Farm Mechanization & Conservation Agriculture for Sustainable Intensification (FACASI)

HIGHLIGHTS OF SOUTH-SOUTH TRIP REPORT TO BANGLADESH

1. STUDY TOUR OBJECTIVES

As FACASI focuses in the main on mechanization based conservation agriculture (CA) as part of a sustainable conservation strategy, it was felt invaluable to organize an exchange visit to Bangladesh which has considerable experience in both mechanization and conservation agriculture. Success stories in agricultural mechanization development in Bangladesh have demonstrated the possibility of delivering mechanization to smallholder farmers by promoting appropriate scale machines and by involving the private sector in unsubsidized business models. As one of the most densely populated countries of South Asia, Bangladeshi agriculture is characterized by small and fragmented fields. However, 80% of the land is prepared mechanically, making Bangladesh agriculture the most mechanized in South Asia.

A two week study tour on Farm Mechanization for African Stakeholders was organized and carried out under the auspices of The Farm Mechanization & Conservation Agriculture for Sustainable Intensification (FACASI) project. The purpose of the study tour was to learn from the Bangladesh experience in introducing 2WTs and conservation agriculture implements. More specifically, the study visit had the following objectives:

- To share of experiences and broaden knowledge on 2WT technologies and accessories, in particular for Conservation Agriculture with similar projects funded by ACIAR and USAID
- To strengthen partnership and collaboration with Bangladesh Agricultural Research Institute specifically with Agricultural Engineering and post-harvest division in broad areas of agricultural mechanization research for the benefit of both countries.
- To meet with private sector service providers and manufacturers
- To participate in a conference on Conservation Agriculture for Smallholder Farmers in Asia and Africa

The study tour took place over the period 1st to 7th December leading up to a five day conference - *Conservation Agriculture for Smallholders* supported by a number of organizations including CIMMYT and ACIAR.

2. PARTICIPANTS

The Team comprised experts from the four FACSASI countries: Ethiopia, Kenya, Tanzania and Zimbabwe. The visit was organized and coordinated by CIMMYT Ethiopia in partnership with the CIMMYT Bangladesh. The participants included:

- David Kahan Ethiopia, CIMMYT (Project objective 2 leader)
- Eng. Girma Moges Ethiopia, EIAR (project PI)
- Dr. Joseph Mutua Kenya, KENDAT (project PI)
- Eng. W.M. Baitani, Centre for Agricultural Mechanization and Rural Technology (CAMARTEC), Tanzania
- Mr Clopas Rukuny – University of Zimbabwe

The study tour included field visits traversing the north and central parts of Bangladesh to the USAID funded CSISA BD and CSISA MI project and ACIAR's project - *Promoting 2WT-based CA in Bangladesh.* The field visit was designed to meet with scientists of the main agricultural research organizations participating in the project: the Bangladesh Agricultural Research Institute, the Wheat Breeding Centre; observe project field trials and demonstrations; and meet with farmers and service providers in a series of focus group discussions.

3. PROGRAMME

The methodology of the study tour consisted of:

3.1 Institutions and centres visited:

Different visits were made to purposefully selected learning sites for mechanization, conservation agriculture specifically research centres, equipment manufacturing companies, CA research sites, service providers etc. Visits were also made to smallholder farmers' fields, farmer associations/cooperatives.

At all sites, sufficient time was provided to allow for in-depth interaction between the Bangladesh hosts and the African visitors. The open discussions - but stratified/guided by CIMMYT - enabled pinpointing of specific issues without losing the context of the Bangladesh situation.

3.2 Presentations:

Presentations were made by CIMMYT project staff of CSISA-MI and project management of the Monash University led project - *Promoting 2WT-based CA in Bangladesh*.

3.3 Field visits

Field visits were made to purposefully selected learning sites for mechanisation, conservation agriculture, equipment manufacturing, CA research, technology transfer, and business modelling. Visits were made to smallholder farmers' fields, farmer associations/cooperatives, machinery testing, training and research institutions.

At all sites, quality time was provided to allow for in-depth interaction between the Bangladesh hosts and the African visitors. The open discussions - but stratified/guided by CIMMYT - enabled pinpointing of specific issues without losing the context of the Bangladesh situation.

3.4 Participation in the Conservation Agriculture Conference

The delegation participated in the international conference *Conservation Agriculture for Smallholders in Asia and Africa.* The keynote address was given by Dr. Amir Kassam, Reading University and FAO who provided an overview of the current status of Conservation Agriculture globally and the challenges in designing and adapting CA to smallholder agriculture.

4. CONTEXT FOR 2WT MECHANIZATION

4.1 2WT in Bangladesh

The Bangladesh rural economy has witnessed significant changes in recent decades. The numerical dominance of marginal and small farms is increasing at a rate 2.7 percent per annum, while those of the medium and large farms have actually fallen. Bangladesh agriculture is overwhelmingly dominated by small farms. The number of agricultural labour households as a proportion of all rural households and number of farm holdings providing wage labour to other farms has decreased markedly over the last two decades and this has resulted in an uptake of mechanization. This trend has been paralleled by a reduction in the land available for crop cultivation - shrinking at a rate of 1 percent per annum, which has resulted in a reduction of average farm size from 0.81 hectare in 1983/84 to 0.61 hectare in 2000 and 0.4 ha. In 2014 with simultaneous increase in fragmentation and subdivision of holdings.

Mechanisation of irrigation equipment received a boost in the late 1980s with a broad-based policy change including the liberalisation of markets for inputs, removing ban on imports of machinery by the private sector and reduction of tariffs. The policy promoted private sector investment due to reduction in the cost of imported agricultural machinery. Both economic and non-economic factors fuelled mechanisation. First, with growing scarcity of fodder, the maintenance of farm animals for providing draft power became costly. This development triggered mechanisation of tillage operations and reduced dependence on draft power animals. Second, rapid expansion of paved roads from farms to markets and the support of microfinance provided by NGOs, created job opportunities for the landless in rural trade and transport operations. As a result and over time, the agricultural labour market became tight and with it, agricultural wage rates started to rapidly increase. This resulted in a wage hike that compelled farmers to seek labour-saving technologies in agricultural operations. As a result, a market for selling machine services developed. Finally, the 1970 cyclone and the high mortality of draft animals also triggered the need for low cost mechanization. Following the 1988 flooding several policy changes prompted the import of tillage mechanization through providing a tax exemption on agricultural machinery imports, waiving the policy of standardization certification, eliminating the public sector monopoly import and promoting private sector participation in machinery imports. These measures were supported by Government through a modest subsidy scheme aimed at promoting farm machinery.

Small scale Irrigation proved to be the entry point for mechanization and the most dynamic private sector activity involving. 1.7 million owner/managers of mechanized irrigation pumps and 0.16 million

rural mechanics, who provide services for installation, repair and servicing of irrigation pumps and other forms of small mechanization. The rapid spread of these irrigation technologies opened up opportunities for a variety of non-farm activities. Access to Chinese machines provided the 'tipping point' for the sector to take off. Mechanized tillage operation went hand in hand with irrigation. Additionally, the cost of keeping livestock and the shortage of fodder was another trigger for the rise of 2WTs together with the right enabling conditions – a strong research base and a vibrant private sector.

Bangladesh currently boasts a highly mechanized agricultural economy, with 80% of land preparation conducted using two-wheeled tractors (2WT) with attachable power tillers. Estimate of the number of 2WTs in the country are 450,000 and there are further opportunities to bring these new technologies to scale. Although 2WTs are used for haulage, within farmers' fields, they are primarily used for land preparation and ploughing. The 2WT being a flexible asset is also used to power a diverse range of field operations: transportation, irrigation, paddy threshing, maize shelling, milling rice etc. Power tillers are used for different purposes depending on the environment, the ability of farmers to buy attachments and the availability of credit facilities. In this was 2WT are used throughout the year to increase profits and employment. Such benefits have had a positive implication for their wide adoption. The increased use of mechanized tillage for land preparation has also created powerful linkage effects on non-farm activities. Numerous private manufacturers produce large quantities of farm equipment and pumps. Also, there has been a rapid growth of local engineering workshops and development of second hand engine market in intensively irrigated regions of the country. These do not only support the growth of minor irrigation sector, but also have generated productive employment for skilled and semi-skilled rural youth. All these generated additional non-farm activities and income for operators and metallurgy workshop workers.

4.3 Agro-machinery Industry

The agro-machinery industry in Bangladesh is said to worth over 400 million USD and sales of small single-cylinder diesel engines and 2WTs make up over half of this total. The other half comprises products fabricated by small and medium manufacturers who make threshers, trailers, centrifugal pumps, and diesel engine and tractor spare parts. Manufacturing of spare parts for irrigation engines and power tillers has widely spread down to local level. Many of them were simple artisanal businesses but have now upgraded their production in response to increased demand for the more sophisticated equipment such as power tiller tines, thresher, hand weeders, irrigation pumps, diesel engine accessories, etc. They market their produce through dealers and retailers, but small artisans also sell the products directly to farmers. There are also divisions of labour not only within the manufacturing workshops but also between the workshops in different locations of the country. With the development of the road network and telecommunications the manufacturing and marketing of equipment are becoming both horizontally and vertically integrated to take advantage of the availability of cheap labour, raw materials and market opportunities.

Currently, there are more than 10 000 small and medium sized local metal working workshops manufacturing agricultural machinery. These range from small 'one welder' workshops employing 2-3 individuals to larger concerns employing much higher numbers of staff. The major problems the

manufacturers face are inadequate bank loans, high interest rates, lack of essential tools, skill training, lack of business development information and services, interrupted power supplies, and property rights. The growth in the machinery import sector has contributed to the growth in rural engineering and industrial capacity and capability, where imported diesel engines supplement locally manufactured technologies.

BARI works in close contact with local manufacturers in R&D as well as promotion. The strategies for promotion include demonstrations, providing subsidies for purchasing machines, provide training, support services, feedback to R&D improvement. The cost of locally manufactured machinery is more costly than importing from outside. There are no patents currently in Bangladesh but the situation is changing.

5. FIELD VISITS

Visit to Farm machinery and Post-harvest Process Engineering at Bangladesh Agricultural Research Institute (BARI) (Day 3): On day 3 the team visited Farm machinery and Post-harvest Process Engineering of Bangladesh Agricultural Research Institute situated at the outskirt of Dhaka, the capital. A very warm reception was made by the director and the scientists. A presentation was made by the senior scientist to the team on the overall vision, mission of the unit and its contribution to science and development towards the country's development plan. The organizational structure, a summary of the different research programs and the achievements and partnership with different stakeholders were also presented. Following the presentation, a thorough discussion was conducted with the director and senior scientists as to how to exchange technologies for the benefit of both countries. Approaches in mechanization research coordination and management system were also discussed as well as modalities for technology promotion and transfer to different users.

Farm machinery and Post-harvest Process Engineering (FMPE) is one of the 16 research division of BARI mandated to do research in the area of agricultural mechanization mainly for small to medium sized famers. FMPE has four major research focus area such as design and development, testing and performance evaluation, postharvest process engineering and renewable energy. Their major research revolves around the development of suitable farm machinery for different agricultural operation, development of new machine and refinement the existing ones, utilization of rural energy for agricultural use, study the suitability of imported agricultural machinery and dissemination of developed machinery through field demonstration and training. To conduct this research, FMPE has good research facilities comprising a workshop, post-harvest laboratory and machine testing laboratory. FMPE, since its inception has developed more than 34 different technologies and recently developed solar pumps (4), manual groundnut shellers (2), power groundnut shellers (3) a coffee roaster, potato slicer, turmeric plosher (1), coffee grinders (5) and coffee roasters (6).

Visit to different farmers' fields (days 4, 5 and 6): The team visited more than 20 long term mechanization based CA trails in farmer fields in different regions of the country: namely Briand, Charghat and Durgapur. The team also conducted two separate focus group discussion with famers and service providers to get in depth knowledge on mechanization based CA and familiarise the team with sustainable intensification.

Briand Multipurpose Development Authority (BMDA): On day 7, the team visited the BMDA irrigation facility to understand the prepaid metering system where farmers are charged for water use. BMDA was established with the objective of augmenting surface water resources and its use, increasing irrigation facilities by using underground water through Deep Tube Wells and formulating and implementing command area development project for creating water supply system for irrigation and development of irrigation and others. Farmers are given credit cards to charge them for water use. Every pump station has a prepaid meter with a LCD display which is hung on after the energy measuring meter. The farmer will be able to charge an amount of his choice from the local BMDA offices or from a dealer. Each local office will have a *Vending Station (VS)* and each vending dealer will have a *Mobile Vending Unit*

6. OBSERVATIONS

6.1 2WT based accessories

Seeder-fertilizer drills: For precision management and conservation agriculture seed and fertilizer drills for two wheeled tractors are widely available. They are increasingly being imported and sold within Bangladesh, but commercial availability and farmer adoption tends to be low. Domestically produced drills for the 2WT are increasingly becoming to farmers as well. On their own merits, seeder-fertilizer drills represent a tremendous advance in precision management that boosts input use efficiencies and crop yields. These drills can be easily used for conservation agriculture (CA) by removing the majority of the blades attached to the drill's rotovator. This is referred to as 'strip' tillage.

Bed planters: Farmers who irrigate their crops normally flood the entire field, which is wasteful and inefficient because only a portion of the water applied is actually used by the crop. Bed planters are increasingly being used for saving water in irrigated environments and can be easily attached to the 2WTs. Using the furrows between raised beds, water can be channelized across the field, resulting in irrigation savings up to 40%. By combining bed planting with fuel-efficient axial flow pump or small engine based irrigation, significant water and cost savings can be achieved, resulting in high yielding, profitable crops. There was an interest among the Zimbabwe delegation to consider importing bed planters particularly for vegetable production.

Versatile Multi Crop Planters: The Versatile Multi-Planter (VMP) is an innovative multi-functional and multi-crop planter for smallholder farmers. It is combined with 2WT and is a modification of a standard rotary cultivator where modified tines are spaced along a modified rotor shaft for strip tillage. The VMP is capable for seed and fertilizer application in variable row spacing using single-pass shallow tillage, strip tillage, zero tillage, bed planting and conventional tillage system. The cost of the VMP is high and it is difficult to transport owing to its weight. The VMP is at an early stage of commercialization in Bangladesh.

Multi-crop reapers: Manual harvesting is labor demanding and time consuming, and increases women's drudgery. In some parts of the country, farmers harvest their rice late because they simply cannot find enough labourers to cut and remove rice from the field. This results in delays, and post-

maturity losses. Delays also set back the planting of the subsequent second season crop. In 2002, manufacturers started designing and fabricating self-propelled reapers using Chinese diesel engines of under 6 hp or attached to a 2WT. The reapers mechanically harvest the crop, reduce labor and the cost by 50-60%. Where rice is followed by wheat, the same reapers can be used for rapid harvesting of both crops. Reapers are therefore essential for intensification by growing more than one crop per year.

Threshers: The spread of small horsepower, belt-driven threshers and maize shellers has been very rapid. Prior to the mid 1990s Bangladesh had little mechanized threshing of any crops. Then much of the rice and wheat was being threshed by hand or by trampling (treading) with 2WTs or animals. Reports suggest that currently 100 percent of maize is being shelled by powered maize shellers and over 80 percent of wheat and a large percentage of rice is being threshed by machines. There is also widespread use of the less expensive hold-on type open drum threshers for rice. All threshers and maize shellers are powered by the Chinese diesel engines that are identical to the ones used on pump-sets and in some cases by the larger diesel engines of 2WTs.

6.2 Local service providers

The business model widely operating in Bangladesh is the individual local service provider model where 2WT mechanization services are provided as custom hire. The service provider model addresses the constraints of smallholder farmers on fragmented holdings while overcoming the barriers to reaching large numbers of farmers. Local service providers are rural entrepreneurs contracted by even the poorest farmers to till, transplant, weed, irrigate, manage, and harvest their fields. The projects visited build on this foundation to reach farmers at scale. Market development approaches are being deployed to orient and sensitize entrepreneurs to the needs and opportunities of servicing farmers at scale. By definition, LSPs are effective. They are rural entrepreneurs who have invested in machineries, and who are therefore motivated to maintain profitable businesses and attract farmer clients by offering quality services. Most LSPs are business people specializing in providing mechanization services. Some LSPs have local agents to develop demand, take orders and negotiate.

6.3 Policy and institutional issues

The recent growth of rural non-farm activities has been propelled mainly by the acceleration of growth in crop sector agriculture. This has largely been facilitated by rapid spread of small-scale tubewell irrigation, power tiller utilization and so on. The major policy variables contributing to these changes are liberalization of market and trade regimes, and large-scale privatization of agriculture i.e. input market, output trade, deregulation of equipment import and distribution, rationalization of subsidies, etc. While various reform measures are being implemented in macro-economic and sectoral levels, the main strategies for the development of the 2WT mechanization sector are:

1. Mainstreaming mechanization sector: institutionalizing mechanization initiatives and providing proper space and focus to sector priorities in major government plans and policies.
2. Strengthening key drivers of the mechanization chain: sustaining agricultural growth momentum, tapping urban and export market, putting rural remittances to productive work and finding new drivers.

3. Strengthening rural-urban linkages: stimulating urban consumer demand for mechanization products, developing agro-processing, fostering rural-urban business linkages, and expanding rural-urban continuum.
4. Removal of barriers to entry: making markets function better through provision of infrastructures, rural electrification, skill training, literacy and numeracy, appropriate rural financial services, business development services and reducing cost of doing business through improvement of law and order situation.

Kick-start subsidies were seen to be vital to begin the 2WT mechanization process but the issue is the way subsidies should be designed and administered. It was recognised that direct government subsidies on the price of machines needed to be discouraged unless limited for a given period of a programme but it's sometimes difficult for governments to wean themselves out of subsidies. Discussions with economists in Bangldesh dealing with mechanization suggested the following guidelines: 1) to provide subsidies to incentivize the private sector to import machinery and spare parts; 2) to subsidize extension services (demonstrations, operating costs); 3) to bring in the private sector as trainer, manufacturer etc. from the outset; or 4) for Government to promote sales of 2WT for the private sector to step in. It was recognised to be better to work with the private sector from the outset. Subsidies should also be channelled towards private sector importers rather than for government to import and deliver tractors at subsidised rates.

7. CONCLUSIONS AND LESSONS LEARNED

The study tour gave the FACASI participants a perspective on the history of smallholder mechanization in the country, an understanding of the triggers that accelerated the spread of mechanization, and the challenges and opportunities that lie ahead. It was a valuable learning experience and well appreciated. Some of the more specific lessons are listed below:

- Time frame for the adoption of 2WT based conservation agriculture machineries. 2WT were introduced over thirty years ago. Conservation based equipment – seeders – have only been promoted together with CA over the last decade
- With mechanization, there are no signs of declining productivity or agricultural employment and women's employment in agriculture increased.
- More people are moving to urban areas and are migrating overseas resulting in a labour shortage in rural areas that is a trigger for change.
- It was also observed that we need to look beyond agricultural mechanization and recognise that mechanization should be seen as part of rural development.
- In Bangladesh maize is a cash crop used to produce poultry feed (90% feed, 10% household consumption)
- Strip tillage field trials for maize suggest that there have been both yield increases and cost savings resulting in substantial increases in profitability.
- Farmers use 2WT for multiple uses such as tillage, pumping transportation etc.
- Need for a field presence to manage/ monitor the project in the field

- Although Government subsidies were used to start the industry over time the price differential equalized out and the private sector began to enter the market. Currently there is no differential between government and private sector imported machinery.
- 'Smart subsidies' seem to be needed to kick start 2WT mechanization. But some consideration is needed to design the subsidies in a way that market distortion is avoided. Who should receive the incentive in the supply chain- the dealer, manufacturer, service provider or farmers. Examples of smart subsidies used include providing a discount to SPs or farmers if they attend a training in CA.
- The flat topography and excellent feeder and main road system make service provision a lucrative operation.
- Service providers in many situations provide specialized services rather than 'bundles of services' as we have hypothesized for Africa. This is due to the easy access between farmers and the multiple crops that they are able to grow annually.
- The capacity of local manufacturing is weak and there is little post sales service support. The sector largely depends on Chinese imports as well as availability of spare parts. In many cases 2WT users replace engines with new or refurbished version rather than undertaking repairs. If engines are recycled in China there could be a market to refurbished engines in Africa.
- A more proactive strategy is needed to develop Private-Public Sector Partnerships with Chinese importers and domestic companies. Priority should be given to partner with Chinese companies that have an R&D division.
- There is some evidence that 2WTs may be a stepping stone to buying 4WTs which are seen to have some advantages. The cost of hiring services are lower for 4WTs because of the faster work rate and they are also better for transportation. In China for example, 2WTs are not popular. This is an interesting hypothesis: are 2 and 4WTs separate markets?
- More attention should be given in SSA to the spare parts market.

8. ANNEXES

Annex 1 **Pre-Conference Field Visit Program**

1 – 7 December, 2014

Day	Time	Activities
Monday 1 December		FACASI Team will arrive in Bangladesh
Tuesday 2 December		Dr. Mahesh Kumar Gathala (CIMMYT-Bangladesh) will lead the program
Wednesday 3 December		Dr. Mahesh Kumar Gathala (CIMMYT-Bangladesh) will lead the program
Thursday 4 December		Dr. Mahesh Kumar Gathala (CIMMYT-Bangladesh) will lead the program
	8:00 a.m.	ME Haque will lead the group (other than FACASI) to visit Bangladesh Agricultural Research Institute, and Bangladesh Rice Research Institute to meet with DG, Directors and Divisional Heads of BRRI and BARI.
	9:30 a.m.	Meeting at BARI (other than FACASI Group)
	11:00 a.m.	Meeting at BRRI (other than FACASI Group)
	12:30 p.m.	Lunch at BRRI (other than FACASI Group)
	1:00 p.m.	Start for Rajshahi (other than FACASI Group)
Evening	7:00 p.m.	ME Haque will arrive at Hotel Nice International with other participants. Dinner and Meeting at Hotel Aristocrat with Local Administration; DAE (ME Haque will arrange)
Friday 5 December	7:00 a.m.	Breakfast
	7:30 a.m.	Start for Durgapur
	8:30 a.m.	Visit long-term CA Trial (Rice-lentil-mungbean) in farmers field
	9:00 a.m.	CA Farmers Field Visit including CIMMYT Trials
	10:30 a.m.	Focus Group Discussion (Farmers + VMP Service Providers)
	11:30 a.m.	Return back to Rajshahi
	12:30 p.m.	Packet lunch on the way to Godagari
	1:30 p.m.	Visit long-term CA Trial (Rice-wheat-mungbean) in farmer field
	2:00 p.m.	CA Farmers Field Visit including CIMMYT/Dr Ilias Hossain Trials
	3:30 p.m.	Focus Group Discussion (Farmers + VMP Service Providers) at Digram and Choighati
	5:00 p.m.	Return back to Rajshahi Night halt at Rajshahi
Saturday 6 December	6:00 a.m.	Start for Rajbari (packet Breakfast on the way)
	10:30 a.m.	Visit long-term CA Trial (Rice-lentil-jute) in farmer field
	11:30 a.m.	CA Farmers Field Visit including CIMMYT trials.
	1:30 p.m.	Lunch
	3:00 p.m.	Focus Group Discussion (Farmers + VMP/PTOS Service Providers) at Baliakandi
	5:00 p.m.	Start for Faridpur Night halt at Faridpur (ME Haque, RW Bell, W Vance will leave to Mymensingh)
		MK Ghatala will take care rest of the program in Faridpur
Sunday 7 December		
	4:00 p.m.	Conference Registration at BAU

Annex 2 **Conference on Conservation Agriculture for Smallholders in Asia and Africa**

7 - 11 December, 2014

Many small holder farmers in Asia, Africa, and other regions are practicing aggressive soil tillage to grow crops. Tillage is practiced with the intention of loosening seedbeds, controlling weeds, aerating soil by creating artificial porosity to facilitate sowing and covering of seed in the seedbed. However, research results from many regions of the world show that increase of tillage intensity may harm soil physical, chemical and biological properties which limit crop yield. This is primarily caused by declining soil organic matter, its oxidation being accelerated by tillage, particularly in warmer climates, and exacerbated by the limited return of above-ground biomass to the soil due to its competing use for other purposes. In large-scale commercial agriculture, declining soil quality has been effectively addressed in many parts of the world by conservation agriculture (CA) —cropping systems based on minimum tillage, crop residue retention and appropriate crop rotations and associations. Various forms of CA are now practiced on more than 110 million ha annually, mostly in USA, Canada, Brazil, Australia, Argentina etc.

Small holder farmers have not adopted CA practices yet for many reasons, including —lack of knowledge, perceived complexity of new system, unavailability of market-ready minimum tillage implements, limited access to herbicides, and the change of mind set required before shifting to CA. However, opportunities are opening up to make it easier for small holder farmers to change from excessive tillage to various forms of minimum tillage. A more diverse range of CA implements are being developed for small holders starting from hand tools or animal-drawn implements to planters mounted on two-wheel tractors or small 4W tractors (up to 35 hp). Effective CA practices for small holders would also enable them to capture the economic benefits already enjoyed by the large-scale users of CA, viz. reduced fuel and labour costs and improved timeliness of operations. However, there are many biophysical and socio-economic constraints to small holder farmers in adopting CA and it will be necessary to develop effective strategies to jointly improve the emerging technologies with them.

It is noted that CA in many areas evolved through innovation networks linking farmers, extension personnel, researchers, engineers, mechanics, input suppliers, and credit providers. Such a partnership approach would also seem necessary to bring CA to small holder farmers. Much has been learnt already about the development of CA for smallholders in Asia and Africa. It is timely to bring together the learning and to chart a course for future developments that can help smallholders find CA an attractive option. To assemble and document CA developments to date and to establish linkages among the collaborators working on CA for small holders, an international conference on Conservation Agriculture for Smallholders in Asia and Africa is planned in Mymensingh, Bangladesh during 7 - 11 December, 2014.

Themes of the conference:

i) Machinery: Design and development of CA-based crop establishment and herbicides spraying machinery, implements, tools for smallholders;
ii) Weed management: Suitable weed management options (chemical, mechanical, crop rotation and biological);
iii) Soil, water and agronomy;
iv) Commercialisation adoption and continuous improvement of CA-based technologies;
v) Policy and institutional framework for the adoption of CA.

Sponsored by:

- Food and Agricultural Organization of the United Nations (FAO)
- Australian Centre for International Agricultural Research (ACIAR)
- International Development Enterprises (iDE), Bangladesh
- Murdoch University, Australia

Organized by:
- Bangladesh Agricultural University
- Bangladesh Agricultural Research Council
- Bangladesh Agricultural Research Institute
- Bangladesh Rice Research Institute
- International Development Enterprises
- Murdoch University, Australia
- Department of Agriculture and Food of Western Australia
- Australian Centre for International Agricultural Research
- Food and Agricultural Organization of the United Nations
- International Rice Research Institute
- International Maize and Wheat Improvement Centre
- PROVA, Bangladesh
- Syngenta - Bangladesh
- Bayer Crop Science - Bangladesh
- ACI Formulation
- Alim Industries Limited
- Service Providers and Lead CA Farmers of Banglades

There were more than 150 scientists from all over the world and Africa was well represented in the conference by more than 15 delegates. More than 70 papers and 20 posters were presented during the conference. And also six keynote speeches were made by different professors who come from Murdoch (Australia) and Bangladesh Agricultural University, scientists from FAO and from other institute.

Annex 3 Conference papers

The papers and posters are presented in five different sessions as follows:

- Design and development of - and access to - Conservation Agriculture machinery, implements and tools for smallholders, Saidi Mkomwa, Li Hongwen and Jacky Desbiolles

- Evaluation of a mechanical rice transplanter under minimum tillage unpuddled soil conditions, M.A. Hossen, M.M. Hossain, M.M. Alam, M.E. Haque and R.W. Bell

- Residue Handling Capacity of the Versatile Multi-crop Planter for Two-wheel Tractors, M.E. Haque1*, R.W. Bell, M. Jahiruddin, W. Vance, M.A. Islam, and N. Salahin

- Mechanised Dry Direct Seeding of Rice: a Cambodian Development, S. Pao, N. Pen J. Desbiolles, B. Som, S. Chea, S. Chuong, S. Justice

- Optimising the furrow cutting process in rotary strip-tillage, M. A. Matin, J. M. A. Desbiolles and J. M. Fielke

- Evaluation of Two Wheel Tractor Operated Seed Drill (Gongli Africa) in Arusha, Tanzania, W.M. Baitani and G. L. Mwinama

- Furrow Openers Design can Improve Seed Placement and Emergence in Strip Tillage, M. A. Hoque, M. M. Hossain, ATMZ Uddin, T.J Krupnik, D.B. Pandit, S Yasmin, M.K. Gathala

- Application of a Slack-based DEA Model for Benchmarking Energy Inputs Use Efficiency of Selected Conservation Tillage Technology Options, Sreejith Aravindakshan, Frederick J. Rossi, and T.J. Krupnik

- Cost Effective Small No-till Seeder for Two Wheel Tractor in Bangladesh, Md. Israil Hossain, Jeff Esdaile, MK Gathala, TP Tiwari and Md. Ilias Hossain

Session 2 POSTERS

- Impacts of Conservation Tillage Machinery on Service Provider's Livelihood: A Farm Level Study M. A. Monayem Miah and M.E. Haque

- Weed Management in Wheat (*Triticum aestivum* L.) under Minimum Tillage and Crop Residues, M.M. Hossain, M. Begum, M.M. Rahman and A. Hashem

- Cowpea an efficient intercrop in banana improves soil health and income under Conservation Agriculture Production System (CAPS), S. N. Dash, S. Behera, K. N. Mishra, P. K. Roul, C. Chan Halbrendt, T.W.Idol and A. Pradhan

- Productivity, Profitability and Soil Properties as Influenced by Maize Based Conservation Agriculture Production Systems in Rainfed Uplands of India, P. K. Roul1, K. N. Mishra 1, S. N. Dash1 , Aliza Pradhan2, T.W. Idol2 , C. Chan Halbrendt2

- Aerobic rice cultivation on adoption of water saving technologies and improving agronomic practices during summer season under conservation agriculture, Zaman and Gangarani Th.

- Conservation agriculture for smallholders farming on efficient water resources utilization to combat adverse effect of global warming, Zaman, D. Pal and P. B. Chakraborty

- Management of weeds through bio-herbicides in soybean, Debesh Pal, A. Zaman, Heipormi Sungoh and R.K.Ghosh

- Optimization of seedling density as influenced by seed rate for mechanical transplanting, M.A. Hossen1, M.M. Hossain1, M.E. Haque2, R.W. Bell2 and M.A. Rahman3

- Conservation Agriculture-the light house to sail for sustainable agricultural growth in Bangladesh, Md. Nazim Uddin Mondal

- Performance Evaluation of Compressor and Lever Operated Type Sprayers for Weed Control, M.S. Hossen1, M.M. Hossain1 and ME Haque2

- Performance of Maize Hybrid under Conventional and Strip-Tillage Systems in Three Districts of Bangladesh, Md. Saiful Islam, Anup K Gosh, Khaled Hossain, Mahbubur Rahmand, Abul Khayer, Mustafa Kamarul Hassan, Jagdish Timsina and Mahesh K Gathala

- Weed Incidences and Crop Performance of Zero Tilled Dry Seeded Rice under Different Weed Management Options, M.H Rashid, J. Timsina, M.K Gathala, M.M Kamal and J.K Biswas

- Productivity of Lentil as Influenced by Different T. Aman Rice Varieties in High Barind Tract , M.E.A. Pramanik, M.A. Salam, A.K. Chaki, A.S.M.M.R. Khan and M. Akhtar Hossain

- Soil Moisture Conservation as Influenced by Mulching and Tillage and its Effect on Potato Yield in High Barind Tract, A.K.Chaki1, M.A. Salam, A.S.M.M.R. Khan, A.K. Choudhury and M.E.A. Pramanik
- An Introduction of a Change Hypothesis to Promote Small-scale Farmer-friendly 2WTs Innovation in Conservation Agriculture, Bangladesh, Ismat Ara
- Conservation agriculture increases land and water productivity of a rice-wheat-mung system on the High Ganges River Flood Plain of Bangladesh, M.J. Alam, E. Humphreys and M.A.R. Sarkar
- Study on inundation periods of land for mechanical transplanting under minimum tillage unpuddled transplanting, M.A. Hossen1, M.M. Hossain1, M.M. Alam1, M.E. Haque2, and RW Bell2,

- Development of the riding-type rice transplanter for unpuddled transplanting, M.A. Hossen1, M.M. Hossain1, M.M. Alam1, M.E. Haque2 and R.W. Bell2
- Effect of different green manures on rice productivity and soil conservation, M.R. Islam, N. Jahan and M.H. Sumon
- Practices of Conservation Agricultural Technologies in Diverse Cropping Systems in Bangladesh, M. Akteruzzaman1, Hasneen Jahan, M.E. Haque
- Effect of Application Timings of Pre Emergence Herbicides on Weed Efficacy and Crop Phytotoxicity in Dry Seeded Rice, Sharif Ahmed,
- Computational Modelling and Finite Element Analysis of Strip Tillage Components for Fabrication Purposes E. Lam1*, M. A. Hoque 12, R.K. Das3, M.K. Gathala1, T.J Krupnik1
- Fodder Chopper for Livestock Producers: A Case Study of Commercialization of Machinery for Smallholders in Bangladesh, M.E. Haque1*, R.W. Bell1, S.R. Waddington2, N.R. Sarker3, and M. Jabed Ali4
- Soil organic carbon sequestration and soil fertility improvement under systems of rice intensification (SRI) technique, Dilip Kumar Das
- Pea as Relay Crop in between Monsoon rice and Summer rice: a Resource Conservation Technology
- Md. Omar Ali1, Matiur Rahman2, William Erskine3 and Al Imran Malik 3
- Comparison of greenhouse gas emission characteristics between rice cropping and fallow season in a temperate paddy soil MD. Mozammel Haque1, Pil Joo Kim2, 3
- Effect of Different Tillage Options on Soil Moisture Conservation in Chickpea and Lentil Field under Rainfed Conditions M.A. Salam, M.E.A. Pramanik, A.S.M.M.R. Khan, A.K. Chaki and S. Ishtiaque
- Pulses De-husking Mill for Smallholders: A Case Study of Commercialization of Machinery for Small Entrepreneurs in Bangladesh M.E. Haque1*, R.W. Bell, Abdul Karim, M.G. Neogi
- Sustainable Livelihood Outcome through Water Resource Management: A Case Study on Household Character in North West Region in Bangladesh, Iffat Ara, Jeff Connor, Bertram Ostendorf, John Kandulu
- Strengthening Conservation Agriculture in Cambodia, Sovuthy Pheav, Stéphane Boulakia, Rada Kong, ViraLeng, Veng Sar, Kem Soeurng, Olivier Husson, FlorentTivet, and Lucien Séguy
- Influence of conservation tillage on livelihood improvement in the deltaic eco-system of Sundarban, India, P. B. Chakraborty, A. Bakley, A. Zaman, and A. Chanak

Session 3: Weed Management: Suitable weed management options (chemical, mechanical, crop rotation and biological)

- Weed Management in Conservation Agriculture, D. Lemerle and A. Hashem2
- Crop Establishment Techniques and Weed Control Strategies for Zero-till Planted Soybean-Wheat Rotation in India, Seema Sepat and AR Sharma
- Weed Control Efficacy of Herbicides in Wheat under Strip Tillage System, M. M. Rahman, T. Zahan, A. Hashem , M. Begum R. W. Bell and M. E. Haque
- Weed Control Efficacy of Herbicides in Unpuddled Transplanted A*man* (Summer) Rice, T. Zahan, M. M. Rahman, A. Hashem, M. Begum, R. W. Bell and M. E. Haque
- Weed Management in Mustard (*Brassica napus* L.) under Minimum Tillage and Crop Residues, M. M. Hossain, M. Begum, M. M. Rahman, A. Hashem, R. W. Bell and M. E. Haque
- Row Spacing, Herbicides and Nitrogen Effect on Crop-Weed Competition in Cereal-Broadleaf Crop Rotation, Hashem, W. Vance, R. Brennan and R. Bell
- Productivity of garlic grown under different tillage conditions and mulches under organic production systems Md. Abdur Rahim, Md. Ahsanul Kabir, Md. Shamsul Alam and Phillip W. Simon
- Evaluation of Conservation Tillage and Weed Management Options on Production Potential and Weed Incidences in Dry Seeded Rice, M.H Rashid, J. Timsina, N. Islam, M.K Gathala and J.K Biswas
- Wheat cultivation under conservation tillage options: a promising, low cost and profitable technology for small holders in Faridpur (Bangladesh) Md. Elahi Baksh, Frederick J Rossi, Md. Mohi Uddin, Zakaria Hasan, Fazlul Haque, Timothy J. Krupnik, Azahar Ali Miah, and Thakur P. Tiwari
- Soil Health, Weed Dynamics and Wheat Grain Yield in Different Rice-Wheat Rotations, Muhammad Farooq
- Including Maize in a Rice-Wheat Cropping System with Minimum Tillage and Crop Residue Retention, M. Ataur Rahman

Session 4: Soil and water management, and agronomy for smallholder

- Soil-water relations and water productivity in smallholder conservation agriculture systems of Southern Africa and South Asia, Christian Thierfelder and Tim Krupnik
- Soil organic carbon, water stable aggregates and microbial attributes as influenced by conservation agriculture production system (CAPS) in a *Fluventic Haplustepts* under North Central Plateau zone

of Odisha, Kshitendra Narayan Mishra1, Ayesha Mohanty1, Pravat Kumar Roul1, Satyanarayan Dash1, Catherine Chan-Halbrendt2, Travis Idol2, and Aliza Pradhan

- Effects of Minimum Tillage Practices and Crop Residue Retention on Soil Properties and Crop Yields under a Rice-based Cropping System, N. Salahin1, M. Jahiruddin2, M.R. Islam2, R.W. Bell3, M.E. Haque3 and M.K. Alam1

- Minimum tillage and increased residue retention improves soil physical conditions and wheat root growth in a rice-based cropping system, M. A. Islam1, R. W. Bell1, C. Johansen2, M. Jahiruddin3, M. E. Haque1

- Changes in soil organic C, nitrogen and chemical properties under no-till cropping systems on a Red Oxisol in Cambodia, Florent Tivet1,2, Stéphane Boulakia1, Sovuthy Pheav3,2, Vira Leng2, Rada Kong2, Lucien Séguy4

- Impact of Phosphorus Placement Methods after Three Years of Different Tillage Practices on Maize Productivity and Soil Properties, Md. Khairul Alam1, N. Salahin1, S. Pathan2, R.A. Begum1, A.T.M.A.I. Mondol 1 and R.W. Bell3

- Grain yield and phosphorus accumulation of field grown chickpea to subsoil phosphorus under a dry topsoil in the High Barind Tract, Enamul Kabir

- Effect of Tillage Type on Soil Water Content and Chickpea Yields
- W. H. Vance1, R. W. Bell1, C. Johansen2, M.E. Haque1, A. M. Musa4, A. K. M. Shahidullah4 and M. N. N. Mia3

- Tillage and Nutrient Management in Boro Rice under Rice-Mustard-Rice Cropping System, P.C. Goswami1, D. Mahalder1, M. K. I. Rony1, M. H. Rashid2

Session 5 Commercialisation, adoption and continuous improvement of conservation agriculture-based technologies

- Commercialisation, Adoption And Continuous Improvement of Conservation Agriculture-Based Technologies, Rafael Fuentes Llanillo

- Adoption and Impact of the Raised Bed Technology in Rajshahi District of Bangladesh, M. A. Monayem Miah1, Moniruzzaman1, S. Hossain2, J. M. Duxbury3, J. G. Lauren3

- Conservation Agriculture Packages in the Subsistence farming System of Eastern India, A.K.Chowdhury, P.M.Bhattacharya ,P.K.Mukherjee, T.Dhar and A.Sinha

- Agronomic performance of Pigeon pea Relay Intercropping with Maize or Sorghum under Minimum-Tillage of Ghana and Burkina Faso, H. Omae1, R. N. Issaka2, A. Barro3, M. M. Buri2, S. Simpore3, J. Kombiok4, J. Ali2 and F. Nagumo1

- Adoption of Conservation Agriculture in South-western Bangladesh, M. Harunur Rashid1, Debabrata Mahalder2, M. Khairul Islam Rony2, Palash Chandra Goswami2, Timothy Russell2

- Strip Tillage in Maize: Farmers' preferences and profit potential in Charland of Bangladesh D.B. Pandit, M.A. Arafat, M.E. Haque, M.A. Alam, T.J. Krupnik, T.P. Tiwari and M.K. Gathala

Session 6 Policy and institutional framework of conservation agriculture

- Improving Soil and Crop Productivity through Resource Conservation Technologies in Drought Prone Area, M. I. Hossain, M.E. Haque, M.R.I. Mondal and M K Sultan

- Wheat Requires Less Amount of Applied Fertilizers in Long Term Zero Tillage, M.A.Z. Sarker, M.M. Akhter and A. Hossain

- Conservation systems improves soil physical health and resource use efficiency in rice-wheat rotation Ahmad Nawaz1 and Muhammad Farooq

- Effects of Conservation Agriculture and Nitrogen Fertilization on Carbon Footprint in the Wheat-Mungbean-Rice Cropping System, M.A. Kader, S. Farhan, M.E. Haque and M. Jahiruddin

- The Impact of Conservation and Conventional Tillage Systems on Hydro-physical Properties of a Ferric Acrisol S.A. Mesele1, B.F. Amegashie1, C. Quansah1 and R.C. Abaidoo1

- Direct Seeded Rice (DSR) - Sustainable Rice Production System in East India Plateau, Ashok Kumar, Abdul Mannan Choudhury, Dr. Bill Bellotti, Dr. Peter S Cornish.

- Policy and institutional arrangements for the promotion of conservation agriculture for small farmers in Asia and Africa Peter Hobbs, Simon Lugandu and Larry Harrington

ACKNOWLEDGEMENTS

It was the unanimous view of the African stakeholders that the study tour to Bangladesh has been immensely successful. The support and hosting of the learning tour by the Bangladesh Agricultural Research Institute (BARI) is much appreciated. We express gratitude to the well-thought and meticulously implemented programme developed by Enamul Haque (iDE-Bangladesh), Mahesh Kumar (CIMMYT-Bangladesh), Timothy Krupnik (CIMMYT-Bangladesh) and Frederic Baudron (CIMMYT-Ethiopia). We are grateful for the support to FACASI by the Australian Centre for International Agricultural Research (ACIAR) which made the whole event possible.