence with regard to RCTs.

Impact on cash cropper/large farmers

- Cash cropper/large farmers, being more influential, were more able to convince to other categories of farmers about the advantages of ZT technology. Hence, their interactive role helped in greater promotion of the technology.
- They also influenced other cash cropper/large farmers not aware of the technology and thus enhanced purchases of ZT machines from manufacturers.

- Cash cropper/large farmers also played an important role in influencing relevant government officials over providing subsidy for ZT machines.
- Since landless farmers mostly work with cash cropper/large farmers, they were most influenced by them.
- The workshop provided opportunities for large farmers owning machines to acquire new customers eager to use the new technology.

Overall impact of the workshops

- The number of villages wanting to participate in the ZT technology programme increased from 42 to 132, with indirect influence on around 1000 villages.
- The number of stakeholders increased from around four to more than a dozen.
- They further strengthened scientist–farmer interactions and there were increased numbers of farmers (of all categories) as well as scientists from Banaras Hindu University, the Indian Institute of Vegetable Research and even from ND University of Agriculture and Technology, Faizabad.
- They helped enhance the confidence of farmers as the number of speakers (farmers) increased significantly over the three years. In the first workshop, it was mostly large and marginal farmers who took an active part. But in the subsequent two workshops, participation by landless and subsistence farmers increased significantly.
- They strengthened participatory research involving all categories of farmers. The proportion of subsistence and marginal farmers attending these workshops was around 75% of the total farmer participants. Landless farmers also joined in gradually and increased their participation from negligible at the first workshop to around 10%. This was achieved by encouraging farmers to attend and by timing the workshops at the right time so that the landless were able to attend.
- They strengthened the fusion of plant breeding and engineering to optimize utilization of the potential of different management practices.
- They contributed to an increased in the area under ZT from 10,000 acres (2002–03) to around 100,000 acres in the crop season 2004–05.
- They helped in providing suggestions for fine tuning of machines by manufacturers, thereby leading to more acceptance of the ZT technology.

(b) Training-cum-group meetings organized by BHU scientists

A number of training-cum-group meetings was organized in Bhurkura and Karhat villages and in neighbouring villages. The major objectives of these meetings were:

1. To demonstrate and develop confidence among the farmers about the efficient use of ZT technology in farmers' fields, which was gaining popularity in the rice–wheat cropping areas of whole of the eastern India.
2. To create awareness among the farmers about new high yielding varieties of wheat for different management conditions to optimize the use of their limited resources.
3. To seek an integrated fusion of farmers' resources and knowledge with new cost effective technologies.
4. To solve any other problems being faced by farmers with regard to using the technology.

The training-cum-group meetings were always organized in the farmers' fields (randomly selected without bias, and where everyone felt comfortable) and were conducted without any use of audio, tents, chairs or involvement of ornamental dignitaries. The meetings were

organized at four stages in the crop cycle: (i) prior to sowing; (ii) during sowing when around two-third of sowing was still to be done; (iii) one month later; iv) at crop maturity. This way the entire season was covered to promote proper use of the technology and remove any doubt among farmers on its use. This also enabled frequent interactions with farmers and helped in winning their confidence.

For each meeting the following activities were conducted:

1. Generally, all categories of farmers were informed a week in advance of the meeting. However, on occasion, no prior information was given in order to catch farmers actually at work in their fields.
2. At the beginning of the meeting, all the available farmers were informed in the field about the purpose of the meeting (a process taking a few minutes).
3. Farmers and scientists walked around different fields and thus were divided into different groups with different (generally 3–4) scientists having different specializations. This helped the scientists to develop friendships with all categories of farmers, and also to remove farmers' hesitation from interacting, which is very common with landless or small and marginal farmers. Thus, such arrangements helped in attracting all groups of farmers (landless, subsistence, marginal and cash cropper/large) to attend the meeting without hesitation.
4. Farmers were given practical training with a few important tips about proper use of the new technology. In addition, pamphlets with photographs and simple descriptions were also given.
5. All farmers were encouraged to speak more, encouraging discussion to take place. Scientists spoke last.
6. Suggestions regarding improvements needed to the machine were recorded for communicating to the manufacturers.
7. Finally, all participants would sit together for refreshments and any last discussion.
8. The Meeting ended with informal thanks to all.

(c) Impact of training-cum-group meetings on different group of farmers

The impact of training-cum-group meetings on each category of farmers can be understood from the following:

Impact on landless farmers

- Landless farmers, being mostly uneducated, are more effectively convinced through the 'seeing is believing' approach. The training-cum-field visits played an effective role in this respect. Thus adoption and dissemination of the technology became faster among weaker sections of farmers.
- Sound linkages were created between landless farmers and innovative farmers and collaborating scientists.
- The process opened doors for other technologies and options to improve the livelihoods of these farmers, such as better varieties, seed production, diversification, other RCTs, bio-agents, etc.
- The meetings brought about a change in the mindset of landless farmers towards innovative technologies and helped build more confidence in them.
- They also helped scientists to broaden their understanding of the realities of rural farming and to find effective approaches to promote ZT technology.

Impact on marginal farmers

- Seeing the success of ZT in different fields for themselves, marginal farmers' discussions with scientists and other stakeholders shifted from 'questions related to

use of ZT technology' to other aspects such as, when and from where to purchase machines, how to improve marketing of the increased produce, etc.

- Marginal farmers became strongly attracted to the technology and thus its adoption and dissemination happened faster.
- The process created a strong bond between marginal farmers and other stakeholders including scientists.
- Marginal farmers started looking for other new technologies and options to improve their rural livelihoods, such as better varieties, seed production, marketing, diversification, other RCTs, bio-agents, etc.
- A link was created between farmers and manufacturers with scientists serving as a conduit for making further improvements to the machine.
- Marginal farmers had more opportunities to meet different farmers interested in the technology, and this gave greater scope for custom hiring of machines.
- The meetings brought about a change in the mindset of farmers towards innovative technologies and helped build more confidence in them.

Impact on subsistence farmers

Subsistence farmers were exposed to the use and field performance of ZT and this strengthened their confidence in innovative RCTs.

- Subsistence farmers were attracted to the technology and thus adoption and dissemination of technology became faster.
- The process created strong linkages between subsistence farmers and scientists and other stakeholders.
- It opened doors for other technologies and options to improved rural livelihood, such as better varieties, seed production, marketing, diversification, other RCTs, bio-agents, etc.
- The meetings helped scientists to broaden their understanding of the realities of rural farming and to find effective approaches to promote ZT technology.
- A link was created between subsistence farmers and manufacturers with scientists serving as conduit for making further improvements to the machine
- The meetings also brought about a change in the mindset of Subsistence farmers towards innovative technologies and helped build more confidence in them.

Impact on cash cropper/large farmers

- Training-cum-field visits influenced large farmers capable of purchasing machines. Thus many large farmers started purchasing ZT machines for their own work and also for custom hiring.
- Large farmers adopted ZT technology quickly and they started looking for good quality machines for extending this technology to other crops.
- The process created strong linkages between large farmers and scientists, other stakeholders and all groups of farmers interested in using the machines.
- Large farmers became more responsive to innovative technologies such as new varieties, seed production, marketing, diversification, other RCTs, bio-agents, etc.
- Links were created between influential farmers, scientists and manufacturers for making further improvements to the machine
- The meetings also brought about a change in the mindset of farmers towards innovative technologies and helped build more confidence in them.

2.3.3 Development of maps showing the spread of zero tillage technology and new varieties, 2003 onwards

(a) Development of maps

A number of maps of villages adjoining the core project villages of Karhat and Bhurkura have been included: Maps 1–6 (for Bhurkura) and Maps 7–10 (for Karhat). These are discussed in more detail below.

(b) List of maps

The list below indicates the maps that were produced for the study. The maps are a visual display of the adoption and uptake of ZT machine and new seed varieties during the lifetime of the project.

Map 1
Map of villages around village Bhurkura, Mirzapur displaying purchase years of ZT machines.

This map indicates that between 2003 and 2004, the use of the ZT machine spread to four new districts surrounding the core project village of Bhurkura. The purchasers of the machines were Cash croppers and Subsistence farmers.

Map 2
Map of villages around village Bhurkura, Mirzapur displaying ZT coverage during the 2004–05 crop season. The percentage area under ZT was calculated using actual survey data for the total area under cultivation for wheat and that covered by ZT.

From 2003 to 2005, the use of the machine spread to six villages. In the core project village, 75% of the area is sown by ZT machine. In the adjoining districts, this percentage is much less but this is to be expected since the technology is slowly filtering out.

Map 3
Map of villages around village Bhurkura, Mirzapur displaying adoption of ZT after its introduction in 2000-01.

Since its introduction in 2000-2001, all types of farmers have been using the machine. Although the numbers are small it is encouraging to see that Marginal farmers are using the machine.

Map4
Map of villages around village Bhurkura, Mirzapur displaying adoption of new wheat varieties along with ZT.

The adoption of new wheat varieties is spreading from the core village of Bhurkura. It would be interesting to capture the length of time it takes for adoption to reach 70%+ in the surrounding villages.

Map 5
Map of villages around village Bhurkura, Mirzapur displaying adoption of quality seed production along with ZT and new varieties.

The adoption of quality seed production seems quite popular, with the adoption of seed production along with ZT being practised in at least four other villages.

Map 6
Map of villages around village Karhat, Mirzapur displaying purchase years of ZT machines.

This map indicates that between 2003 and 2004, the purchasers of the ZT machine came from 12 new villages surrounding the core project village of Karhat. The purchasers of the machines were Cash croppers and Subsistence farmers.

Map 7
Map of villages around village Karhat, Mirzapur displaying adoption of ZT sowing.

This map indicates that the adoption of the machine is increasing and spreading across other villages but the machine is still in the hands of the Cash cropper and Subsistence farmers.

Map 8
Map of villages around village Karhat, Mirzapur displaying ZT coverage during the 2004–05 crop season. The percentage area under ZT was calculated using actual survey data for total area under cultivation for wheat and that covered by ZT.

From 2001 to 2005, the use of the machine spread to six villages. In the core project village, 75% of the area is sown by ZT machine. In the adjoining villages, this percentage is much less but this is to be expected since the technology is slowly filtering out.

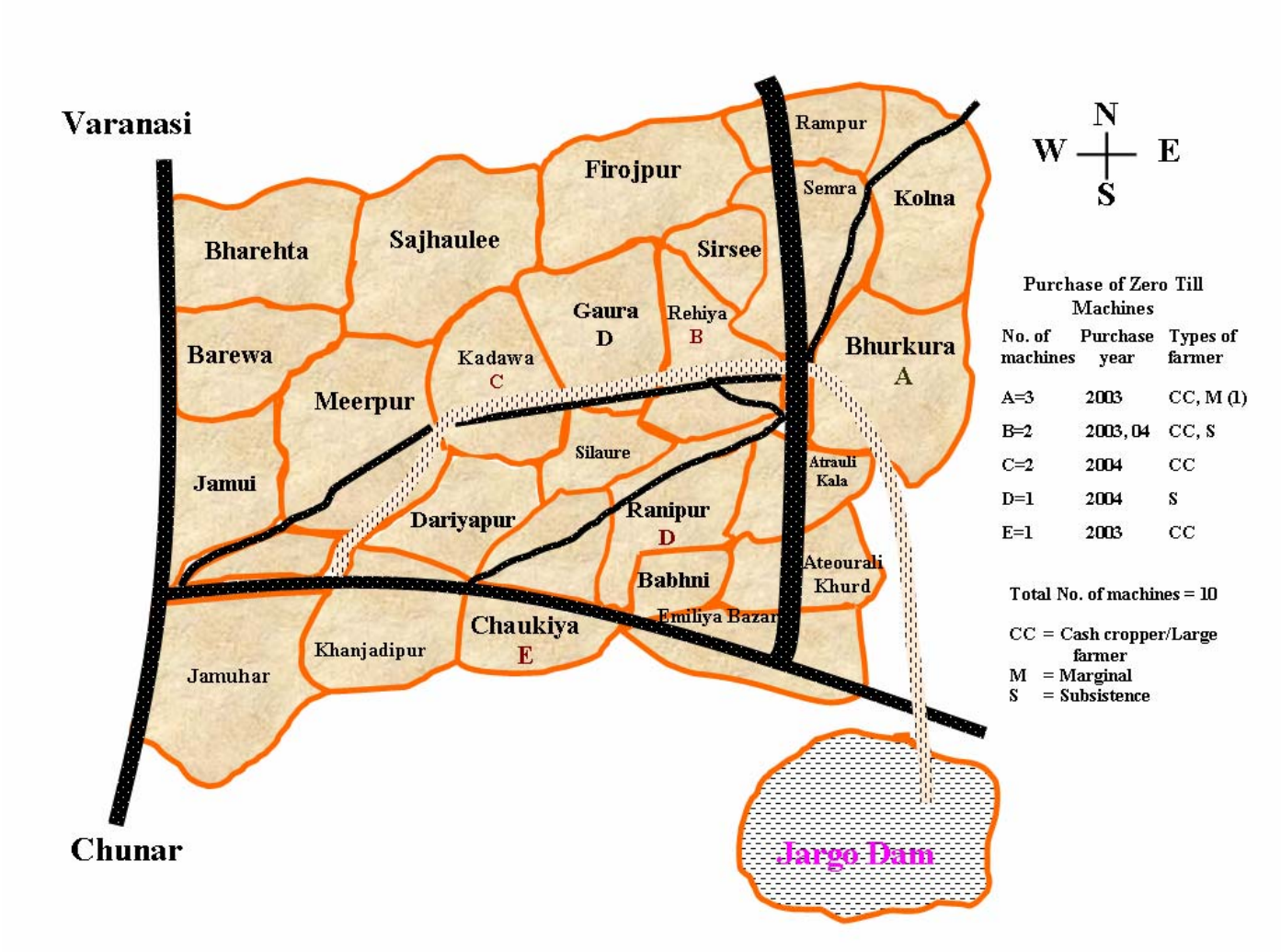
Map 9
Map of villages around village Karhat, Mirzapur displaying adoption of quality seed production along with ZT and new varieties.

The adoption of quality seed production seems quite popular with the adoption of seed production along with ZT being practised in at least four other villages.

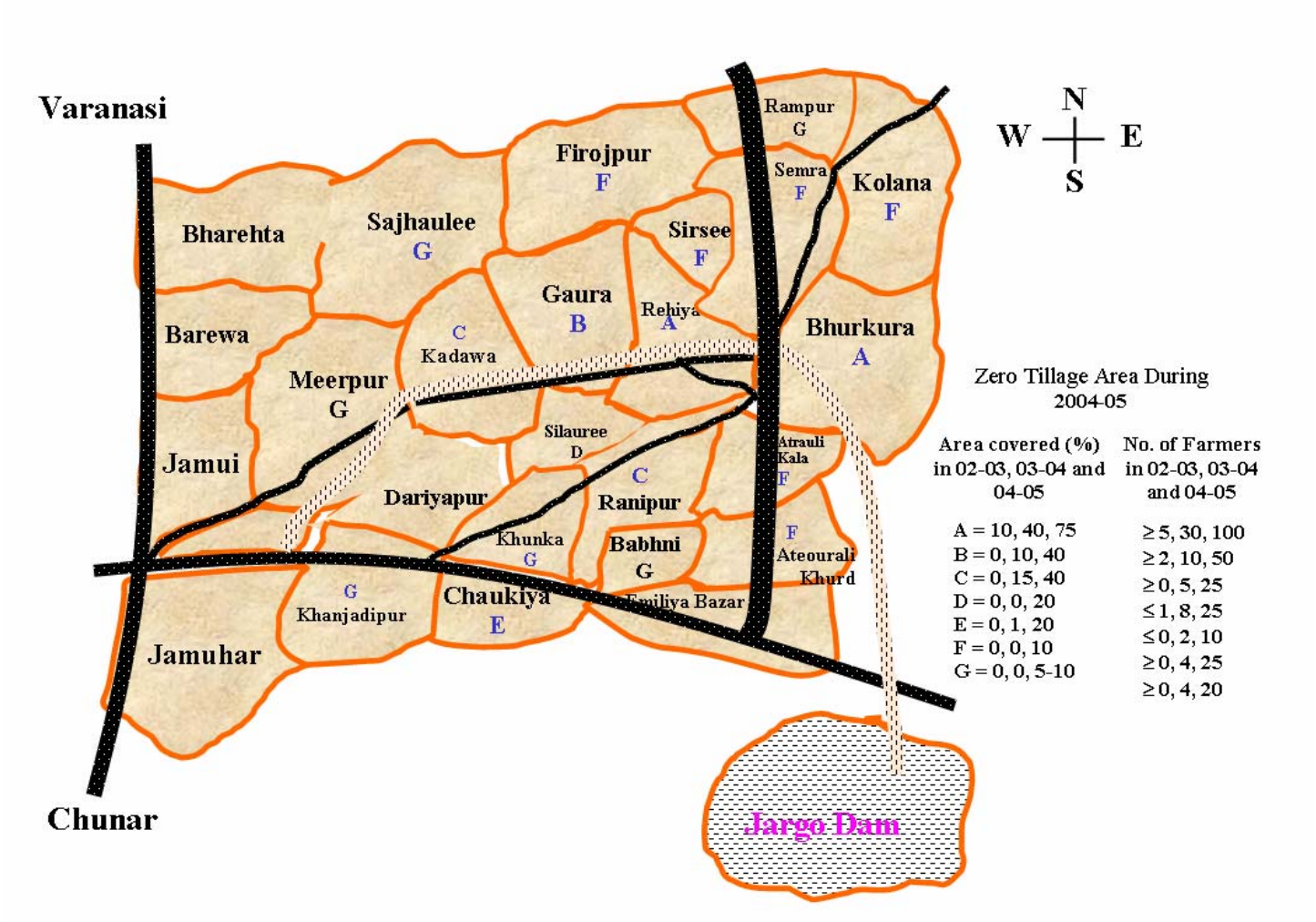
Map 10
Map of villages around village Karhat, Mirzapur displaying adoption of new wheat varieties along with ZT.

The adoption of new wheat varieties is spreading from the core village of Karhat. It would be interesting to capture the length of time it takes for adoption to reach 70%+ in the surrounding villages.

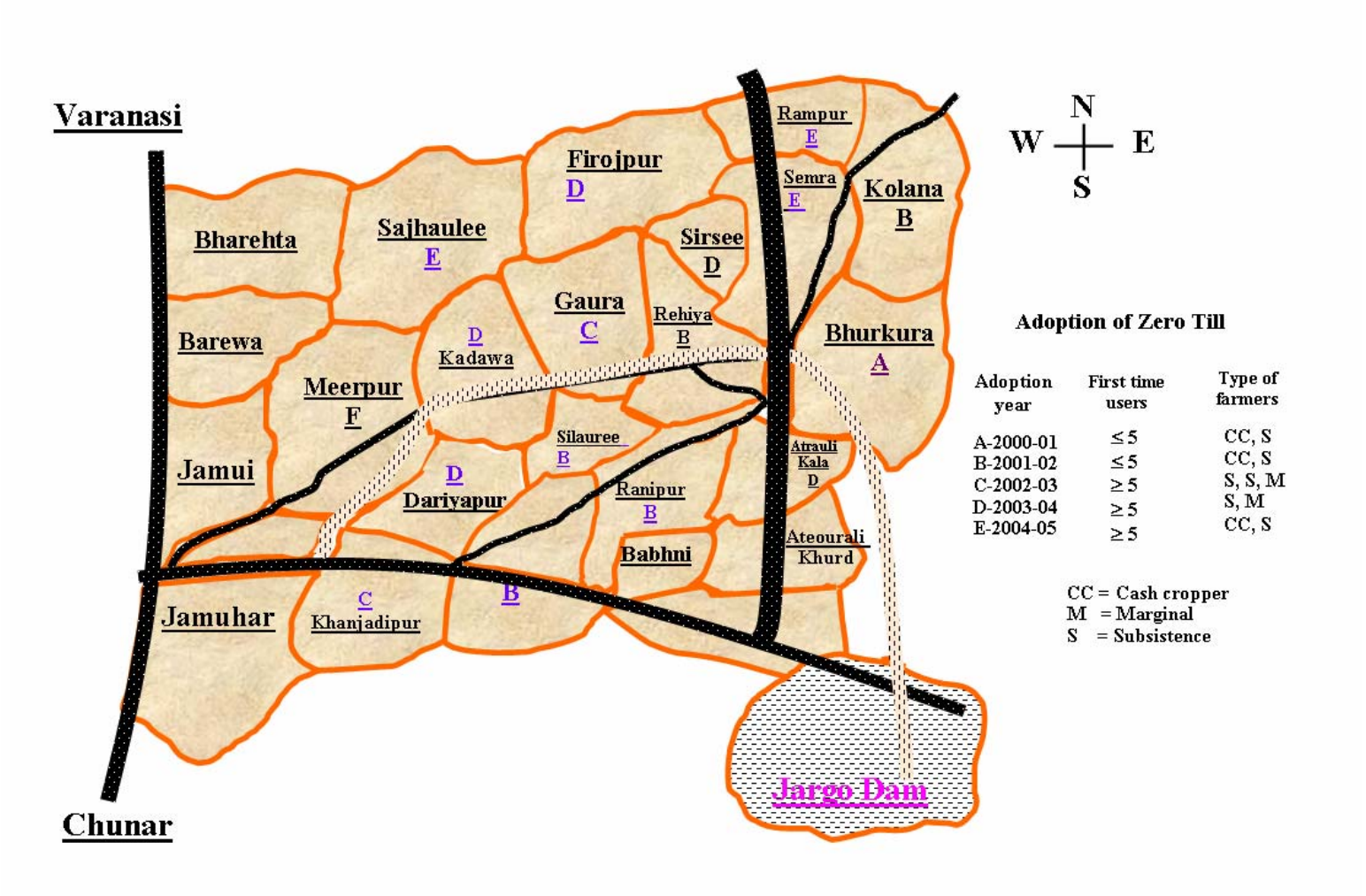
Map 1: Map of villages adjacent to Bhurkura village showing purchase years of ZT machines



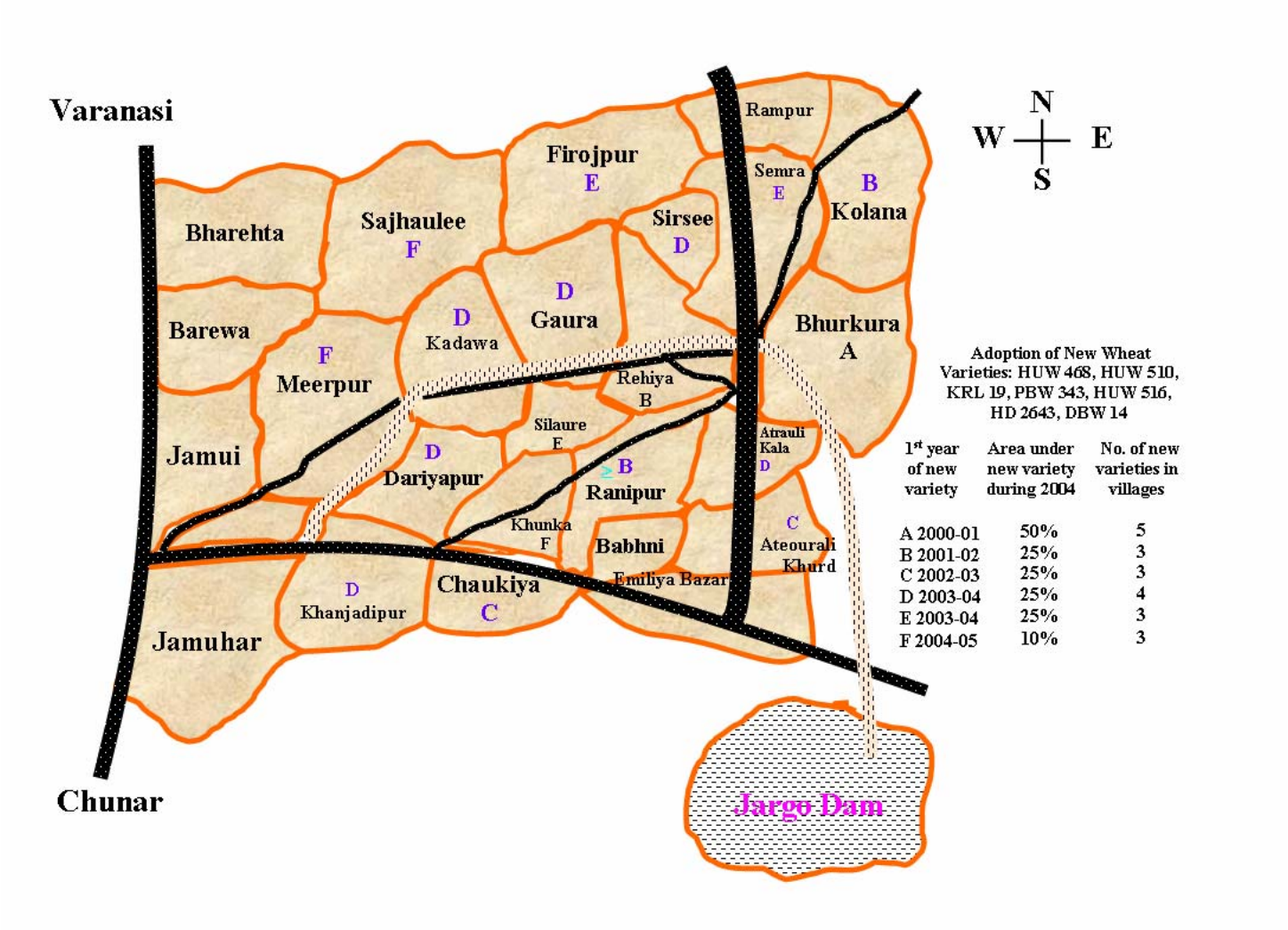
Map 2: Map of villages adjacent to Bhurkura village, showing ZT coverage during 2004-05 crop season



Map 3: Map of villages adjacent to Bhurkura village, showing adoption of ZT after its introduction in 2000-01

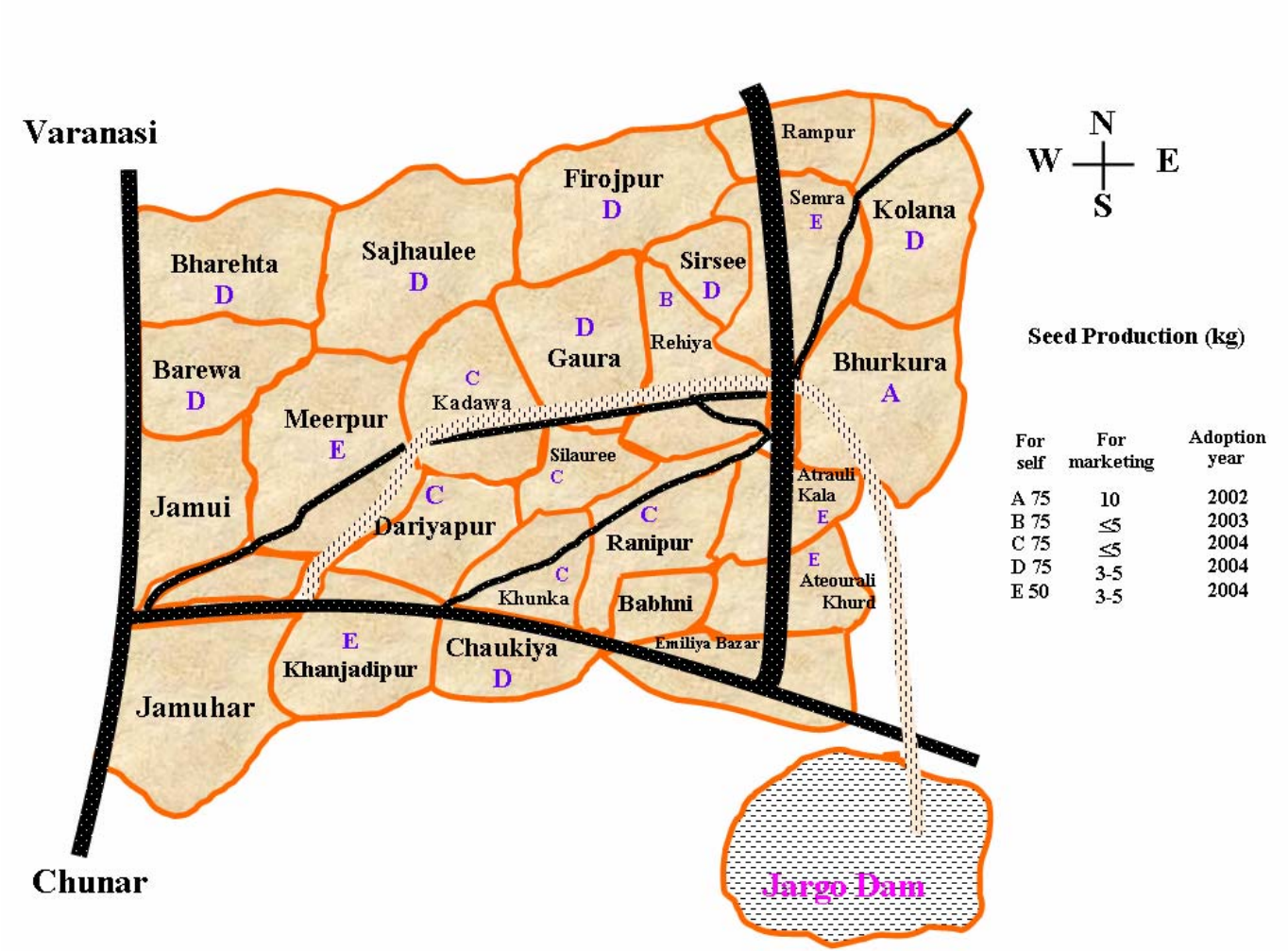


Map 4: Map of villages adjacent to Bhurkura village, showing adoption of new wheat varieties along with ZT

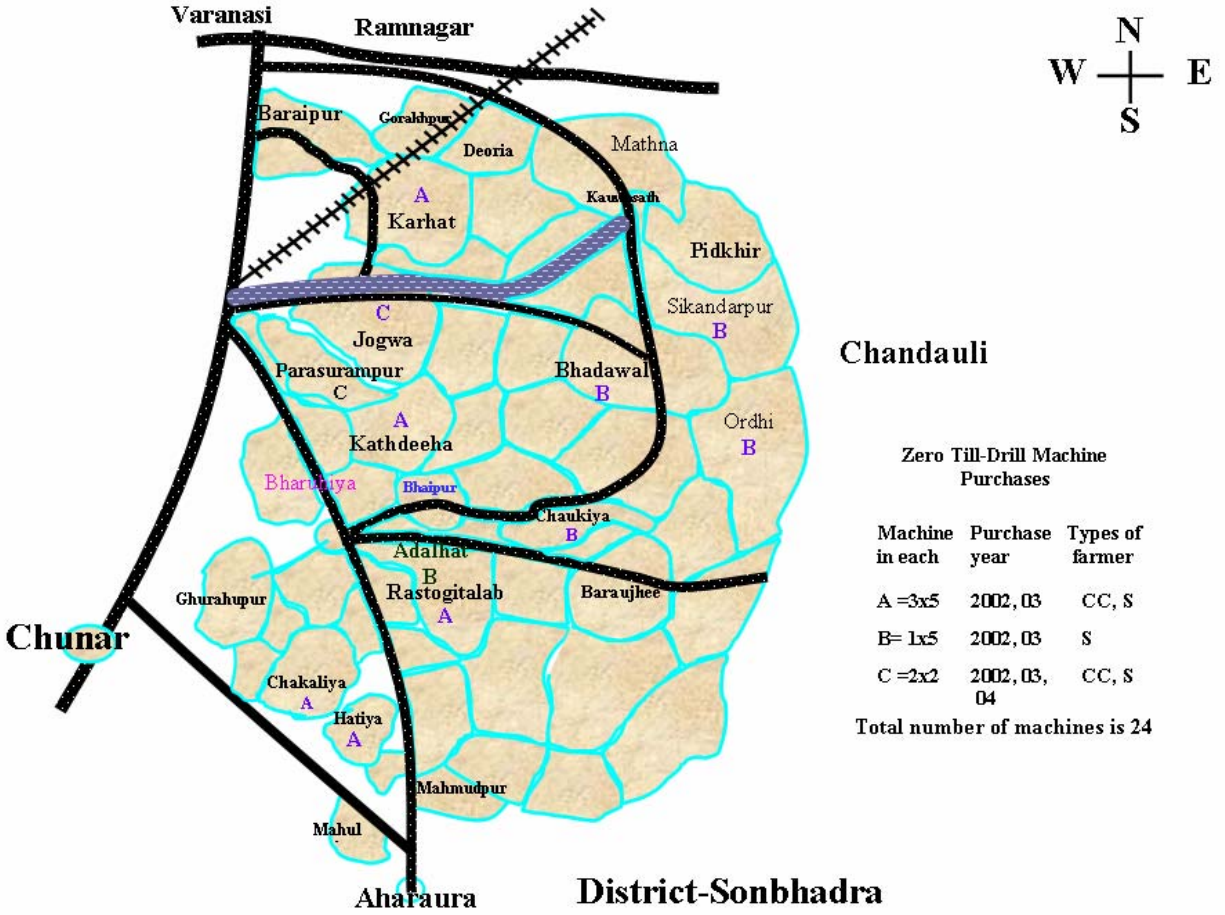


Study by A. K. Joshi, R. Chand & V. K. Chandola. Analysed & compiled by Dr Tahseen Jafry, March 2007.

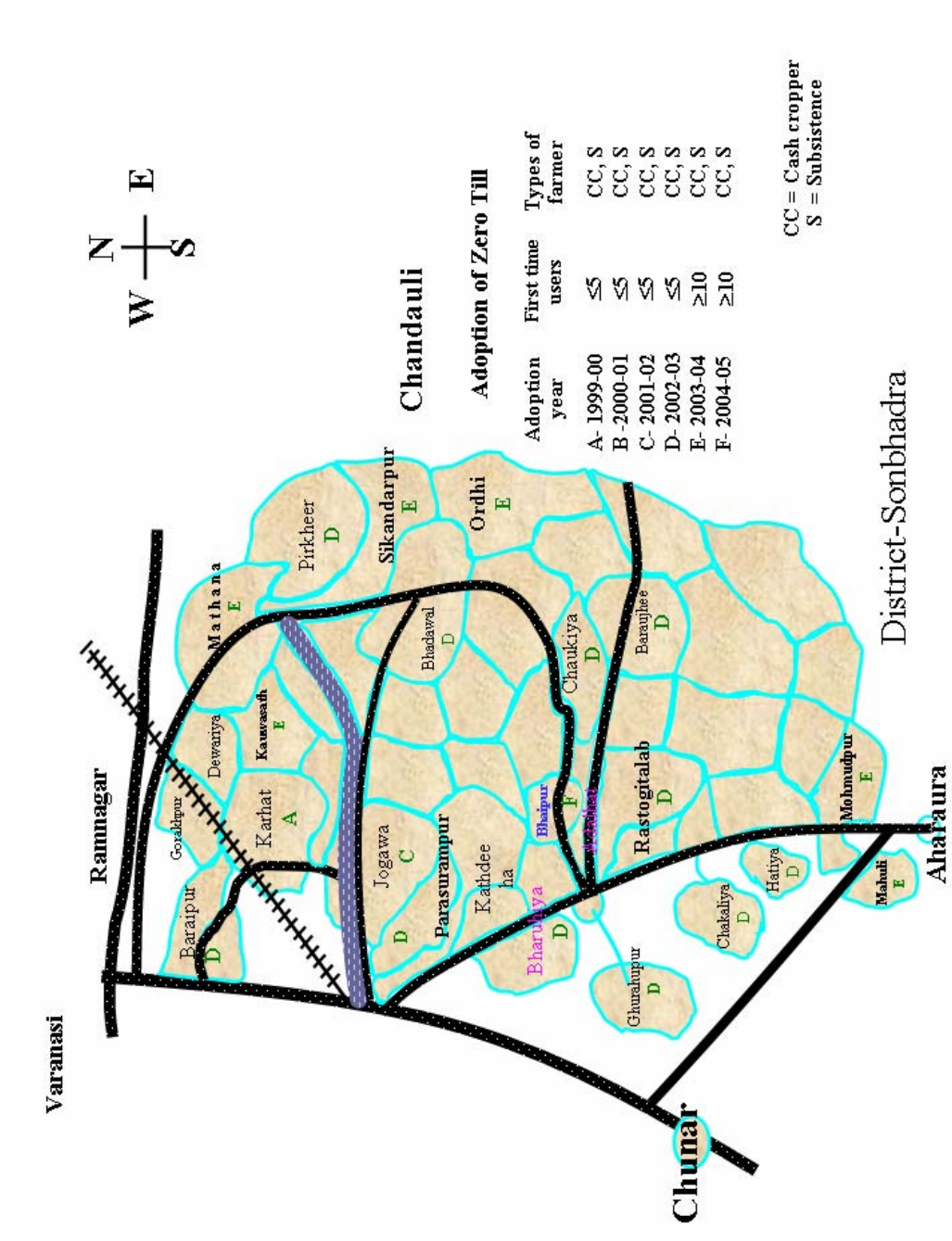
Map 5: Map of villages adjacent to Bhurkura village showing adoption of quality seed production along with ZT and new varieties



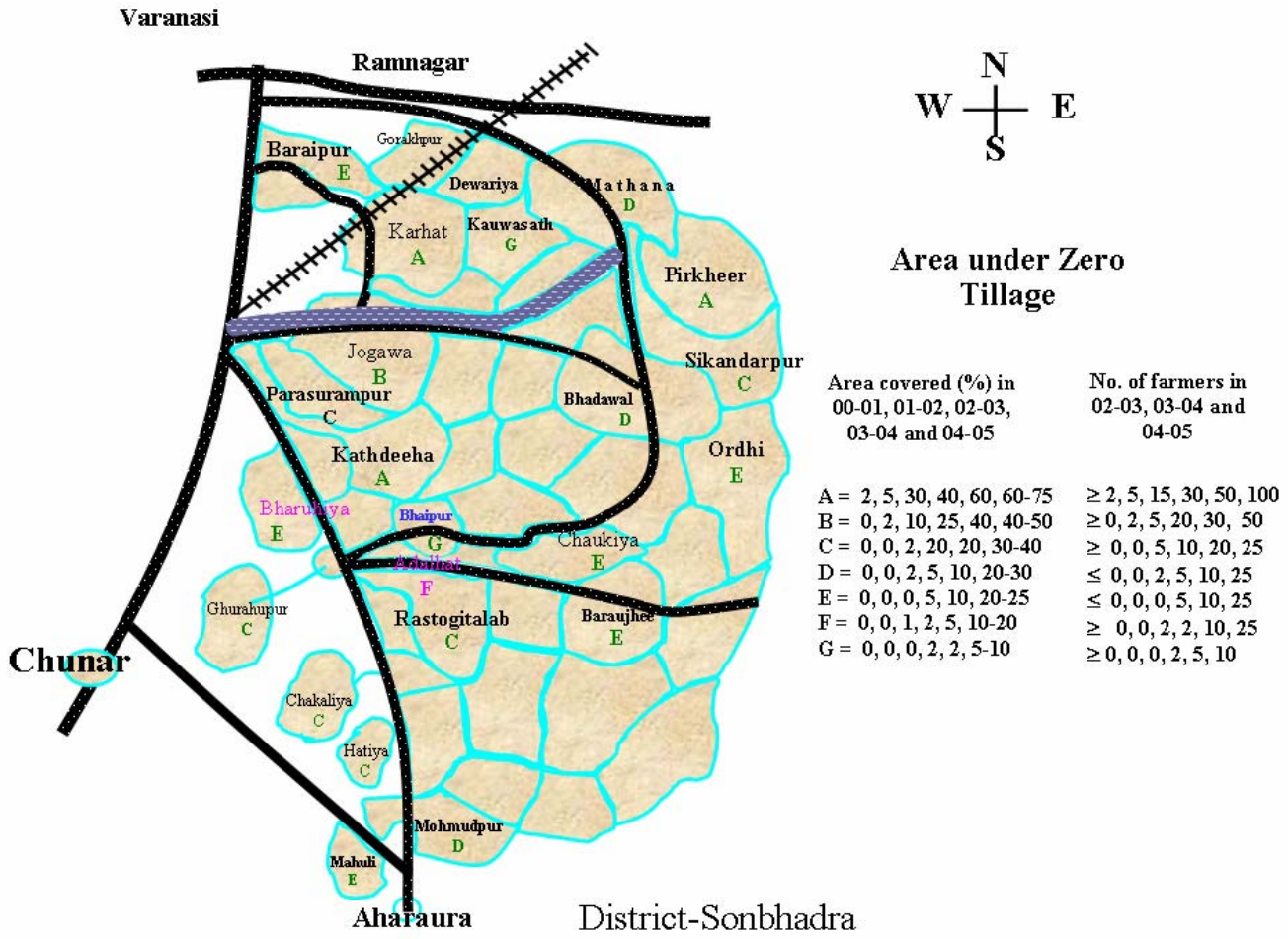
Map 6: Map of villages adjacent to Karhat village, showing purchase years of ZT machines



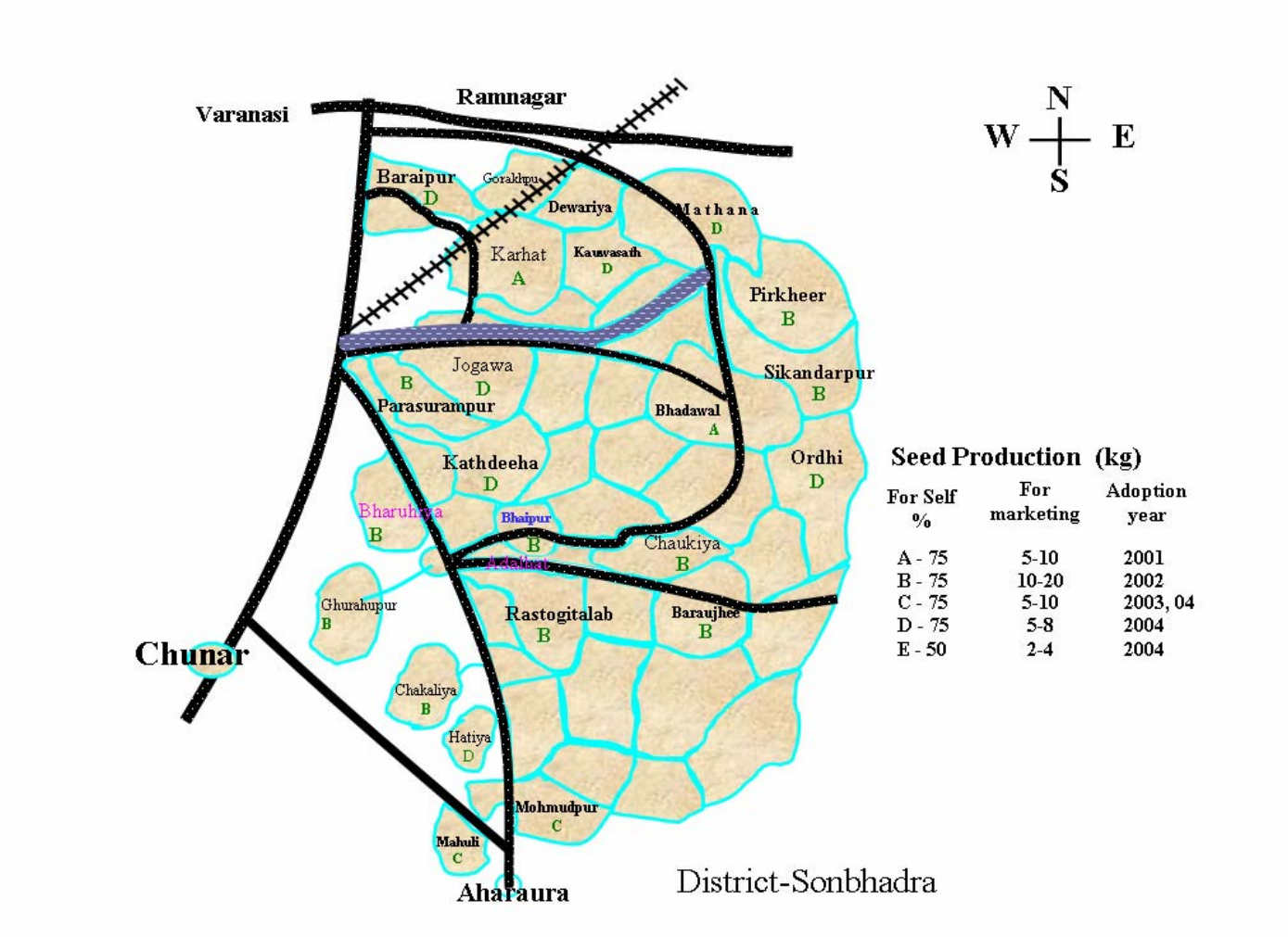
Map 7: Map of villages adjacent to Karhat village, showing adoption of ZT sowing



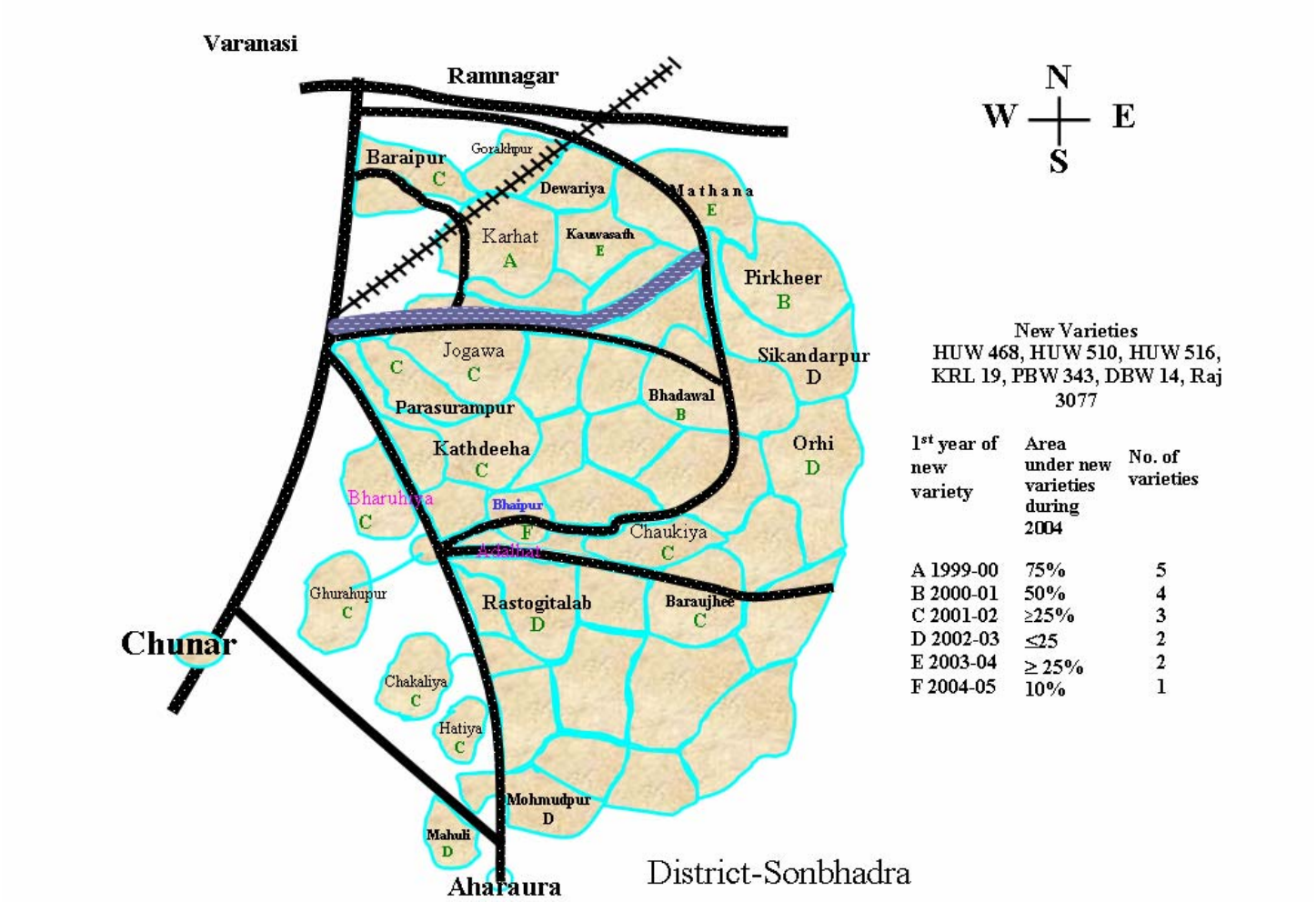
Map 8: Map of villages adjacent to Karhat village, showing ZT coverage during 2004-05 crop season



Map 9: Map of villages adjacent to Karhat village, showing adoption of quality seed production along with ZT and new varieties



Map 10: Map of villages adjacent to Karhat village, showing adoption of new wheat varieties along with ZT



2.3.4 Information on the spread of ZT machine in project satellite villages

Information was collected from a number of neighbouring villages surrounding the core project villages to get an understanding of the impact the ZT machine is making on the ground. The results are shown in Maps 1-10.

The results can be summarized as follows

The data collected in this research show that during the course of three growing seasons, the area of wheat sown with the ZT machine has been increasing compared with the area under conventional tillage. The increase is greater in some villages, than in others. The percentage of the total wheat crop area sown using the ZT machine ranges from 7–50% across the villages. The majority have approximately 20% sown with ZT wheat.

It is also interesting to note that in the villages where the technology is being used, the machines are actually owned by farmers who then hire them out to other farmers within and outside the village. The data indicate that farmers from outside of the villages travel up to 5 km to hire the machine. The farmers hear about the technology through farmer–farmer contact or from BHU scientists. Cash croppers are by far the biggest group who use the ZT machine followed by subsistence, marginal and landless farmers. The hire charges for the machine range between 350–450 Rs per acre. This high cost may be the reason why the poorer farmers do not use the machine. In a few villages the ZT machine is being used to sow other crops such as mustard, gram, barley, pea and paddy rice but this is a very small scale activity being practised by only a few farmers. It would seem that the machine is really only used for one purpose, i.e. to sow wheat.

The main benefits of using the ZT machine, as reported by the farmers, are cost savings in land cultivation, seed saving, better placement of fertilizer, saving in irrigation water, easier harvesting because sowing is in lines (this helps women because it is mainly women who do the harvesting work), saving in time and labour for sowing the crop, and higher yields and larger grains due to an advancement in sowing date.

Other issues associated with the machine were reported to be lack of timely availability, a concern that continuous use of the machine may cause dicotyledonous weeds and that the machine is not suitable for multi-crop sowing.

Other observations from the farmers include: “a field sown by ZT looks impressive and it is becoming a sign of progress being made by the villages.”

Box 1. Village: Rehiya, District: Mirzapur

Total number of households: 150
Total number of cultivating households (farmers): 125
Total area of arable land (acres): 400
First year of using ZT wheat in the village: 2001–02

Year (rabi season)	Total area under wheat (acres)	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat	No. of ZT machines in village (demo and/or privately owned)
2005-06	360	140	80	3 owned
2004-05	360	150	80	2 owned + 1 demo
2003-04	370	100	50	1 owned + 1 demo
2002-03	370	10	6	1 demo

Main source of information for ZT wheat: Progressive farmers of Bhurkura and BHU Scientists

For ZT wheat sown in 2005–06 *in the village*:

Farmer category	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat
Landless	3.0	2
Marginal	16.0	12
Subsistence	71.0	55
Cash cropper	50.0	10
Total	**140.0**	**80**

For ZT wheat sown in 2005-06 *in the village*:

- Total area (acres) sown with ZT machines from outside the village: None.
- Number of ZT machines from outside the village: None
- Origin of ZT machines from outside the village: N.A.

For ZT wheat sown in 2005-06 *outside the village:*

- Total area (acres) sown outside the village with ZT machines from village: 40.0
- Number of ZT machines from the village also working outside the village: 3 (occasionally)
- Destination of ZT machines from Rehiya village:

Village name: Gaura	Distance from village (km): 2.5
Village name: Phirojpur	Distance from village (km): 3.5
Village name: Sirsee	Distance from village (km): 3.0
Village name: Silauree	Distance from village (km): 2.5
Village name: Dariyapur	Distance from village (km): 5.0
Village name: Kadawa	Distance from village (km): 2.5

What is the service charge for ZT machine? (Rs per acre): Rs 350 (US$8.5)

Is the ZT machine being used for other crops in the village? Yes

Crop	Total area sown with ZT machine last season (acres)	Total no. of farmers using ZT machine	Year of first use
Mustard	1.0	1	2004-05
Gram	1.0	1	2004-05
Barley	2.0	1	2004 -05
Paddy	2.0	3	2004 -05

Main benefits of ZT (as related by farmers)

- Around 50% saving in the cost of tractor/machine hiring for preparing field + sowing.
- 40 % seed saving.
- Better placement of fertilizer.
- Sowing advanced by ten days leading to increased yield by around 400 kg/ha.
- Wheat grains are bolder.
- 50% saving in irrigation (both water + time).
- Since sowing is in line, harvesting is easier.
- Reduction in drudgery.

Main problems with ZT

- Machines are few in comparison to demand.
- Better multi-crop machines are needed.
- Continuous use of ZT may cause dicotyledonous weeds

Has anyone abandoned ZT? No one has abandoned it.

Other observations about ZT:

- Line sowing helps in rouging and weeds management
- Fewer foliar diseases due to space planting

Box 2. Village: Kadawa, District: Mirzapur

Total number of households: 100
Total number of cultivating households (farmers): 95
Total area of arable land (acres): 470

Year (rabi season)	Total area under wheat (acres)	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat	No. of ZT machines in village (all owned)
2005-06	440	85	30	2
2004-05	460	50	10	2
2003-04	460	16	5	0
2002-03	450	0	0	0

First year of using ZT wheat in the village: 2003-04

Main source of information for ZT wheat: Progressive farmers of Rehiya

For ZT wheat sown in 2005-06 *in the village*:

Farmer category	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat
Landless	-	-
Marginal	-	-
Subsistence	10	6
Cash cropper	40	4
Total	50	10

For ZT wheat sown in 2005-06 *in the village*:

- Total area (acres) sown with ZT machines from outside the village: 4.0
- Number of ZT machines from outside the village: 1
- Origin of ZT machines from outside the village:
  Village name: Rehiya Distance from village (km): 2.5

For ZT wheat sown in 2005-06 *outside the village:*

- Total area (acres) sown outside the village with ZT machines from the village: 3.0.
- Number of ZT machines from the village also working outside the village: 1 (not always)
- Destination of ZT machines from the village:
  Village name: Gaura Distance from village (km): 3.0

What is the service charge for ZT machine? (Rs per acre): Rs 350

Is the ZT machine being used for other crops in the village? Yes

Crop	Total area sown with ZT machine last season (acres)	Total no. of farmers using ZT machine	Year of first use
Gram	1.0	1	2004-05
Lentill	1.0	1	2005-06
Paddy	5.0	6	2005-06

Main benefits of ZT

- Around 40-50 % saving in seed.
- Better placement of fertilizer.
- Better yields due to 10 days advancement in sowing.
- Bolder grains.
- 50% saving in irrigation.
- 50% reduction in time given for sowing the crop.

Main problems with ZT

- Machine not suitable for multi-crop sowing.
- Continuous use of ZT may increase dicotyledonous weeds

Has anyone abandoned ZT? No

Other observations about ZT

- Change in mindset of farmers in favour of reduced tillage.
- “They hire machine from Rahian village”.

Box 3. Village: Khundka, District: Mirzapur

Total number of households: 35
Total number of cultivating households (farmers): 35
Total area of arable land (acres): village revenue 288 acres but village farmers under 134 acres

Year (rabi season)	Total area under wheat (acres)	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat	No. of ZT machines in village (indicate whether demo and/or privately owned)
2005-06	125	27.0	9.0	-
2004-05	125	12.0	2.0	-
2003-04	-	-	-	-
2002-04	-	-	-	-

First year of using ZT wheat in the village: 2004-05

Main source of information for ZT wheat: Progressive farmers of Ranipur (Jay kumar)

ZT wheat sown in 2005-06 *in the village*:

Farmer category	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat
Landless	-	-
Marginal	-	-
Subsistence	13.0	7.0
Cash cropper	14.0	2.0
Total	27.0	9.0

For ZT wheat sown in 2005-06 *in the village*:

- Total area (acres) sown with ZT machines from outside the village: 9.0
- Number of ZT machines from outside the village: 1
- Origin of ZT machines from outside the village:
  Village name: Ranipur Distance from village (km): 2.0

For ZT wheat sown in 2005-06 *outside the village:*

- Total area (acres) sown outside the village with ZT machines from the village: None.
- Number of ZT machines from the village also working outside the village: N/A
- Destination of ZT machines from the village: N/A

What is the service charge for ZT machine? (Rs per acre): Rs 350

Is the ZT machine being used for other crops in the village? No

Main benefits of ZT:

- 40 % seed saving.
- Better placement of fertilizer.
- 10 days sowing advance.
- Bolder grains.
- 50% irrigation saving.

Main problems with ZT:

- "Lack of timely availability of machine to all needy farmers."
- Continuous use of ZT may cause more dicotyledonous weeds.

Has anyone abandoned ZT? No

Other observations about ZT:

- Change in the mindset of farmers about reduction in tillage for sowing.

Box 4. Village: Ranipur, District: Mirzapur

Total number of households: 100
Total number of cultivating households (farmers): 90
Total area of arable land (acres): 400

Year (rabi season)	Total area under wheat (acres)	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat	No. of ZT machines in village (indicate whether demo and/or privately owned)
2005-06	370	70.0	25	1 owned
2004-05	375	25.0	10	1 owned
2003-04	375	10.0	4	-
2002-04	375	8.0	2	-

First year of using ZT wheat in the village: 2001-02

Main source of information for ZT wheat: Progressive farmers of Bhurkura

For ZT wheat sown in 2005-06 *in the village*:

Farmer category	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat
Landless	-	-
Marginal	10.0	12
Subsistence	40.0	10
Cash cropper	20.0	3
Total	70.0	25

For ZT wheat sown in 2005-06 *in the village*:

- Total area (acres) sown with ZT machines from outside the village: none
- Number of ZT machines from outside the village: n/a
- Origin of ZT machines from outside the village: n/a

For ZT wheat sown in 2005-06 *outside the village:*

- Total area (acres) sown outside the village with ZT machines from the village: 27.0
- Number of ZT machines from the village also working outside the village: 1
- Destination of ZT machines from the village:
  Village name: Khundaka Distance from village (km): 2.0
  Village name: Atrauli khurd Distance from village (km): 3.0

What is the service charge for ZT machine? (Rs per acre): Rs 350

Is the ZT machine being used for other crops in the village? Yes

Crop	Total area sown with ZT machine last season (acres)	Total no. of farmers using ZT machine	Year of first use
Pea	20.0	10	2004-05
Paddy	1.0	2	2005-06

Main benefits of ZT

- Around 40–50% saving in seed.
- Better placement of fertilizer.
- Better yields due to 10 days advancement in sowing.
- Bolder grains.
- 50% irrigation saving.

Main problems with ZT

- Machines are few in comparison to demand.
- A fear among farmers that continuous use of ZT may cause more dicotyledonous weeds.

Has anyone abandoned ZT? No.

Other observations about ZT

- Change in mindset of farmers about ZT.
- "Crop sown by ZT looks better in advanced stage."

Box 5. Village: Bhadawal, District: Mirzapur

Total number of households: 300
Total number of cultivating households (farmers): 150
Total area of arable land (acres): 800

Year (rabi season)	Total area under wheat (acres)	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat	No. of ZT machines in village (indicate whether demo and/or private owned)
2005-06	750	50	5	1 owned
2004-05	750	35	3	1 owned
2003-04	760	30	1	1 owned
2002-03	750	30	1	1 demo

First year of using ZT wheat in the village: 2000-01

Main source of information for ZT wheat: Progressive farmers of Karhat and BHU Scientist

For ZT wheat sown in 2005-06 *in the village*:

Farmer category	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat
Landless	-	-
Marginal	-	-
Subsistence	20	4
Cash cropper	30	1
Total	50	5

For ZT wheat sown in 2005-06 *in the village*:

- Total area (acres) sown with ZT machines from outside the village: none
- Number of ZT machines from outside the village: n/a
- Origin of ZT machines from outside the village: n/a

For ZT wheat sown in 2005-06 *outside the village:*

- Total area (acres) sown outside the village with ZT machines from the village: 5
- Number of ZT machines hired by farmers from neighbouring villages.
- Destination of ZT machines from the village:
  Village name: Jamalpur Distance from village (km): 3

What is the service charge for ZT machine? (Rs per acre): No charge taken for sowing within the village. However, machine use outside the village is charged at Rs 400 per acre.

Is the ZT machine being used for other crops in the village? No

Main benefits of ZT

- Around 20-40 % saving in seed.
- Better placement of fertilizer.
- Better yields due to 8-10 days advancement in sowing.
- Bolder/larger grains.
- 50% irrigation saving.
- Around 70% saving of time and labour in sowing work.
- Reduction in drudgery.

Main problems with ZT

- A fear among farmers that continuous use of ZT may increase dicotyledonous weeds.

Has anyone abandoned ZT? No

Other observations about ZT

- Change in the mindset of farmers about tillage conservation.
- ZT sown crop looks more attractive than conventional sowing.

Box 6. Village: Bharuhiya, District: Mirzapur

Total number of households: 100
Total number of cultivating households (farmers):80
Total area of arable land (acres):300

Year (rabi season)	Total area under wheat (acres)	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat	No. of ZT machines in village (indicate whether demo and/or private owned)
2005-06	280	50.0	10	1 demo
2004-05	280	50.0	10	1 demo
2003-04	270	20.0	4	1 demo
2002-03	260	10.0	2	1 demo

First year of using ZT wheat in the village: 2002-03

Main source of information for ZT wheat: Progressive farmers of Bhadawal and BHU Scientist

For ZT wheat sown in 2005-06 *in the village*:

Farmer category	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat
Landless	1.0	1
Marginal	4.0	2
Subsistence	15.0	5
Cash cropper	30.0	2
Total	50.0	10

For ZT wheat sown in 2005-06 *in the village*:

- Total area (acres) sown with ZT machines from outside the village: None
- Number of ZT machines from outside the village: n/a
- Origin of ZT machines from outside the village: n/a

For ZT wheat sown in 2005-06 *outside the village:*

- Total area (acres) sown outside the village with ZT machines from the village**:** none
- Number of ZT machines from the village also working outside the village: n/a
- Destination of ZT machines from the village: n/a

What is the service charge for ZT machine? (Rs per acre): Rs 400

Is the ZT machine being used for other crops in the village? No

Main benefits of ZT

- Around 40-50 % saving in seed.
- Better placement of fertilizer.
- Better yields due to 10 days advancement in sowing.
- Bolder grains.
- 50% saving in irrigation.
- 50% reduction in time given for sowing the crop.

Main problems with ZT

- Machine not suitable for multi-crop sowing.
- Continuous use of ZT may increase dicotyledonous weeds.

Has anyone abandoned ZT? No

Other observations about ZT

- "Crop sown by ZT given good look."
- "It is possible to raise a good crop after combine harvest of paddy."

Box 7. Village: Kathdeeha, District: Mirzapur

Total number of households: 122
Total number of cultivating households (farmers): 100
Total area of arable land (acres): 280

Year (rabi season)	Total area under wheat (acres)	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat	No. of ZT machines in village (indicate whether demo and/or privately owned)
2005-06	260	130	60	2 owned
2004-05	265	120	56	2 owned
2003-04	265	100	45	1 owned
2002-03	260	20	5	1 owned

First year of using ZT wheat in the village: 2002-03

Main source of information for ZT wheat: Progressive farmers of Jogawa and BHU Scientist

For ZT wheat sown in 2005-06 *in the village*:

Farmer category	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat
Landless	5	3
Marginal	25	15
Subsistence	80	40
Cash cropper	20	2
Total	130	60

For ZT wheat sown in 2005-06 *in the village*:

- Total area (acres) sown with ZT machines from outside the village: none**.**
- Number of ZT machines from outside the village: n/a
- Origin of ZT machines from outside the village: n/a

For ZT wheat sown in 2005-06 *outside the village:*

- Total area (acres) sown outside the village with ZT machines from the village: 20
- Number of ZT machines from the village also working outside the village: 2
- Destination of ZT machines from the village:
  Village name: Phatepur Distance from village (km): 3.0

What is the service charge for ZT machine? (Rs per acre): Rs 400

Is the ZT machine being used for other crops in the village? No

Main benefits of ZT

- Around 40-50 % saving in seed.
- better placement of fertilizer.
- better yields due to 10 days advancement in sowing.
- bolder grains.
- 50% saving in irrigation.
- 50% reduction in time taken to sow the crop.

Main problems with ZT

- Machine not suitable for multi-crop sowing.
- Continuous use of ZT may increase dicotyledonous weeds.

Has anyone abandoned ZT? No

Other observations about ZT

- "Fields sown by ZT give better impression."
- "It is a sign of progress being made by village."

Box 8. Village: Jogwa, District: Mirzapur

Total number of households: 70
Total number of cultivating households (farmers): 60
Total area of arable land (acres): 300

Year (Rabi season)	Total area under wheat (acres)	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat	No. of ZT machines in village (indicate whether demo and/or private owned)
2005-06	280	80	35	1 owned
2004-05	280	60	30	1 owned
2003-04	280	20	6	1 owned
2002-03	280	10	2	1 owned

First year of using ZT wheat in the village: 2002-03

Main source of information for ZT wheat: Progressive farmers of Bhadawal and BHU Scientist

For ZT wheat sown in 2005-06 *in the village*:

Farmer category	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat
Landless	0	0
Marginal	10	10
Subsistence	30	20
Cash cropper	40	5
Total	80	35

For ZT wheat sown in 2005-06 *in the village*:

- - Total area (acres) sown with ZT machines from outside the village: 10
- - Number of ZT machines from outside the village: 2
- - Origin of ZT machines from outside the village:
  Village name: Parasrampur Distance from village (km): 2.0

For ZT wheat sown in 2005-06 *outside the village:*

- - Total area (acres) sown outside the village with ZT machines from the village: None
- - Number of ZT machines from the village also working outside the village: n/a
- - Destination of ZT machines from the village: n/a

What is the service charge for ZT machine? (Rs per acre): Rs 450

Is the ZT machine being used for other crops in the village? No

Main benefits of ZT

- Around 40-50 % saving in seed.
- Better placement of fertilizer.
- Better yields due to 10 days advancement in sowing.
- Bolder grains.
- 50% saving in irrigation.
- 50% reduction in time taken for sowing the crop.

Main problems with ZT

- Cost of machine is high and beyond the purchasing power of majority of farmers.
- Machine not suitable for multi-crop sowing.
- Continuous use of ZT may increase dicotyledonous weeds.

Has anyone abandoned ZT? No

Other observations about ZT

- "Fields sown by ZT give better impression."
- "It has become a sign of progress being made by village."

Box 9. Village: Parasurampur, District: Mirzapur

Total number of households: 80
Total number of cultivating households (farmers): 50
Total area of arable land (acres): 400

Year (rabi season)	Total area under wheat (acres)	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat	No. of ZT machines in village (indicate whether demo and/or private owned)
2005-06	370	75.0	20	2 owned
2004-05	375	100.0	15	2 owned
2003-04	375	50.0	5	1 owned
2002-03	370	20.0	2	1 owned

First year of using ZT wheat in the village: 2002-03

Main source of information for ZT wheat: Progressive farmers of Karhat and BHU Scientist

For ZT wheat sown in 2005-06 *in the village*:

Farmer category	Total area under ZT wheat (acres)	Total no. of farmers using ZT wheat
Landless	2.0	3
Marginal	5.0	5
Subsistence	20.0	10
Cash cropper	50.0	5
Total	75.0	20

For ZT wheat sown in 2005-06 *in the village*:

- Total area (acres) sown with ZT machines from outside the village: none
- Number of ZT machines from outside the village: n/a
- Origin of ZT machines from outside the village: n/a

For ZT wheat sown in 2005-06 *outside the village:*

- Total area (acres) sown outside the village with ZT machines from the village: 12
- Number of ZT machines from the village also working outside the village: 2
- Destination of ZT machines from the village:
  Village name: Jogawa Distance from village (km): 2.0

What is the service charge for ZT machine? (Rs per acre): Rs 500

Is the ZT machine being used for other crops in the village? Yes

Crop	Total area sown with ZT machine last season (acres)	Total no. of farmers using ZT machine	Year of first use
Pea	10.0	6	2003-04

Main benefits of ZT

- Around 40-50 % saving in seed.
- Better placement of fertilizer.
- Better yields due to 10 days advancement in sowing.
- Bolder grains.
- 50% saving in irrigation.
- 50% reduction in time taken to sow the crop.

Main problems with ZT

- Cost of machine is high and beyond the purchasing power of majority of farmers.
- Machine not suitable for multi-crop sowing.
- Continuous use of zero till may increase dicotyledonous weeds.

Has anyone abandoned ZT? No

Other observations about ZT

- "Fields sown by zero tillage give better impression."
- "It has become a sign of progress being made by village."

2.3.5 Women's *Trichoderma* group

A women's *Trichoderma* producing group was established in Rehiya village, Mirzapur District, Uttar Pradesh, India in 2002 by the team of scientists from BHU promoting participatory research related to various other activities viz. ZT, new varieties, seed production, etc. Currently, this group consists of the women members of around ten mainly marginal families producing *Trichoderma* on a commercial scale (Fig. 4). The interesting aspect of this production is that the women are using the facilities already available in the kitchen of each household and no other special equipment is being used. In other words, the women had to make no investment to start this activity. On the other hand, they began to get benefit from the first year through their own use of the product and also through marketing it to other farmers.

Fig. 5. Commercially available Trichoderma

Objectives

There were three main objectives to establishing this group. First, to promote the use *Trichoderma* as a bio-control agent in crop production; secondly, to empower women with respect to their technical and financial status in the villages; and thirdly, to promote confidence among farmers about production and usage of new technologies at a village level.

Role of Banaras Hindu University

Although it was the result of a team approach, the lead role was played by Dr Ramesh Chand, Plant Pathologist of the team.

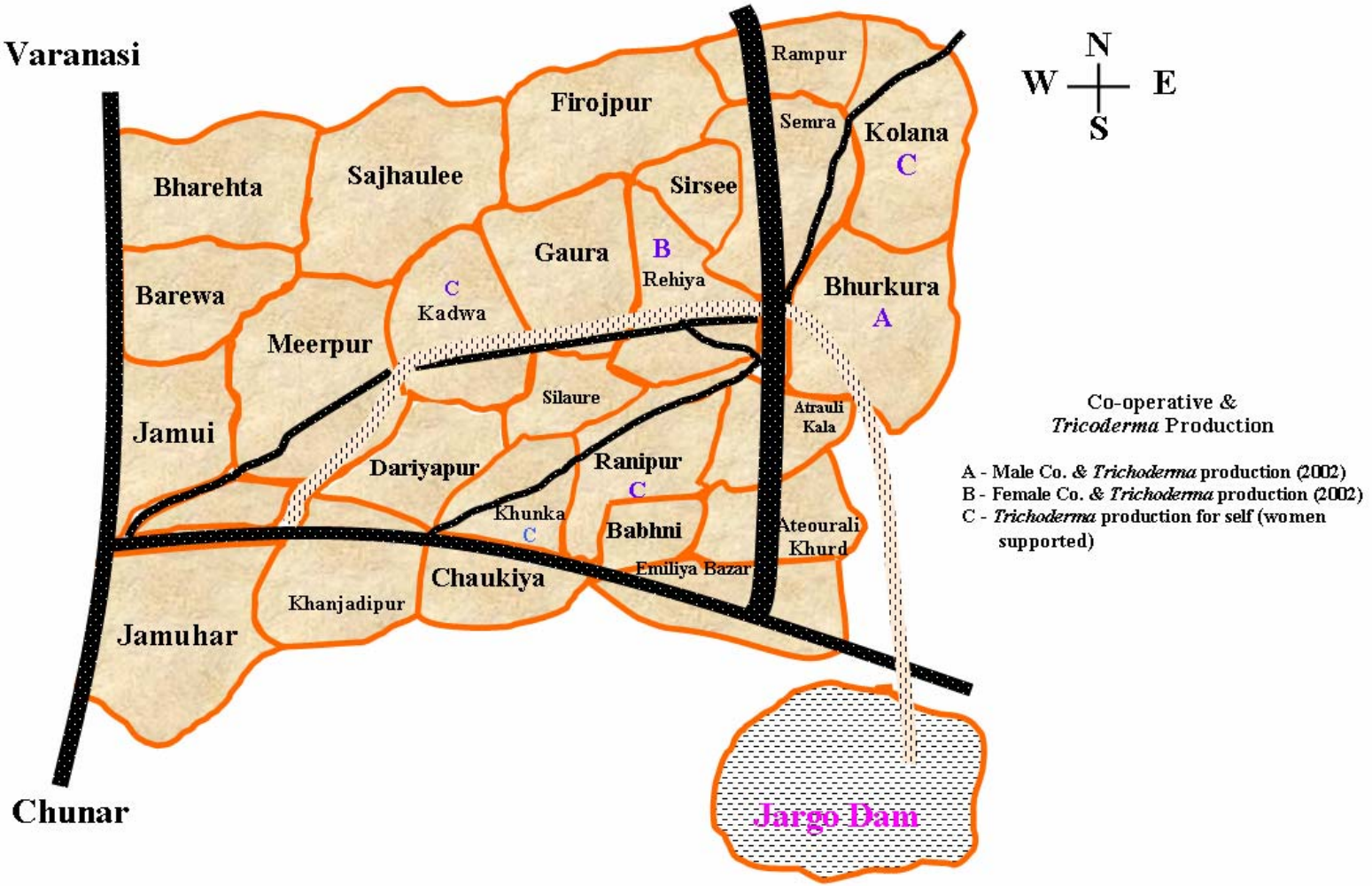
The role of Banaras Hindu University in this activity was as follows:

- A low cost, easy and effective methodology was developed for a reusable *Trichoderma* product at village level.
- Initially, farmers were given training for the preparation of *Trichoderma* in the village itself and its method of use in different crops was explained to them.
- Pure inoculum of the fungus *Trichoderma*, maintained in the laboratory of Ramesh Chand, BHU, was given to farmers for multiplication.
- Farmers were encouraged to involve their whole families, especially women, in production and multiplication of *Trichoderma* for crop protection, especially in paddy, since it is the dominant crop in the region and displays an encouraging response to this bio-agent.
- Farmers were encouraged to form a Working Group or Cooperative to initiate production and marketing of *Trichoderma,* since the formulations available on the market were costly and supply was not able to meet demand.
- As villagers found that production of *Trichoderma* was easy and well suited to women; they were encouraged to form a Women's group for the purpose of production.
- To ensure good quality of the bio-agent, frequent monitoring was conducted by the BHU team.
- For benefit of both producers and users, the women's group was persuaded to keep to a low price for the product. The price was set at Rs 50/kg, which was around four to six times lower than the current price prevailing on the market.
- Using different stakeholders, proper promotion was conducted among the actual users, giving benefits to both producers and the users.

Spread of *Trichoderma* production and usage technology

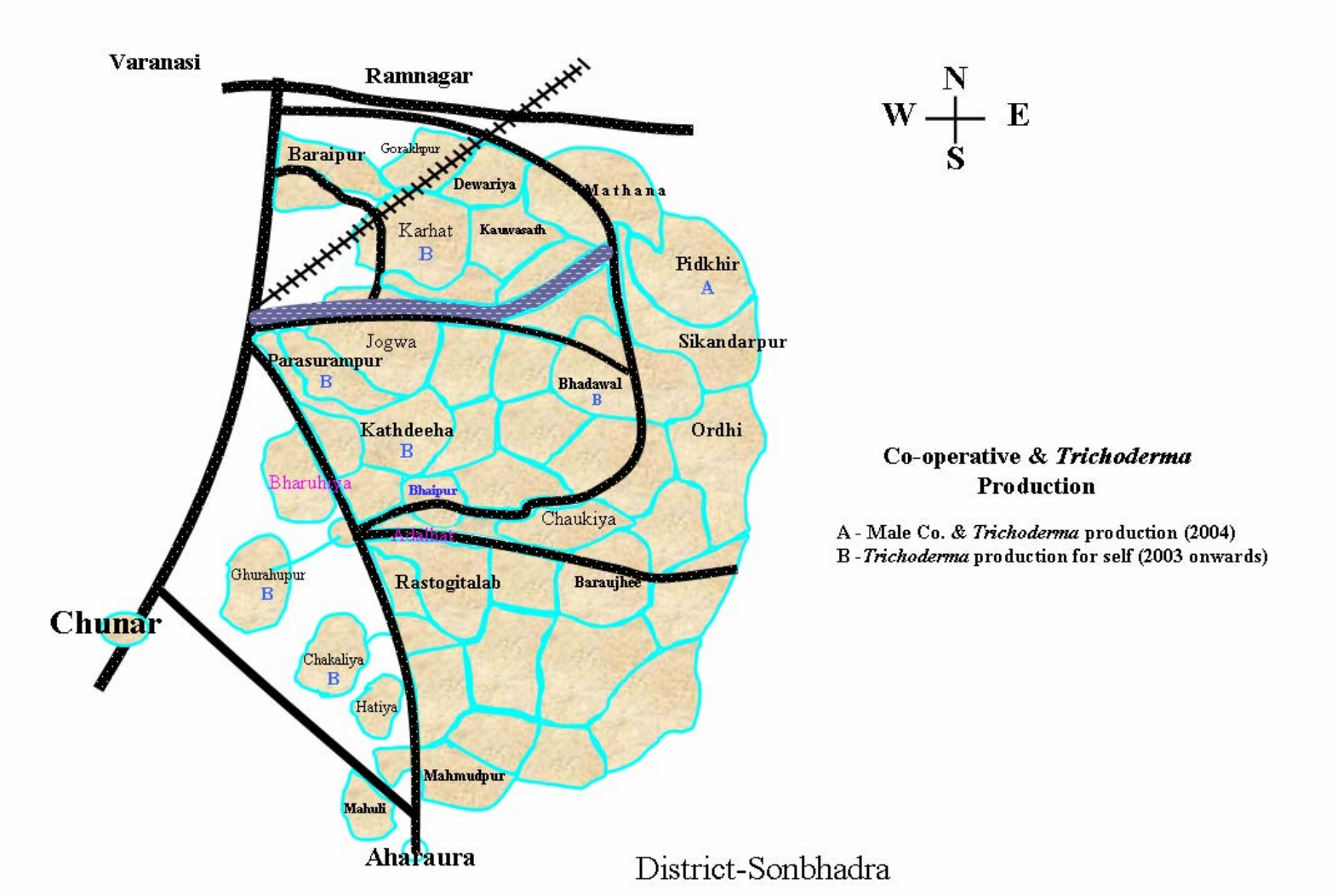
Trichoderma production and usage in and around the villages of Bhurkura and Karhat is shown in Maps 11 and 12. It is evident that *Trichoderma* production for home usage has spread to many villages and farmers are taking advantage of this technology.

Map 11: Map of villages adjacent to Bhurkura village, showing adoption of *Trichoderma* production and use



& V.K. Chandola. Analysed & compiled by Dr Tahseen Jafry, March 2007.

Map 12: Map of villages adjacent to Bhurkura, showing adoption of *Trichoderma* production and use



(d) Impact in terms of income, nutrition and health

The establishment of the *Trichoderma* group in the village of Rehiya is proving beneficial not only to the participating women and their families, but also to the village as a whole. Indirectly, it is also sending messages out to farmers of other villages that such technologies should be adopted without delay.

Economic impact

The families of participating women were able to enhance their income through the sale of the reusable *Trichoderma* product. In the first year, the farmers were apprehensive about their sales, but gradually they gained confidence as their experience grew and from communications with users in different places. Table 18 shows that the women's families were able to enhance their annual income from zero to around Rs 2000 per family. In Rehiya village, the average annual family income of the participating women ranges from Rs 20 000 to Rs 50 000. Hence the increased income is substantial by their standards.

Table 18: Income of women participants of Rehiya village, Mirzapur from *Trichoderma* production

Year	Annual income/family (Rupees)
2001	0.00
2002	500.00
2003	750.00
2004	2000.00
2005 (expected income)	3000.00

The increased income from *Trichoderma* production is obviously adding to the benefits for the participating families.

Impact on crop (paddy) health

The users of *Trichoderma* produced at village Rehiya are getting benefit especially through reduction of the sheath blight of paddy which very often causes serious losses to the crop. Table 19 shows the reduction of sheath blight infection in the paddy crop by the farmer of village Rehiya and other villages.

Table 19: Mean sheath blight infection and yield of paddy in *Trichoderma* applied and control plots of 50 farmers of Rehiya village and adjoining villages

Year	Sheath blight infection (%)		Yield obtained (q/ha)	
	Trichoderma applied	Control	Trichoderma applied	Control
2002	5.2	20.0	50.7	46.1
2003	3.8	18.5	52.5	45.3
2004	10.5	40.6	46.5	40.9
Mean	6.5	26.37	49.90	44.10

Social impact

The establishment of the Women's *Trichoderma* group in the village of Rehiya has had the following social impacts in the village.

- The village is now well-known and has more social prestige in the locality. This is reflected by increased visits by different stakeholders to the village and increased invitations for the villagers to attend different agriculturally related meetings.

- The village is being approached by different private companies with a view to strengthening linkages with respect to *Trichoderma* production and other aspects such as seed production
- The women's group was honoured at the farmer–scientist workshop organized at BHU (30 October 2004).
- The women's group inspired farmers to establish a men's *Trichoderma* Group (e.g. in the village of Pidkhir) and to produce the bio-agent for their own use too.
- The stories of the success of this women's group have been published in different print media, converting the village from unknown to a popular one.
- A recent brochure published by CIMMYT, Mexico carries photographs of the women of Rehiya village handling *Trichoderma* produced by them.
- This group has displayed use of 'women' power in adopting of new technologies in agriculture.

Output 3: "New technical innovations evaluated and developed by communities at pilot sites and enabling environments (including local manufacture, micro-finance, input access and training) established for participatory technology development"

3.1 Developing enabling environments for technology dissemination

The third output of the CABI/DFID 'Reaping the Benefits' project is to create an enabling environment for new technologies, such as the ZT machine and new wheat varieties, so that all socio-economic categories of farmers can have access to and benefit from their use. With this is mind, the team from BHU, Varanasi, has created an enabling environment which has allowed farmers to benefit from the technologies. This section describes the processes that the team followed in order to create that enabling environment.

3.2 Zero Till Technology

3.2.1 Model/approach followed over time

ZT technology was introduced by following a 'Farmer Participatory Approach' in which regular farmer-scientist interaction was given highest priority. For effective dissemination of the technology a large number of trials was arranged using the conventional method as the control technology.

The salient features of the model/approach used to create linkages with farmers and to popularize ZT technology were as follows:

1. A participatory approach was used with a major focus on regular interaction between farmers and scientists.
2. A multidisciplinary team of scientists worked with different categories of farmers to provide the simplest possible solutions to the problems related to production of different crops being faced by farmers. The team mainly consisted of a plant breeder, a plant pathologist and an agriculture engineer with active support of entomologists, agronomists, soil scientists and agricultural economists.
3. Farmers of all categories viz., landless, marginal, subsistence, and cash cropper were involved, and were selected for their interest and capacity to adopt the new technology. Landless farmers were encouraged to participate from the very beginning.
4. ZT was first deployed alone and was then used in combination with new high yielding wheat varieties, with conventional practices used as controls.
5. Gradually, other components such as quality seed production, bio-agent (*Trichoderma*) production and its usage, diversification of crops, etc., were included in step-wise manner.
6. Substantial emphasis was placed on creating linkages among farmers from different villages in same district, and also between districts.
7. Roving interaction meetings with farmers were organized on a regular basis during crop seasons.
8. Farmers doing impressive work were honoured in farmer–scientist workshops in order to provide encouragement and develop local leadership for promoting such activities.

9. All categories of farmers were encouraged to initiate activities such as custom hiring of machines, creation of societies/groups, development of better marketing skills, etc., to help increase their income and profit.
10. Substantial promotional material was produced using print as well as electronic media.
11. Visiting scientists from different parts of the country and abroad were also involved in field visits to develop further confidence among farmers.
12. Gradually, other stakeholders were also involved in the promotion of new technologies and also to help give an integrated shape to the programme for enhancing profitability of farmers.

3.2.2 Institutional blockages and challenges

Many institutional blockages and challenges were noticed in the dissemination of technology to the farmers. The blockages and challenges faced by farmers in adopting different technologies such as the ZT machine are as follows:

- A strong mindset favoured the traditional practice of tillage.
- A sense of fear among many institutions over pushing the new technology.
- Absence of a sufficient number of good quality machines and dealers in the eastern Gangetic plains.
- Lack of any incentive to industry and manufacturers from the state government or state agriculture department.
- Unavailability of spare parts at cheap cost.
- Shortage of trained manpower to repair minor defects in the machines.
- Absence of sufficient practical experience regarding the new technology among institutions.
- Lack of adequate promotion by the state agriculture department to further the popularization of technology.
- Lack of activities to promote custom hiring of machines to Landless or Marginal farmers.

3.2.3 Why did this technology move so well despite the institutional blockages?

The reasons for the substantial progress with ZT technology given the constraints identified in 3.2.2 are as follows:

- Strong motivation of the participating scientists and many of the farmers.
- Careful selection of progressive and determined farmers ready to use the new technology.
- An interactive approach involving farmers and scientists, which led to the quick removal of any doubts about the technology.
- Early involvement of farmers of all categories in different villages uniformly spread over various districts.
- Full use of linkages among different categories of farmers in different villages.
- Involvement of a group of scientists from different disciplines to provide integrated solutions to the farmers' queries.
- Regular roving interactive meetings with farmers over the whole crop season.

- Timely involvement of all stakeholders (government, NGOs, private sector, etc.) showing interest in the activities.
- Financial and technical support of institutions, both national (ICAR, New Delhi mainly through DWR, Karnal) and international (CIMMYT, South Asia Regional Office, Nepal & RWC, India; University of Bangor, UK; DFID, UK; etc.), in promoting popularization of technology using participatory methods.
- Substantial promotion of the advantages of ZT technology using both print and electronic media and all possible forums.

3.2.4 What are the options to move forward?

Various options to move forward beyond the scope and remit of the project could be as follows:

- Deployment of committed workers (farmers, scientists, other stakeholders) in technology promotion and refinement.
- Greater support to popularization of the technology by the state government through agriculture and other associated departments.
- Incentives to manufacturers for providing good quality machines at a lower cost.
- Provision of subsidies on raw materials as well as the finished product (the machine) to manufacturers and farmers, respectively.
- Involvement of the network of government institutions at village, block and district level by the state government.
- Mass education about the benefits of resource conservation in agriculture.

3.2.5 What could be the ways to scale up the technology?

Various options to scale up the technology beyond the scope and remit of the project could be as follows:

- Greater investment by the public and private sectors in R&D for the technology to develop low cost, more efficient multi-crop machines.
- Paying due attention to regular feedback from the users of machines through periodic joint meetings of all stakeholders.
- Greater involvement in the scaling up process of the network of government institutions at village, block and district level by the state government.
- Extending the use of ZT technology to as many crops as possible.
- Keeping a watch on the benefits or emergence of any new issue (insect pests, weeds, etc.) on long term basis.
- Drawing lessons from the experience of conservation agriculture in other parts of the world.

3.2.6 How can private enterprise and other stakeholders be engaged in the scaling out?

Various options to engage private enterprise and other stakeholders in scaling out the technology could be as follows:

- Introduction of new incentives to manufacturers, dealers and repair centres.
- Encouragement of small scale industries dealing with resource conservation machines at the village level.

- Providing sufficient credit to entrepreneurs for them to establish small to medium sized machine manufacturing units.
- Provision of substantial subsidy of ZT machines for farmers and service providers.
- Promotion of activities leading to greater interaction of manufacturers and other stakeholders with scientists and farmers.

3.2.7 What had most impact? What did not work so well?

The following aspects of the project had most impact:

- Interactive working by farmers and other stakeholders.
- Selection of appropriate farmers from each group (landless, marginal, subsistence and cash cropper).
- Use of good quality machines.
- Step by step movement so that only one technology was introduced at a given time.
- Deployment of multidisciplinary team of scientists.
- Creating linkages among farmers of different villages.
- Honouring farmers doing impressive work.
- Wide use of electronic and print media.
- Use of all possible linkages with different stakeholders.

The following project intentions did not work so well:

- Participation of the state government agriculture department.
- Promotion of manufacturers at a local level.

3.2.8 What worked for each category of farmer?

Landless farmers

- Involvement of Landless with other categories of farmers from the very beginning.
- Greater use of Landless in the operation of machines from the very beginning.
- Giving full recognition to landless farmers in farmer–scientist interactive meetings.
- Honouring farmers doing impressive work.

Marginal farmers

- Involvement of marginal farmers with other categories of farmers from the very beginning.
- Greater use of marginal farmers to promote the benefits of the ZT machine in new locations.
- Honouring farmers doing impressive work.
- Using marginal farmers to influence government policies favouring promotion of the ZT machine. For example, timely supply of machines and providing subsidies to farmers.

Subsistence farmers

- Involvement of subsistence farmers with other categories of farmers from the very beginning.
- Significant use of subsistence farmers in the operation of machines.

- Giving full recognition to subsistence farmers in farmer–scientist interactive meetings and also in media coverage.
- Honouring farmers doing impressive work.

Cash cropper farmers

- Involvement of these farmers with other categories of farmers from the very beginning.
- Greater use of cash cropper farmers to promote the benefits of machine in new locations.
- Using these farmers to influence government policies favouring promotion of the ZT machine. For example, timely supply of machines and providing subsidies to farmers.
- Honouring farmers doing impressive work.

3.2.9 What was farmers' feedback on dissemination activities focusing on each socio-economic group?

Landless farmers

- Reported minor defects of the machine along with the need for cheaper solutions.
- Gave information about locations and persons having interest in such technologies.
- Made suggestions on arrangements for custom hiring.

Marginal farmers

- Reported minor defects of the machine along with the need for cheaper solutions.
- Gave information about locations and persons having interest in such technologies.
- Made suggestions about creating linkages with farmers groups, societies and other stakeholders.
- Made suggestions about creating linkages between the state agriculture department and prominent manufacturers for increasing the availability of good machines.

Subsistence farmers

- Reported minor defects of the machine along with the need for cheaper solutions.
- Gave information about locations and persons having interest in such technologies
- Made suggestions on custom hiring and sharing of machines.

Cash cropper farmers

- Reported minor defects of the machine along with the need for cheaper solutions.
- Gave information about locations and persons having interest in such technologies.
- Made suggestions for creating linkages with farmers groups, societies and other stakeholders.
- Made suggestions for creating linkages between the state agriculture department and prominent manufacturers for increasing the availability of proper machines.
- Made suggestions about influencing state government officials to make the necessary effort to meet the growing demand for machines and also to introduce a substantial subsidy.

3.2.10 What are the overall lessons?

The overall lessons are being listed below:

1. A participatory approach with a strong interactive component is an effective way of technology transfer in villages having poor linkages with sources of technology.

2. Proper choice of farmers at the early stage of technology transfer is crucial to make the technology move.
3. Involvement of all categories of farmers is important for quick adoption of a technology by large numbers of farmers.
4. It is important to give full recognition to landless farmers in farmer–scientist interactive meetings.
5. Honouring farmers and organizations doing impressive work is a good way of creating healthy competition among farmers and helps in technology dissemination.
6. A multidisciplinary team of scientists capable of answering all kinds of farmers' queries is important in making strong linkages with farmers and other stakeholders.
7. The media (print as well as electronic) needs to be used judiciously to make technology known to large section of farmers.
8. Roving seminars with farmers in working villages and sites is very helpful in winning confidence of farmers and removing any doubts about the new technology.
9. Farmers should be given one technology at a time in order to make the impact of each one clear. Too many things should not be introduced at once.

3.3 Quality Seed Production of Improved Wheat/Other Crops Varieties

3.3.1 Model/approach followed over time

This technology was also introduced following a 'Farmer Participatory Approach' in which regular farmer–scientist interaction was given high priority. For effective dissemination, large numbers of seed production plots were organized in farmers' fields and regular farmer–scientist interaction was encouraged.

The salient features of the model/approach used to create linkages with farmers and to popularize quality seed production were as follows:

1. A participatory approach was used with a major focus on regular interaction between farmers and scientists.
2. A multidisciplinary team of scientists worked with different categories of farmers to provide solutions to most of the problems related to production of different crops being faced by farmers. The team mainly consisted of a plant breeder, a plant pathologist and an agriculture engineer with active support of entomologists, agronomists, soil scientists and, agricultural economists.
3. Farmers of all categories viz., landless, marginal, subsistence and cash cropper, were involved, with selection based on their interest and capacity to adapt to quality seed production. Landless farmers were also encouraged to participate from the very beginning.
4. Quality seed production was introduced in areas where participatory research for ZT and new wheat varieties was becoming successful; seed production was initiated for new high yielding wheat varieties.
5. Substantial emphasis was placed on creating linkages among farmers from different villages.
6. Roving interactive meetings with farmers were organized on a regular basis during the crop season.

7. Farmers doing impressive work were honoured in farmers–scientists workshops in order to provide encouragement and develop local leadership for promoting such activities
8. Farmers were encouraged to form societies and groups for seed production and its marketing to increase their income and profit.
9. Substantial promotional material was produced using print as well as electronic media.
10. Visiting scientists from different parts of the country and abroad were also involved in field visits to develop further confidence among farmers.
11. Gradually, other stakeholders were also involved in the promotion of new technologies and to help enhance profitability of farmers through better marketing.

3.3.2 Institutional blockages and challenges

The institutional blockages and challenges for quality seed production that were detected are as follows:

- Lack of facilities for providing training for farmers in quality seed production in different crops.
- Absence of linkages between institutions and landless, marginal and subsistence farmers.
- Absence of incentives to small scale seed agencies from the government.
- Absence of government schemes for involving landless or marginal farmers in seed production activities.
- Shortage of seed testing laboratories to provide seed testing facilities for farmers.
- Absence of a defined marketing network for shifting all the quality seed produced by farmers, especially landless or subsistence farmers.
- Absence of suitable schemes from the state government to promote seed production or the establishment of seed villages for different crops.
- Lack of credit facilities for farmers to protect them from the necessity for distress sale of seeds as grain during the off season.

3.3.3 Why did this technology move so well despite the institutional blockages?

The reasons for substantial popularization of quality seed production were as follows:

- Strong motivation of the participating scientists and many of the farmers.
- Use of an interactive approach involving farmers and scientists, which led to quick solutions to farmers' questions.
- Use of linkages among different categories of farmers from different villages.
- Involvement of farmers of all categories in different villages uniformly spread over various districts.
- Involvement of a group of scientists from different disciplines to solve all possible queries farmers might raise.
- Regular roving interactive meetings with farmers over the entire crop season.
- Creation of farmers' groups and societies by farmers for marketing the seed produced.

- Timely involvement of all stakeholders (government, NGOs, private sector, etc.) for better marketing of the seed the farmers produced.
- Financial and technical support of institutions, both national (ICAR, New Delhi mainly through DWR, Karnal) and international (CIMMYT, South Asia Regional office, Nepal; University of Bangor, UK; DFID, UK; etc.) in promoting popularization of technology using participatory methods.
- Substantial promotion of the quality seed production being done by farmers using both print and electronic media and all possible forums.

3.3.4 What are the options to move forward?

Various options to move forward beyond the scope and remit of this project could be as follows:

- Deployment of committed workers (farmers, scientists, other stakeholders) in technology promotion.
- Greater support for popularization of the technology by the state government through agricultural and other associated departments.
- Involvement of the network of government institutions at village, block and district level by the state government.
- Greater efforts to create farmers groups and societies for seed production in different crops.
- Mass education about the benefits of quality seed in agriculture.
- Acceptance of participatory seed production methods by ICAR.
- Ensuring better marketing by creating proper linkages with the existing sector of the seed industry.
- Ensuring simple credit facilities for Marginal and Subsistence farmers to avoid distress sale of seeds.

3.3.5 What could be the ways to scale up the technology?

Various options to scale up the technology could be as follows:

- Greater investment by the public and private sectors in propagating quality seed production for of different crops by farmers.
- Giving due attention to regular feedback from farmers.
- Greater involvement in the scaling up process by the network of government institutions at village, block and district level by the state government.
- Extending quality seed production to all possible crops.
- Organizing efforts to create seed villages and marketing of the seed they produce.
- Promotion of a community approach for seed production of cross/often-cross pollinated crops like pigeon pea, mustard, maize, etc., that require substantial isolation distances.

3.3.6 How can private enterprise and other stakeholders be engaged in the scaling out?

Various options to engage private enterprise and other stakeholders could be as follows:

- Introduction of new incentives for quality seed producers.
- Encouragement to small seed industries at a village level.

- Providing sufficient credit to entrepreneurs for them to establish seed industries and seed storages.
- Promotion of activities leading to greater interaction of seed producers and other stakeholders.
- Launching effective schemes, by the government, for quality seed production at the community level.

3.3.7 What had most impact? What did not work so well?

The following project activities had most impact:

- Interactive working by farmers and other stakeholders.
- Selection of appropriate farmers from each group (landless, marginal, subsistence and cash cropper).
- Assisting farmers in creating societies and farmer groups for seed production.
- Deployment of a multidisciplinary team of scientists.
- Honouring farmers doing impressive work.
- Wide use of electronic and print media.
- Use of all possible linkages (public sector viz., National Seeds Corporation, and private sector) with different stakeholders for marketing seed produced by farmers.

The following activities did not work so well:

- Participation of the state government agriculture department.
- Marketing of all the seed produced by subsistence farmers; some seed was sold as grain in the form of distress sales.

3.3.8 What worked for each category of farmer?

Landless farmers

- Involvement of Landless with other categories of farmers from the very beginning.
- Giving full recognition to Landless farmers in farmer–scientist interactive meetings in order to build up their confidence.
- Creating linkages between landless farmers and other socio-economic catagories of farmers.
- Involvement in the creation of farmer societies and groups for seed production.

Marginal farmers

- Involvement of marginal farmers with other categories of farmers.
- Greater use of marginal farmers in promoting the benefits of quality seed production.
- Honouring marginal farmers doing impressive work.
- Linking these farmers with public (such as National Seeds Corporation, State Seed Corporation) and private seed producing agencies.
- Involvement in the creation of farmer societies and groups for seed production.
- Honouring farmers doing good work.

Subsistence farmers

- Involvement of subsistence farmers with other categories of farmers from the very beginning.

- Giving full recognition to subsistence farmers in farmer–scientist interactive meetings and also in media coverage.
- Linking these farmers with public and private seed producing agencies.
- Involvement in the creation of farmer societies and groups for seed production.
- Honouring farmers doing good work.

Cash cropper farmers

- Involvement of these farmers with other categories of farmers.
- Greater use of cash cropper farmers in promoting the benefits of quality seed and its production.
- Honouring cash cropper farmers doing impressive work.
- Linking these farmers with public (such as National Seeds Corporation, State Seed Corporation) and private seed producing agencies.
- Involvement of cash cropper farmers in the creation of farmer societies and groups for seed production.
- Honouring farmers doing good work.

3.3.9 What was farmers' feedback on dissemination activities focusing on each socio-economic group?

Landless farmers

- Quality seed production for crops like wheat and paddy can be done by farmers but its marketing would be a difficult task.
- Linking landless with marginal or cash cropper farmers involved in seed production would be beneficial.
- Landless farmers also provided information about locations and persons having interest on seed production.

Marginal farmers

- Creation of linkages with farmers groups, societies and other stakeholders would be beneficial for enhancing quality seed production.
- More incentives to seed growers are needed for scaling up of seed production in villages.
- Attractive schemes should be launched to promote the seed industry in the state.
- Regular training programmes related to quality seed production for different crops should be organized by the state agriculture department.
- Marginal farmers also provided information about locations and persons having interest on such technologies

Subsistence farmers

- Quality seed production for crops like wheat and paddy can be done by farmers without any difficulty but its marketing would be a difficult task.
- Linking Subsistence farmers with marginal or cash cropper farmers involved in seed production would be beneficial for them.
- Easy credit facilities are needed to help subsistence farmers initiate quality seed production programmes.
- Regular training programmes related to quality seed production for different crops should be organized by the state agriculture department.

- Subsistence farmers also provided information about locations and persons having interest on such technologies

Cash cropper farmers

- Regular meetings were suggested for farmer and scientists with state government officials to promote policy changes in favour of seed production by farmers.
- Linkages of farmers groups, societies and other stakeholders need to be strengthened to promote the seed industry.
- Creation of linkages with public and private sector were suggested for the production and marketing of quality seed.
- Regular training programmes related to quality seed production of different crops should be organized by the state agriculture department.
- Cash cropper farmers also provided information about locations and persons having interest on such technologies

3.3.10 What are the overall lessons?

The overall lessons are being listed below:

1. A participatory approach with a strong interactive component is an effective way of technology transfer in villages having poor linkages with sources of technology.
2. Proper choice of farmers at the early stage of technology transfer is crucial to make the technology move.
3. Involvement of all categories of farmers is important for quick adoption of a technology by large numbers of farmers.
4. It is important to give full recognition to landless farmers in farmer–scientist interactive meetings.
5. Honouring farmers and organizations doing impressive work is a good way of creating healthy competition among farmers and helps in technology dissemination.
6. A multidisciplinary team of scientists capable of answering all kinds of farmers' queries is important in making strong linkages with farmers and other stakeholders.
7. The media (print as well as electronic) needs to be used judiciously to make technology known to large section of farmers.
8. Roving seminars with farmers in working villages and sites is very helpful in winning confidence of farmers and removing any doubts about the new technology.
9. Regular field oriented short training programmes are very helpful in recruiting new farmers for quality seed production.
10. Proper marketing of the seed produced is crucial for the growth and sustainability of seed production by farmers.

Overall Discussion

Output 1

Impact studies of using the zero tillage machine

The results of the impact studies indicate that for the two core project villages of Karhat and Bhurkura, all the farmers are benefiting from the use of the ZT machines. The main benefits are improved productivity, reduced cost of cultivation and sowing, and saving of time. This has benefited women indirectly because it is the role of women to ensure that there is sufficient food available to feed the family. The use of the ZT machine has meant that there are surpluses in wheat production which can be stored for future use and thus the women are released from some of the pressures of ensuring food security. Further, the time saved in cultivation has been shown to be used to grow vegetables for home consumption. This also contributes to improving the diets of the farming families in the project villages and in those to where the technology has spread.

The issue of labour displacement has been raised. The results of this study suggest that displaced labourers do get employment opportunities in areas other than agriculture. Looking forward, it would be interesting for the project to keep abreast of the issue and perhaps to monitor the extent to which labour is being displaced as the technology spreads to other villages.

The main reason for non-adoption by all groups of farmers was availability at the right time. Many of the larger farmers indicated that they would not consider buying the machine because it is expensive and it is used for only a short period in the agricultural calendar. A cost–benefit analysis would indicate that the outlay on a ZT machine can be fully repaid with savings/profits of one or two seasons; it is the initial up-front expense that deters farmers from purchasing it. During this research, it became clear that custom hiring of the machine was in strong demand by the farming community. The area of wheat coverage is large and the number of machines available in the area is not sufficient to meet the need. If the technology is in such high demand, it raises the question of why the private sector has not flooded the market with this technology. How to engage with the private sector to disseminate the technology was addressed under Project Output 3.

Impact studies of adoption of new varieties

The results of this research show that in the core villages most of the villagers have adopted the new varieties. This was mainly attributed to the DFID funded project on Plant Varietal Selection conducted under CIMMYT and BHU prior to the CABI project but there are still some farmers who have not adopted newer varieties (see Table 8 under Output 1) The availability of quality seed as well as affordability is given high importance in this. However, this research shows that it is lack of knowledge and information about the new varieties that has a major influence on adoption. Farmers in general need convincing about the use of new seed varieties and seemed to be ‘dependent’ on the BHU scientists for guidance and information. However, the scientists are not in a position to reach multiple numbers of villages nor districts. Thus information knowledge systems need to be developed to reach all categories of farmers.

The results of this study revealed that marginal farmers are dependent on relatives and other farmers for information (the majority are illiterate) whereas subsistence and cash cropper farmers have many more sources, such as newspapers, radio and direct contact with scientists. Women farmers are also dependent on their male counterparts for information and knowledge. This highlights the fact that educating farmers about new seeds requires tailor made training and development of information packages that can be understood by the farmers it is aimed at.

Output 2

Agricultural knowledge systems pertaining to the zero tillage machine and replacement of varieties

One of the mechanisms that the BHU team developed to get knowledge and information to farmers was to hold farmer–scientist workshops to encourage dialogue. Many other stakeholders were invited to these workshops, such as private sector organizations and government departments. Three workshops were held over 3 years. During the course of the 3 years, the number of farmers from the marginal and subsistence groups increased considerably. Landless and marginal farmers were given opportunities to run sessions during the 3rd workshop and there was also a farmer-run question and answer session. Also, the number of stakeholders involved also increased which was indicative of the growing popularity of the ZT machine and the desire for networking to spread the technology.

The main benefits from such workshops were confidence building in farmers, networking and interaction with stakeholders, creating awareness of the technology and creating opportunities for the private sector to acquire customers for future hire schemes.

A number of participatory farmer field training sessions were held in the core project villages of Bhurkura and Karhat on how the ZT technology works, to raise awareness of the new varieties and to allow farmers to give their feedback on the technologies. Marginal farmers in particular benefited from such sessions as it is the 'seeing is believing' approach. These farmers developed a sense of confidence about the new technology for the first time, and also developed a sense of wanting to learn more about how they could access the technology. In addition, marginal farmers were put in contact with manufacturers who also attended the field sessions to build rapport and to take things further. Many subsistence farmers were already accustomed to the ZT technology but the field days also helped their confidence in the use of the technology and build linkages. Large farmers developed a sense of innovation and creativity during the field sessions. Through dialogue with manufacturers, they were exploring how the machine could be changed or improved to suit other field conditions.

The project team have captured how the technology has spread from the core project villages of Bhurkura and Karhat since they have been working on promoting the technology. A number of village maps were produced to visually illustrate the spread across villages. It must be noted here that the BHU team had been working on ZT and replacement of wheat varieties programmes for a number of years prior to the CABI project. It proved very difficult to separate the impacts due specifically to the CABI project from those due to other projects. The results captured in the maps reflect the overall presence of BHU scientists in the area and do not demarcate between specific projects. The results do show that the technologies are spreading to other villages. The speed of the spread is not fast but this may be because the BHU team is the only team working in the area which limits what they can actually do.

The maps are supported by further data on the actual number of hectares planted using the ZT machine in relation to the total area planted using conventional tillage. The results show that in some villages there is considerably more coverage with ZT than in others. The data collected during this study show on average ZT is used on 20% of the wheat area in the villages (data collected from nine villages surrounding the core project villages of Bhurkura and Karhat) using ZT machine. The range of coverage was 7–50%. The results do show that farmers from outside the villages where the machines are normally kept came to hire them. The charges range from 350–450 Rs per acre. However, it is mostly the cash croppers and subsistence farmers who are able to afford these hire charges. One of the downsides of the machine is that it has only one use which puts many farmers off investing in it. Interestingly, women farmers benefit from the machine because the crops are sown in rows which makes harvesting easier (it is usually women's work to do harvesting). An issue was raised which the project team ought to keep track of. This was the concern that continuous use of the

machine may cause increases in dicotyledonous weeds. Overall, the farmers felt that a field sown by the ZT machine looks impressive and gives an indication that the village is progressing.

The dissemination activities conducted by the BHU team have contributed to the spread of knowledge to many other farmers and hopefully the use of the machine and seed of new varieties will continue to increase. It would be worthwhile for the team to continue capturing data as the technologies spread over time.

The BHU team also facilitated the formation of a women's working group/co-operative to initiate the production of *Trichoderma* for crop protection. The BHU team used participatory skills to encourage the formation and functioning of the group at village level. Whole families were encouraged to take interest in the activity which involved the production of *Trichoderma* using facilities already available in the kitchen; no other or special equipment was required. The farmers were trained at village level using the pure inoculum of the fungus from BHU. The women's group was also provided with help and support as regards the commercial sale of the bio-agent. The results presented in this study show that the sale of *Trichoderma* has spread to a number of villages outside Rehiya village (where it was initiated). The women are making substantial profits from the sale of the bio-agent. In 2004 this reached 2000 Rs compared with 500 Rs in 2002. The results of this study demonstrate the bio-agent is showing effectiveness in reducing sheath blight in paddy. The study shows that the BHU have enabled women to develop a successful commercial activity through a process of engagement, dialogue, support and knowledge transfer.

Output 3

Creating enabling environments

The BHU project team has been working on disseminating the ZT technology and new seed varieties for a number of years. The CABI project enabled the team to examine some of the strategies they have been using to promote the technologies and to examine how better enabling environments could be created by looking at the needs of farmers not as a whole group but in terms of farmers belonging to different socio-economic categories. By doing this, the realization that different categories of farmers have different needs in relation to ZT technology and wheat varieties became clearer. This research has shown that a 'one package of practices fits all' approach does not work.

The study team also identified a number of institutional blockages which prevent farmers from adopting the technologies. For the ZT machines, these ranged from lack of back-up support from extension services to the absence of good quality machines being available. For replacement of varieties, they ranged from lack of facilities for providing training for farmers in quality seed production to absence of a defined market network. What made the process of change more complicated was that there seemed to be a real sense and mindset that favoured using the traditional tillage practice as well as a total lack of incentive to change practices.

However, despite many institutional blockages change has taken place. The project team has focussed on adopting participatory approaches for their dissemination activities. One of the main foci has been to ensure the early involvement of all categories of farmers in project activities. This, coupled with continual 'roving' interactive meetings in the farmers' fields, has encouraged farmers to change. In particular, the formation of farmers' groups and societies for the marketing of the seed and *Trichoderma* (bio-agent) they produce has been highly successful.

The project team has identified that for the technologies to be scaled up and scaled out will require the deployment of a number of stakeholders in the dissemination process. The team felt that maintaining a close dialogue with farmers is crucial in bringing about change. However, greater interest and investment by both the public and private sectors are required

to push these technologies on a wider scale. During the duration of the CABI project the team felt that getting the involvement of the state government extension department and manufacturers at a local level proved difficult. Also, the marketing of total seed production was not entirely successful. Although it is thought that the technology would continue to spread, the speed of the spread will not be as fast as it could be without the involvement of the government department and the private sector.

Final Conclusion

This research project has shown that all categories of farmers in the core project villages could benefit from the use of ZT technology and replacement of wheat varieties. If it can be shown that increased wheat yields are leading to improved food security at household levels, then women will benefit indirectly because there will be less pressure on them to provide food. It is interesting note that diets are said to be improving through increased consumption of vegetables. Vegetables can be grown using the time that is saved in labour during cultivation with the ZT machine. Although the issue of labour displacement was raised, the extent to which it is a problem remains unknown but the results of this study suggest that it is a negligible problem. As a recommendation, the project team could monitor the situation and keep records of how the situation changes.

Gaining the benefits of improved agricultural technology life depends on access and control. Although there is considerable demand for the ZT machines, supply is limited and the high cost of hiring them remains a major issue. The project team did facilitate a number of workshops to encourage networking amongst the private sector and government agencies. However, the fact remains that the number of private dealers wanting to provide ZT machines on a hire basis is extremely small. The cost of the machine itself is too high and many farmers do not want to invest in a machine that has a limited use in the agricultural calendar, i.e. land preparation for wheat. This situation seems to suggest that the dissemination and adoption of the machine will be slow in areas beyond the core project villages and the immediate neighbouring villages.

Knowledge and information is critical to the change process. This research has shown that farmers from different socio-economic backgrounds have different requirements for information. The poorer groups are more illiterate and fewer sources of information are available to them than to the better off farmers. The project team concluded that ‘a one package of practices’ does not fit all. Furthermore, the research showed that institutional blockages are preventing farmers from adopting new technologies. It is not just a matter of economics and knowledge. Institutions provide valuable back-up support services; without this support the farmers will find it difficult to change from their traditional practices. Farmers need to feel that organizations are going to help them during the adoption process. Although the BHU team have done an excellent job in providing this level of support in the core project villages, they are physically unable to reach all the outlying villages. In conclusion, the rate of dissemination and adoption of the technologies will not be rapid without further support from other agencies.